RENEWABLE ENERGY SOURCES AND THEIR APPLICATIONS

Editors

R.K. Behl, R.N. Chhibar, S. Jain, V.P. Bahl, N.El Bassam

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Director of the International Research Centre for Renewable Energy, Germany, Chair of World Council of Renewable Energy (WCRE) and also the Head of the Project Concentrating Solar Power for Seawater Desalination Middle East and North Africa Countries. In addition he is EU-Adviser in developing, evaluating and funding of research programmes. Earlier, he has been serving as Chairman of the Working Group 3, Sustainable Rural Energy Network, Integration of wind, solar and bioenergy, (SREN), FAO, United Nations, Rome. Besides, he is President of the International Council of Sustainable Agriculture for Food, Energy and Industry (ICSA), Canada. He has held several other international positions, won various awards in the field of renewable energy, authored many articles, reports and books and serving as editor in three international journals.. He did his under and post graduate studies at university of Bonn, Germany. He began his research career as Assistant Professor at Goettingen University, Germany in 1968. He served German Federal Research Centre (FAL), Braunschweig, Germany for about 28 years in various positions including as Head of the Department of Alternative Energies for more than a decade. Email: info@ifeed.org

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FOREWORD

Adequate and affordable energy availability is essentially needed for all living beings in all walks of life. The major energy sources like coal , natural gas and petroleum products are non-renewable fossil fuels. These are finite and thus can be used only for a finite period. Also, emissions from non-renewable energy sources are major environmental pollutants.

Renewable energy sources, being eco-friendly and distributed globally, offer our planet a chance to reduce carbon emissions, clean the air, and serve as essential input for an overall strategy of sustainable development in agriculture, animal husbandry, industry, transportation , domestic uses such as water supply, sanitation, environmental quality, education etc.. The major renewable energy sources include, solar, wind, hydro, geothermal, sea waives, biomass and biofuels etc. In order to achieve the maximum utilization of renewable energy sources and supplies, the primary task, therefore, is to integrate the various forms of renewable energy.

In India various energy sources include Coal (48%), Natural gas (21%), Nuclear (20%), Hydro (6%), Solar, Wind and Biomass (3%) and other sources pooled together as only 2%. The average annual energy demand per capita in India is 631 kWh (~ 1.7 kwh/day) which is considerably lower as compared to developed countries in western hemisphere, the highest being for Canada followed by USA , Australia and the lowest being for Bangladesh.

India is acclaimed for its sunny areas as most of the country receives more than 4kWh/m^2 /day with more than 300 sunny days per year in the most part of the country. Likewise India has a long sea cost areas and large plains where wind velocity for most part of the year remains high to enable production of wind energy. Globally largest cattle population in India makes it a huge bio-resource (cow dung) of bioenergy. Also, energy parks can be created by planting trees, shrubs in waste and marginal lands and even in deserts. Low lands can be used to produce energy from blue green algae etc. This calls for concerted efforts, political will, sound and pragmatic planning, appropriate technology for effective tapping of vast renewable energy sources in an integrated manner.

Manav Institute of Technology and Management, Jevra , Hisar organized an International Seminar on Renewable Energy for Institutes and Communities in Urban and Rural Settings from April 27-29,2012. Scientists and policy planners from India and abroad participated and deliberated on various aspects of renewable energy including renewable energy sources, technology generation and refinement , domestic and commercial applications of renewable energy and needed policy interventions as support system etc.

This book entitled "**Renewable Energy Sources and Their Applications**" includes papers contributed by the participants and invited guests including scientists, policy planners, industry representatives and NGOs from India and abroad. This book is an excellent source of information on renewable and will be useful to researchers, development functionaries and policy makers. I congratulate the editors for bringing out this valuable and informative book for a systematic reading on renewable energy.

(M. L. Ranga)

Prof.R.S.Jaglan

Application of Renewable Energy Options for Environmental Sustainability- Vision

Prof.R.S.Jaglan

Registrar, Guru Jambheshwar University of Science and Technology, Hisar-125005 ,(Haryana) , India

Global climate change is a matter of concern both within the scientific community and in policy-making circles. Ways and means and available options for mitigating global climate change provide even more fertile ground for intensive debate. A number of countries have prepared contingent plans for addressing the global climate change question at national level however; international cooperation on appropriate and equitable measures for mitigating climate change needs further strengthening.

Fossil fuel reserves are continuously depleting. Also these are potentially major sources of harmful local and global emissions and tend to be concentrated in a few countries. On the other hand, renewable sources of energy are not only environmentally-benign but are better distributed globally. Existing estimates of energy use in Indian states and other developing countries indicate a significant and persistent dependence on traditional energy technologies including coal, gas, cattle dung and biomass based ones and limited use of modern renewable energy technologies.. Focus on a collective wisdom of various stake holders is needed to identify ways and means as well as policy interventions required to promote the use of renewable energy technologies and invent appropriate technologies for urban and rural settings.

Institutes like Manav Institute of Technology and Management at Jevra can serve as a hub for the industry's prominent networking event for inventors/developers, producers/manufacturers, suppliers, large and small energy consumers, investors and lenders, institutions, municipalities, and governments. The management of Manav Institute and whole team of the organizing committee deserve aplause for organizing an international event on renewable energy to identify needed research, development and policy issues and generate a consensus for the use of renewable energy in our daily life. More such international events would interest researchers, research scolars, technology students, manufacturers, development functionaries, policy planners, financial institution, suppliers and government as well as non government institutions. Therefore,

concerted efforts are warranted to develop international linkages to strengthen research and development for continuous enhancement in precision of the technology for sustained efficiencies. Guru Jambheshwar University is a Flagship Government institution to which several Engineering colleges are affiliated. The faculty of these colleges should join hands in promoting eco friendly technologies with expertise from academia and faculty of GJU S&T to ensure proper use of man power and institutional facilities.

PREFACE

In industrial revolution era the conventional energy sources such oil, coal, and natural gas have proven to be highly effective drivers of economic progress, but at the same time emissions from such sources have damaged our environment contributing to global warming and consequent climate change. The Inter Governmental panel on Climate Change (IPCC) has been discussing and raising the issue of containing emissions from fossil fuels and other sources through available scientific and technological options to mitigate the problems of climate change due to gaseous emissions and rising CO_2 levels on account of an oil and coal-powered global economy. Use of carbon sequestration measures and clean and green renewable energy has been persistently suggested..

Renewable energy sources such as biomass, wind, solar, hydropower, and geothermal can provide sustainable energy services. Switching over to renewable-based energy systems is being increasingly considered by various countries globally. With refinements in technology the feasibility and cost of solar and wind power systems have become affordable. Also with the policy interventions and technology refinements, market systems are rapidly evolving in favour of renewable energy systems. Renewable energy supply is dominated by traditional biomass, mostly fuel wood used for cooking and heating, especially in developing countries in Africa, Asia and Latin America. A major contribution is also obtained from the use of large hydropower and solar energy, wind energy, modern bio-energy, geothermal energy, and small hydropower energy sources are being increasingly tapped. Such a situation calls for implementation of aggressive long-term renewable energy programmes and creating awareness about benefits of renewable energy in urban and rural settings for domestic and commercial purposes.

Keeping above facts in view ,the Manav Institute of Management and Technology ,located in the village Jevra, Disst.Hisar (Haryana) , organized an International Conference on Renewable Energy for Institutes and Communities in Urban and Rural Settings from April 27-29 , 2012. About 250 abstracts were received and of them a large number of papers/poster presentations were made by fellow participants. This book entitled " Renewable Energy Sources: Options and Application" includes selected papers contributed by senior and young researchers from India and abroad. For systematic readings these papers have been resolved in various sections like Bio-energy and Biotechnology, Solar and Wind Energy, Food Processing using Solar Dryers , Socio-economic and Policy Issues etc.

The editors of this anthology whole heartedly thank Dr. C.P.Gupta, Chairman and Dr.Seema Gupta, Co-Chairperson, Manav Institute for their constant support, encouragement and vision for organizing this mega International Conference. The generous funding by AICTE, New Delhi is gratefully acknowledged. Editors also thank the authors for contributing their valuable and

informative papers. The technical assistance rendered by Dr. Sandeep Kumar and Dr.Sunil Kumar is thankfully appreciated.

Hope this book will serve useful purpose to research scholars, innovators, policy makers and field functionaries alike.

Editors:

R.K.Behl, Ravindra Chibbar, S. Jain, V.P.Bahl and N. El Bassam

Dr. C.P. Gupta

Manav Institute, Jevra, Disst. Hisar(Haryana), India , is engaged in providing holistic education, various branches of Engineering Technologies, Education and Pharmacy. It serves as a leading hub of education for students as well as innovation centre for inventors and all other stake holders. Located in a rural setting it is an inspiring destination for the young minds keen to understand and practice science and technology applications for the welfare of the society .The Management of Manav Institute has vision and heart to especially promote education in rural as well as urban settings with special emphasis to the upliftment of most economically down trodden section of the society. MI will continue to evolve in ways manifold that are relevant for students and in coherence with training as well market needs for human resource development.

Manav Institute of Technology and Management (MITM) steers AICTE approved programmes in M.Tech (Electronics and Computer Science Engineering), B.Tech. (Civil, Mechanical, Electronics, Electrical and Computer Science Engineering) and Pre- Engineering.

Global climate change is a reality and calls for integrated and concerted action. In contrast to fossil fuel reserves which are potentially major sources of harmful local and global emissions and tend to be concentrated in a few countries, renewable sources of energy are not only environmentally-benign but are better distributed globally. However, the major problems facing the dissemination of renewable energy technologies particularly in developing world are mainly institutional deficiencies, limited information on the renewable energy resource base, and options that could be considered in the future development of renewable energy technologies dissemination. Keeping this in view and with its new flavor of international linkages, Manav Institute of Technology and Management(MITM) organized International Seminar on Renewable Energy for Institutes and Communities in Urban and Rural Settings (April 27-29,2012). This mega event has paved path for faculty/ students exchange with developed countries.

During this International seminar MITM, Jevra attracted attention of world aclaimed scientists from 12 different countries , national and state policy planners , development functionaries and industry representatives to gether and work on a collective wisdom of various stake holders to plan coherent and pragmatic ways and means as well as policy interventions needed to promote the use of renewable energy technologies and invent appropriate technologies for urban and rural settings.

The management of Manav Institute consider it as profound privilege to express gratitude and thank Shri Ranbir Singh Gangwa, Memebr Parliament (Rajay Sabha), Shri Naresh Selwal, Member Legislative Assembly, Haryana, Shri.Jai Singh Bishnoi, Memebr, Haryana Commission for Backward Classes for gracing the inaugural session and sharing their experiences. The patronage provided by Dr.M.L.Ranga, Vice Chancellor , GJU&ST,Hisar,(Haryana), Prof.R.S.Kanwar, Vice Chancellor, Lovely Professional University, Jallandhar (Panjab) and

Prof.V.M.mayande , Vice Chancellor , Agriculture and Technology University, Prabhani (Maharashtra), is thankfully acknowledged . We express our gratitude to about 300 delegates from India and abroad who participated and deliberated in this mega event to identify needed research , development and policy issues and generate a consensus for the use of renewable energy in our daily life . I thank Prof.Meliczek (Germany) , Dr.K.W.Giorgis(Ethiopia), Prof.Ravi Chibbar (Canada), Prof. Theo Kleynhans (South Africa) and Prof. Nasir El Bassam (Germany) for their participation and collaboration through memorandum of Understanding for continued education through faculty and students exchange, joint International Seminars and education programmes. I also thank dignitaries namely Prof. D.P.Singh, former Vice Chancellor, JNKVV, Jabalpur and currently Consultant, Farmers Commission, Haryana for his remarks , Dr. Kamal Gupta , academia from GJUS&T, CCSHAU, other universities , and institutes of research and development in various parts of the country for their gracious and benign presence.

I owe thanks to Dr .R.S. Jaglan, Registrar, GJU S&T, Hisar for his thought provoking speech at plenary session and encouragement to the organizers and delegates..

Thanks are due to Dr.Seema Gupta , Co-Chairperson , Prof.R.K.Behl, Director , New Initiatives, and International Affairs, Dr.Surjeet Jain, Director Principal cum Coordinator International Conference, Mrs.Geeta Beniwal ,Principal, MI Education, Mr.R.K.Harna, Principal,MI Pharmacy, Deputy Directors, Heads of Department s, faculty , all members of various committees for their untiring effort to make this mega event happen successful. I also express my deep sense of gratitude to Press and Media persons to give good coverage to this International conference in Media. Also, all service units of Manav Institute including public relations, transport, and maintenance deserve uplause. I thank one and all who directly or indirectly contributed towards organization of this mega event held first time at an impressive scale in the region in any private sector institute.

I also congratulate the editors for bringing out this publication based on papers presented/intended to be presented. I also congratulate winners of Paper/ Poster Presentation Awards. Manav Institute on its path of progress will organize similar events in future at Jevra, Hisar and abroad.

(C.P.Gupta)

Chairman, Manav Institute,

Jevra, Disst.Hisar(Haryana),India

Contents

Options of Renewable Energy Technologies in Restructuring the Future Energy Generation and Supply in Regional and Global Context

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ABSTRACT

Conventionally, power plants have been large, centralized units. A new trend is developing toward distributed energy generation, which means that energy conversion units are situated close to energy consumers, and large units are substituted by smaller ones. A distributed energy system is an efficient, reliable and environmentally friendly alternative to the traditional energy system.

Keywords : Distributed energy system, distributed energy supply, community power, off-grid systems

INTRODUCTION

The time of cheap oil and gas is over. Mankind can survive without globalization, financial crises and flights to the moon or Mars but not without adequate and affordable energy availability.

Energy is directly related to the most critical economic and social issues which affect sustainable development such as water supply, sanitation, mobility, food production, environmental quality, education, job creation security and peace in regional and global context. Indeed the magnitude of change needed is immense, fundamental and directly related to the energy produced and consumed nationally and internationally. In addition, it is estimated that almost two billion people worldwide lack access to modern energy resources.

Current approaches to energy are non-sustainable and non renewable. Today, the world's energy supply is largely based on fossil fuels and nuclear power. These sources of energy will not last forever and have proven to be contributors to our environmental problems. In less than three centuries since the industrial revolution, mankind has already burned roughly half of the fossil fuels that accumulated under the earth's surface over hundreds of millions of years. Nuclear power is also based on a limited resource (uranium) and the use of nuclear power creates such incalculable risks that nuclear power plants cannot be insured. After 50 years of intensive research, no single safe long-term disposal site for radioactive waste has been found.

Although some of the fossil energy resources might last a little longer than predicted, especially if additional reserves are discovered, the main problem of 'scarcity' will remain, and this represents the greatest challenge to humanity.

Renewable energy offers our planet a chance to reduce carbon emissions, clean the air, and put our civilization on a more sustainable footing. Renewable sources of energy are an essential part of an overall strategy of sustainable development. They help reduce dependence of energy imports, thereby ensuring a sustainable supply and climate protection. Furthermore renewable energy sources can help improve the competitiveness of industries over the long run and have a positive impact on regional development and employment. Renewable energies will provide a more diversified, balanced, and stable pool of energy sources.

Some countries of the EU such as Denmark, Germany, Austria and Spain as well as China or India have already demonstrated the impressive pace of transition which can be achieved in renewable energy deployment, if the right policies and frameworks are in place. Also the new US policy has made clear its determination to massively increase renewable energy in the US, giving strong and clear signals to the world. With rapid and continued growth in the world it is no longer a question of when we will incorporate various renewable energy sources into the mix, but how fast the transition can be managed.

BASIC CHALLENGES

By 2050, humanity will need two to three earths to cover its consumption of resources, if we continue to manage our resources as business as usual. The global energy system currently relies mainly on hydrocarbons such as oil, gas and coal, which together provide nearly 80 per cent of energy resources. Traditional biomass – such as wood and dung – accounts for 11 per cent and nuclear for 6 per cent, while all renewable sources combined contribute just 3 per cent. Energy resources, with the exception of nuclear, are ultimately derived from the sun. Non-renewable resources such as coal, oil and gas are the result of a process that takes millions of years to convert sunlight into hydrocarbons. Renewable energy sources convert solar radiation, the rotation of the earth and geothermal energy into usable energy in a far shorter time.

In IEA Reference Scenario, world primary energy demand grows by 1.6% per year on average in 2006-2030, from 472 EJ (11 730 Mtoe) to just over 714 EJ (17 010 Mtoe). Due to continuing strong economic growth, China and India account for just over half of the increase in world primary energy demand between 2006 and 2030. Middle East countries strengthen their position as an important demand centre, contributing a further 11% to incremental world demand. Collectively, non-OECD countries account for 87% of the increase. As a result, their share of world primary energy demand rises from 51% to 62%. Their energy consumption overtook that of the OECD in 2005 (OECD/IEA 2008).

The major challenge of today's energy system is closely related to a wide scale of essentials such as welfare, dignity, peace, nature and sustainable development:

- Limited oil, gas and uranium resources.
- Almost up to 2 billion of the world population have no access to electricity, gas, oil or clean water.
- Increasing import dependency in most industrialized countries, China and India.
- Energy prices and volatility (the time of cheap oil and gas is over!).
- Climate change and other environmental risks (Energy accounts for 80% of all greenhouse gas (GHG) emission).

- Geo-strategic tensions caused by scare energy resources.
- The extracting, transport, processing and use of fossil and nuclear fuels can be eventually threatening to nature and existence of mankind (i.e. accidents in Gulf of Mexico and Fukushima).
- Worldwide, there is no single safe long term storage facility for high radioactive nuclear wastes.
- Growing World population (2012:7 billon, 2050:9-10 billion).

Figure 1 effectively demonstrates the finiteness of fossil energy resources and the vital role of renewable energies in satisfying the needs of the present and future generations for adequate and affordable energy to ensure sustainable development.

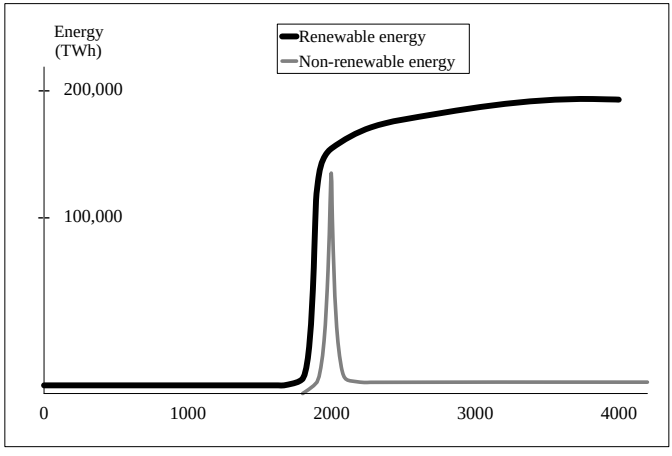


Figure 1. Past, present and future energy sources. (El Bassam, 1992)

CURRENT ENERGY SUPPLIES

Current global energy final supplies are dominated by fossil fuels (388 EJ per year), with much smaller contributions from nuclear power (26 EJ) and hydropower (28 EJ). Biomass provides about 45 ± 10 EJ, making it by far the most important renewable energy source used.

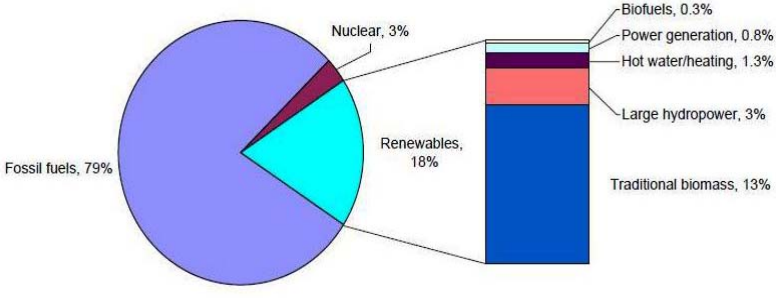


Figure 2. Global Final Energy Consumption, 2006 (REN21, 2007)
Source: REN21 Renewables 2007 Global Status Report.

Renewable energy supplies 18 percent of the world's final energy consumption, counting traditional biomass, large hydropower, and "new" renewable (small hydro, modern biomass, wind, solar, geothermal, and biofuels) (Figure 3). Traditional biomass, primarily for cooking and heating, represents about 13 percent and is growing slowly or even declining in some regions as biomass is used more efficiently or replaced by more modern energy forms.

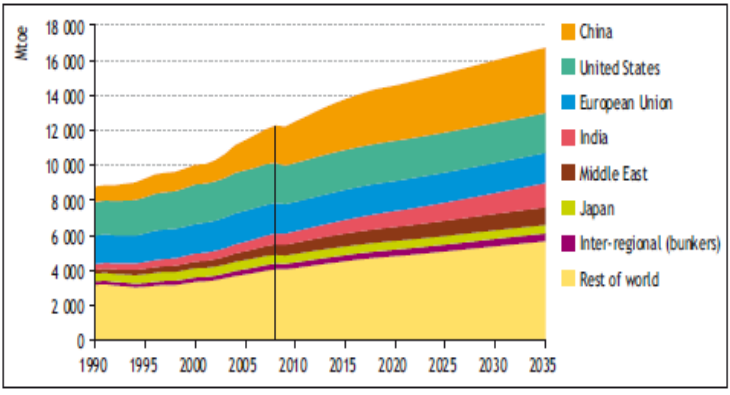


Figure 3. Regional breakdown of world energy demand scenario in the New Policies
Source: Projection of EIA 2009

Peak Oil

Peak oil theory states that any finite resource, (including oil), will have a beginning, middle, and an end of production, and at some point it will reach a level of maximum output. Today we consume around 4 times as much oil as we discover.

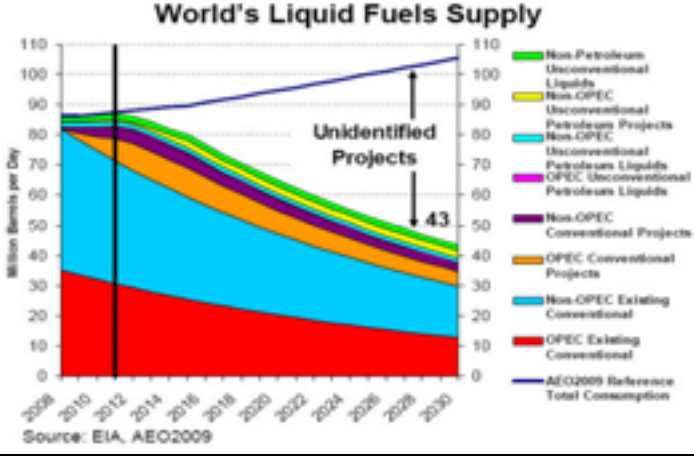


Figure 4. Peak Oil: The decline of global production output will lead to peak cheap oil by 2012 (Projection of EIA 2009)

The peaking of oil extraction was already reached by: USA in 1974; Venezuela in 1998; Norway and Oman in 2001; Mexico in 2004 and Nigeria in 2005.

The "Unidentified Projects" in Figure 5 refers to the potential of renewable energy solutions that require immediate actions which should be on top of the agenda.

The possible future contribution of various renewable energy technologies which should remain the ultimate priority (solar, wind, hydro, biomass, geothermal....) is demonstrated in Figure 6.

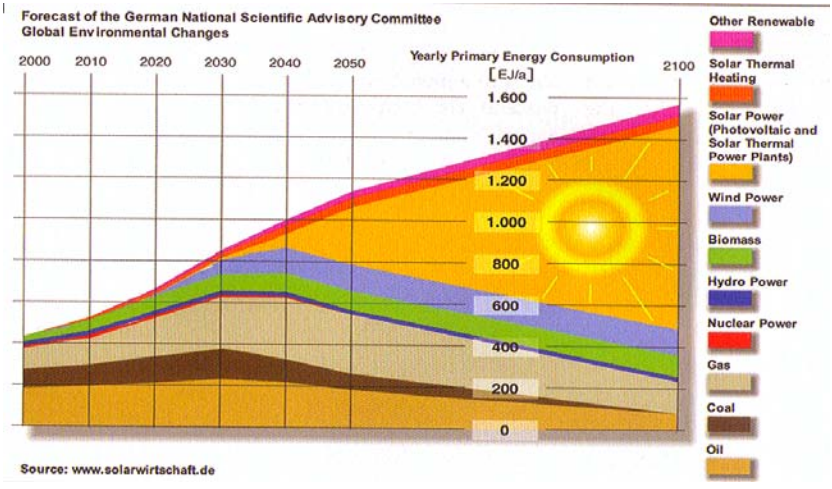


Figure 5. Global energy demand and resources Source: BSU Solar, 2007

AVAILABILITY OF ALTERNATIVE RESOURCES

Energy can not be created; it can be converted from one form to other by technical, biological and chemical means: Solar and wind energy into heat and power energy, biomass into heat, electricity or biofuels etc., and the good news is: We have all what we need of energy resources and the conversion technologies in order to ensure a complete supply of clean and green energy!

Renewable energy offers our planet a chance to reduce carbon emissions, clean the air, and put our civilization on a more sustainable footing. Renewable sources of energy are an essential part of an overall strategy of sustainable development. They help reduce dependence of energy imports, thereby ensuring a sustainable supply and climate protection. Furthermore, renewable energy sources can help improve the competitiveness of industries over the long run and have a positive impact on regional development and employment. Renewable energies will provide a more diversified, balanced, and stable pool of energy sources. With rapid growth in Brazil, China and India, and continued growth in the rest of the world, it is no longer a question of when we will incorporate various renewable energy sources more aggressively into the mix, but how fast?

The technically exploitable amounts of energy in the form of electricity, heat and chemical energy from renewable sources exceed the current world energy consumption by about six fold (Nitsch, F. 2007).

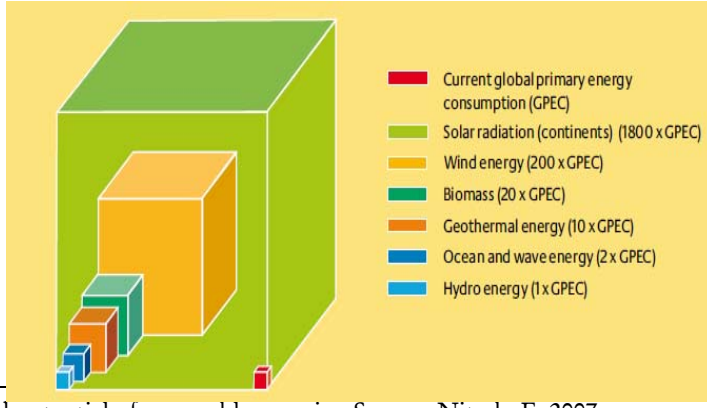


Figure 6. Physical potential of renewable energies. Source: Nitsch, F. 2007

The transition into distributed and decentralized renewable energy systems has to be associated with multiple measures:

- Renewable energies should remain the priority (solar, wind, hydro, biomass, geothermal....)
- Improving the energy efficiency
- Construction of smart grids
- Creating power storage facilities
- Future oriented and innovative policy in national, regional and global context
- Creating a global climate framework
- Intensifying research and education activities
- Improving the cooperation between nations as well as between public and private sectors.

Power Plants

Conventionally, power plants have been large, centralized units. A new trend is developing toward distributed energy generation, which means that energy conversion units are situated close to energy consumers, and large units are substituted by smaller ones. A distributed energy system is an efficient, reliable and environmentally friendly alternative to the traditional energy system.

Distribution means the delivery of electricity to the retail customer's home or business through low voltage distribution lines. Distributed generation is also called on-site generation, dispersed generation, embedded generation, decentralized generation or on-site generation. Decentralized energy or distributed energy, generates electricity, heat and fuels from many small energy sources. It reduces the amount of energy lost in transmitting electricity because the electricity is generated very near where it is used, perhaps even in the same building. This also reduces the size and number of power lines that must be constructed. Both electric demand reduction (energy conservation, load management, etc.) and supply generated at or near where the power is used. A distributed generation system involves amounts of generation located on a utility's distribution system for the purpose of meeting local (substation level) peak loads and/or displacing the need to build additional (or upgrade) local distribution lines.

Distributed Energy Generation:

Distributed generation is also defined as installation and operation of small modular power generating technologies that can be combined with energy management and storage systems. It is used to improve the operations of the electricity delivery systems at or near the end user. These systems may or may not be connected to the electric grid.

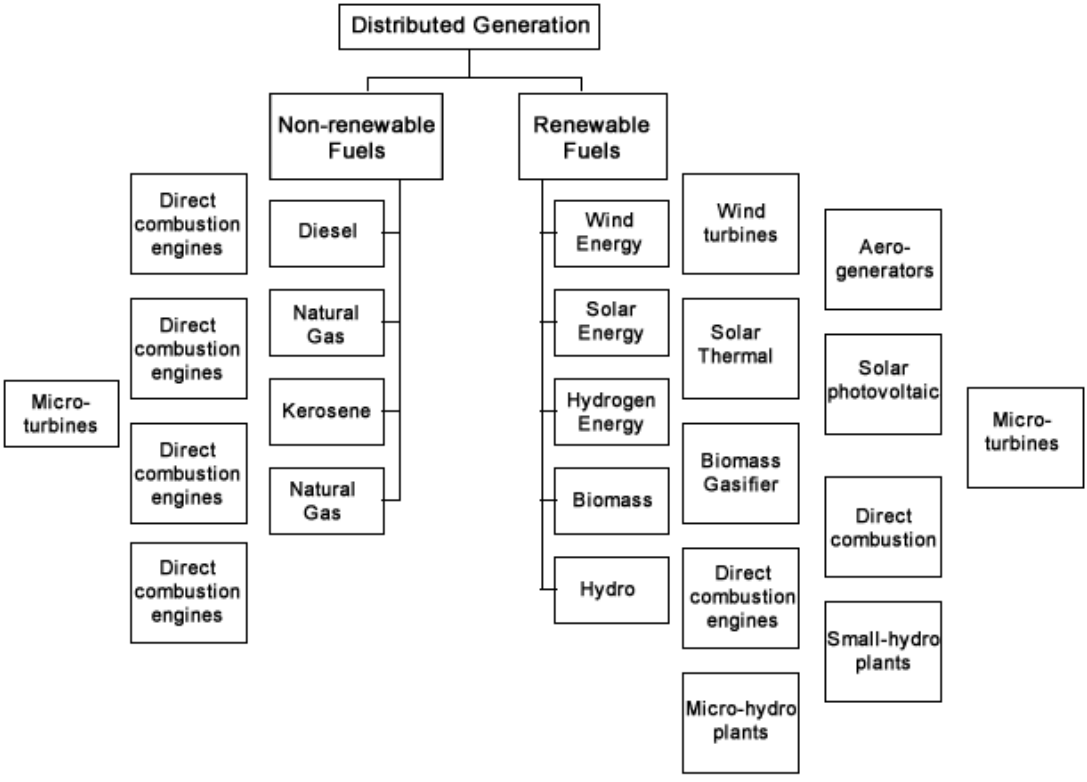


Figure 7: Relevance of distributed generation (www.indiaenergyportal.org/subthemes.php?text=.)

Energy Supply

Typical distributed power sources in a Feed-in Tariff (FIT) scheme have low maintenance, low pollution and high efficiencies. In the past, these traits required dedicated operating engineers and large complex plants to reduce pollution. However, modern embeded systems can provide these traits with automated operation and renewables, such as sunlight, wind and geothermal. This reduces the size of power plant that can show a profit.

When planning a new power and heating or transportation fuels system on a clean piece of paper there will not be any big fossil fuel based power stations or big high voltage transmission lines. Each community in such new energy supply structure will have a variety of local supply technologies based on solar, wind, biomass and other locally available sources of energy.

Solar and wind will be the primary sources of supply. Biomass will be especially important for complementary power and heat when solar and wind is not sufficient. Balancing of fluctuating

power from solar and wind is necessary; chemical and thermal storage solutions will be applied. Such future supply systems can be of many sizes. The smallest will be for one family house or settlement and the biggest for a region or city.

As small scale technologies can be mass produced and thereby cheap, it may well prove preferable to and most economical to divide up cities in many independent and autonomous decentralized systems. In this book we will call them off-grid as there is no advantage to have international interregional grid structures. So far off-grid supply was referred to unserved areas in developing countries without a national grid.

Distributed energy resource systems are small-scale power generation technologies (typically in the range of 3 kW to 10,000 kW) used to provide an alternative to or an enhancement of the traditional electric power system.

Due to the decentralized character of the renewable energies the future rationale option will be to apply off-grid technologies to all types of communities, urban and rural in fossil fuel served communities in the industrialized countries and for unserved regions in developing countries.

As the cost of fossil fuels increasing and of renewable energy technologies declines and government support increases, investors, utilities, and governments are exploring ways to implement or invest in distributed renewable energy programs, projects and companies.

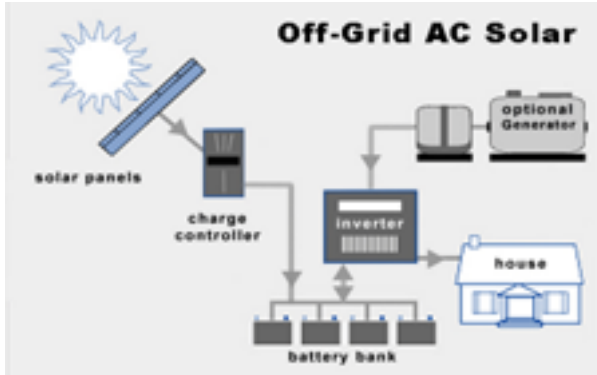
Community Power

Community is a term that has different meanings for different people. In this book a community is defined as a social group of any size whose members live in a specific place. The term thus relates to geographical proximity, or "communities of locality" (Walker 2008), such as a neighbourhood, town, district or city. The publication focuses on distributed energy that is generated and distributed to consumers within a geographic locality. Distributed energy generation can be a continuum of energy generation from a household and multiple buildings scale to a larger community scale. Some energy may be fed back into the electricity grid, but ideally at least some of the total energy generated is distributed and consumed locally.

The contribution book profiles the special topic of Community Power – Citizens' Power, referring to the development and ownership of renewable energy projects by local citizens and communities including farmers and landowners, cooperatives, municipalities, local and regional developers and utilities.

Off-Grid Systems

Off-grid systems provide an independently regulated power supply which has at least the same reliability and quality as a public power grid. The term off-grid refers to not being connected to a grid, mainly used in terms of not being connected to the main or national transmission grid in electricity. Off-grid electrification is an approach to access electricity used in countries and areas with little access to electricity, due to scattered or distant population. It can be any kind of electricity generation. Electrical power can be generated on-site with renewable energy sources such as solar, wind , or geothermal; with a generator and adequate fuel reserves.



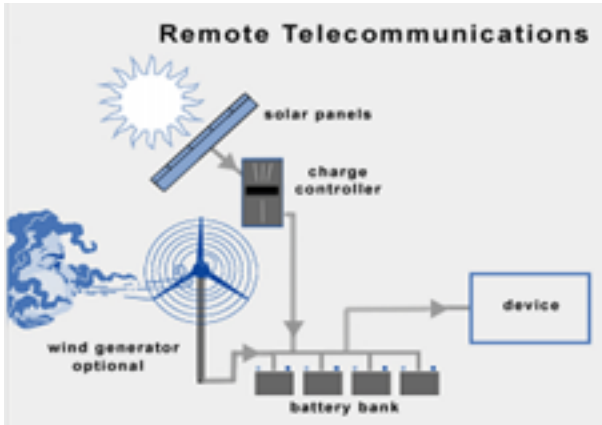


Figure 8: Stand alone off-grid systems

It can also connected to local and national grids to substitute energy supply generated by nuclear or other non-renewable fuel sources, which is being called as green electricity in some industrialized countries.

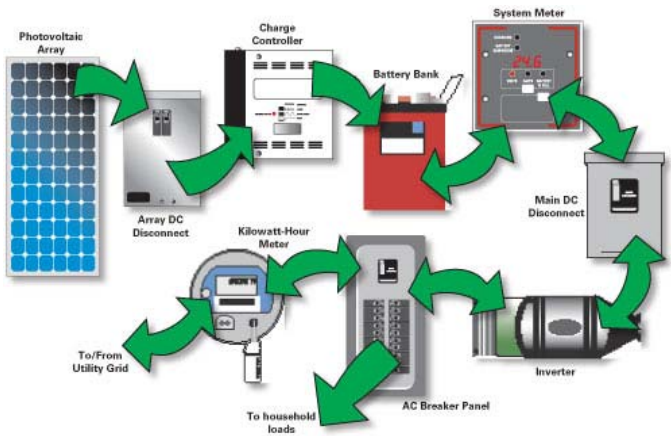


Figure 9: Off-grid system which can be also connected to the grid Reprinted with permission. ©2012 Home Power Inc., www.homepower.com

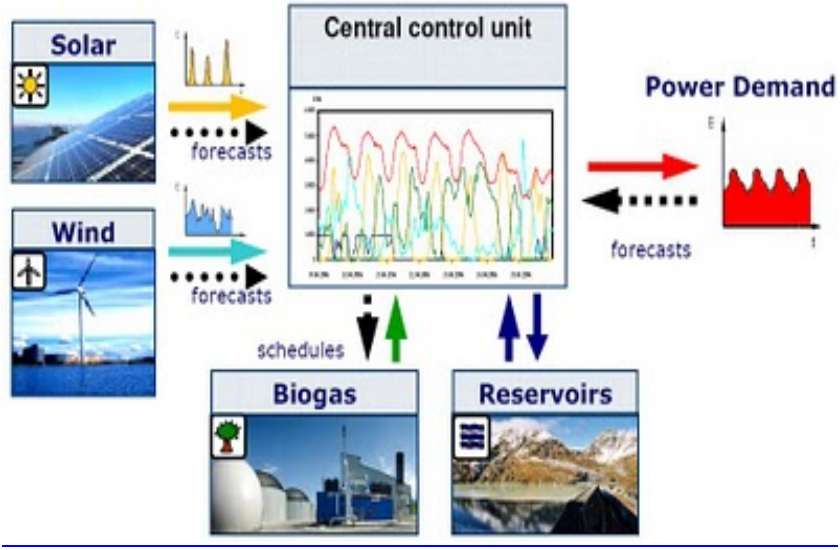


Figure 10: Combined Power Plant
http://www.blog.thesietch.org/2007/12/30/germany-going-100-renewable-or-yet-another-reason-why-america-is-falling-behind/. Accessed March 23, 2010

This paper illustrates the future of off-grid power supply as there is no advantage to have international, interregional grid structures. So far, off-grid supply was referred to communities in developing countries without a national grid. Due to the decentralized character of the renewable energies, the future rationale will be to apply off-grid technologies to all types of communities, urban and rural in fossil fuel served areas in the industrialized countries and for unserved regions as well in developing countries. What hitherto was the exemption may, due to the transition to decentralize energy forms, change to become mainstream. Similar fundamental changes have often appeared in the long historical perspective. Facing the end of the fossil fuel age and the enormous risks of the ongoing climate change, it is time to prepare for the exit of the fossil fuel era. And there are no technological barriers; this is the important message of this publication.

The concept of FAO, UN-Integrated Energy Communities (IEC)

Renewable energy has the potential to bring power to communities, not only in the literal sense, but by transforming their development prospects. There is tremendous latent demand for small scale, low cost, off-grid solutions to people's varying energy requirements. People in developing countries understand this only too well. If they were offered new options that would truly meet their needs and engage them in identifying and planning their own provision, then success in providing renewable energy services could become a reality.

Energy is one of the important inputs to empower people provided it is made available to the people in unserved areas on an equitable basis. Therefore, access to energy should be treated as the fundamental right for everyone. This is only possible if the end users are made the primary stakeholders in the production, operation and management of the generation of useful energy. Despite much well intended effort, little progress has been made and a radical new approach is called for based on the following imperatives:

- Rural development in general and rural energy development specifically needs to be given higher priority by policy makers.
- Rural energy development must be decentralized and local resources managed by rural people.
- Rural energy development must be integrated with other aspects of rural development, overcoming the institutional barriers between agriculture infrastructure and education as well as in the social and political spheres.
- The problem of non-committing policies on the government level, different priorities in each country should be addressed.

The productivity and health of a third of humanity are diminished by a reliance on traditional fuels and technologies, with women and children suffering most. Current methods of energy production, distribution and use worldwide are major contributors to environmental problems including global warming and ecosystem degradation at the local, regional and global levels.

The IEC concept includes farms or decentralised living areas from which the daily necessities (water, food and energy) can be produced directly on-site with minimal external energy inputs. Energy production and consumption at the IEC has to be environmentally friendly, sustainable and ultimately based mainly on renewable energy sources. It includes a combination of different possibilities for non-polluting energy production, such as modern wind and solar electricity production, as well as the production of energy from biomass. It should seek to optimise energetic autonomy and an ecologically semi-closed system, while also providing socio-economic viability and giving due consideration to the newest concept of landscape and bio-diversity management.

GLOBAL APPROACH

In order to meet challenges, future energy policies should put more emphasis on developing the potential of energy sources, which should form the foundation of future global energy structure. In this context, the FAO of the United Nations in support of the Sustainable Rural Energy Network (SREN) has developed the concept for the optimisation, evaluation and implementation of integrated renewable farms for rural communities under different climatic and environmental conditions (El Bassam 1999).

The concept of an Integrated Energy community or settlement includes 4 pathways: 1). Economic and social pathway; 2). Energy pathway; 3). Food pathway; and 4). Environmental pathway.

Specifications of IEC:

- Decentralized, autonomous and location-based production of energy and food and innovation
- Combined use of different renewable energy sources (biomass, solar, wind, etc.)
- Suitability for remote areas: settlements, villages and islands
- It should include job creation, social, economic, ecological, education and training opportunities for the people in the community.

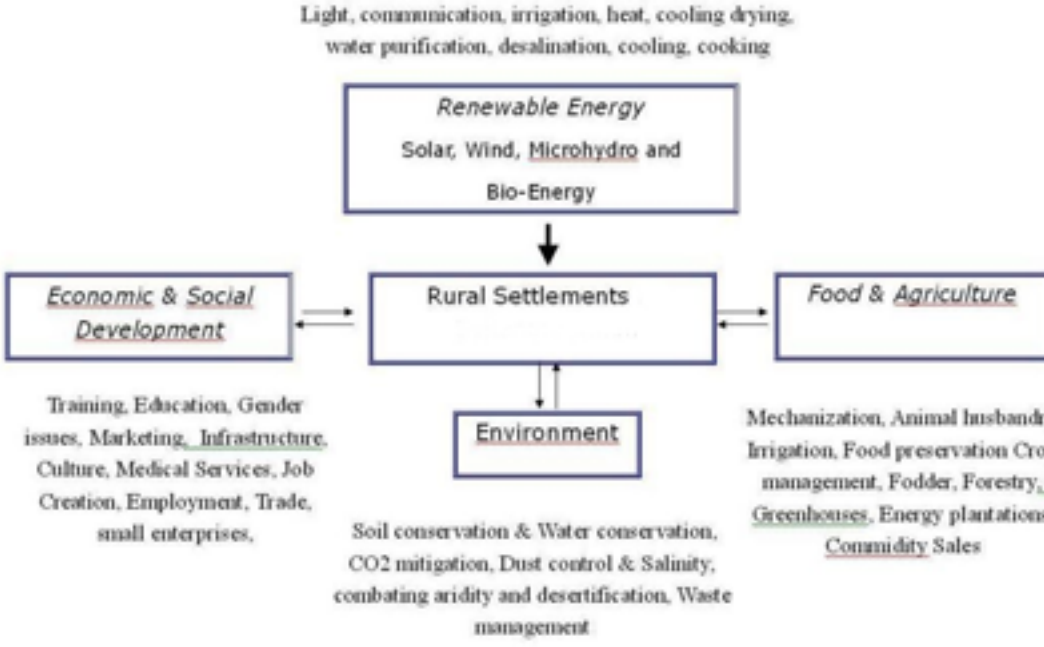


Figure 11: Pathways of the Integrated Energy Community (IEC)

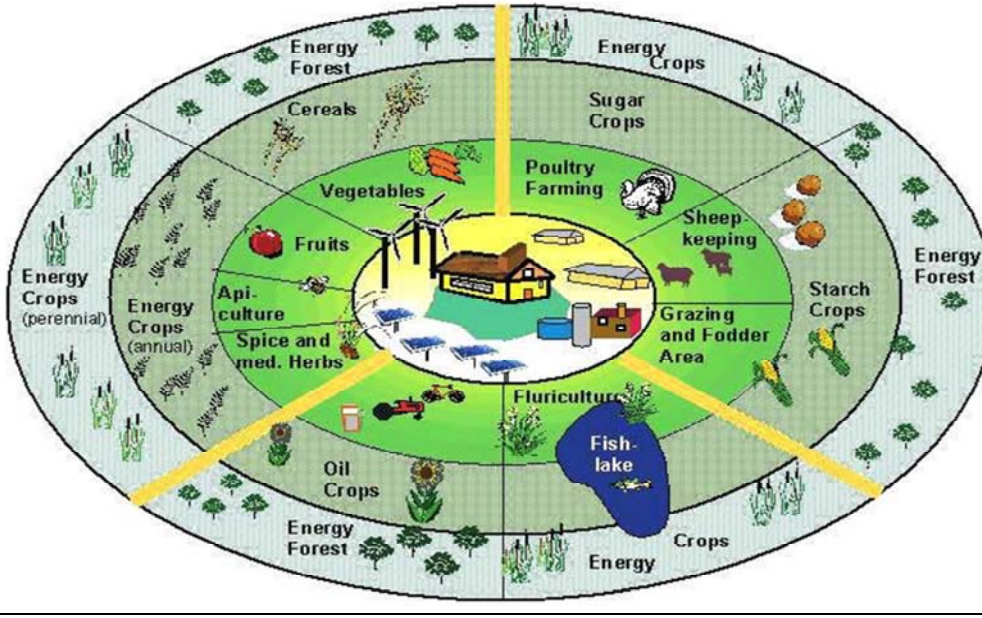


Figure 12: A model for an Integrated Energy Community with Farming Systems. (El Bassam 2001)

Basic data should be available for the verification of an Integrated Renewable Energy Farm (IREF). Various climatic constraints, water availability, soil conditions, infrastructure, availability of skills and technology, population structure, flora and fauna, common agricultural practices and

economic and administrative facilities in the region should be taken into consideration. Renewable energy technologies are available from different natural resources: biomass, geothermal, hydropower, ocean power, solar (photovoltaic and solar thermal), wind and hydrogen. Climatic conditions prevailing in a particular region are the major determinants of agricultural production. In addition to that, other factors like local and regional needs, availability of resources and other infrastructure facilities also determine the size and the product spectrum of the farmland. The same requisites also apply to an IREF. The climate fundamentally determines the selection of plant species and their cultivation intensity for energy production on the farm. Moreover, climate also influences the production of energy-mix (consisting of biomass, wind and solar energies) essentially at a given location and the type of technology that can be installed also depends decisively on the climatic conditions of the locality in question. For example, cultivation of biomass for power generation is not advisable in arid areas. Instead a larger share can be allocated to solar energy techniques in such areas. Likewise, coastal regions are ideal for wind power installations.

Solar Oases

In these studies N. El Bassam (2009) has designed the concept of creating renewable energy **"Solar oases"** by using alternative energy source and desalinated sea water for supplying the population in arid regions with food, energy and water and to establish fundaments for development and

Figure 13: CSP fields, desalination plant and pipe line for desalted water transport

I. Step one: Sea water desalination using concentrated solar thermal power and advanced desalination technologies.

II. Step two: Transport of the water for implementation of farms.

Figure 14: Projection of the oases including housing, lakes food crops and greenhouse facilities

III. Step three: Establishing communities including:
IV. Step four: Farms and food production facilities including green houses, fish lakes etc.
V. Step five: Opportunities for job creation, education, handworks, workshops, education and marketing.

The concept can be also applied for already existing villages and settlements. Specific modifications are then needed.

CONCLUSION

The world still continues to seek energy to satisfy its needs and giving due consideration to the social, environmental, and economic and security impacts. It is now clear that current approaches to energy are unsustainable. It is the responsibility of political institutions to ensure that technologies which enable sustainable development should be transferred to the end users. Scientists and individuals bear the responsibility of understanding the earth as an integrated whole and must recognise the impact of our actions on the global environment, in order to ensure sustainability and avoid disorder in the natural life cycle. Wise policy in a regional and global context requires that demands are to be satisfied and risks be avoided.

Figure 15: The future welfare of the next generations is in our hands

Renewable energy and energy efficiency do not represent an alternative to fossils resources; they are the only options which can ensure sustainable development and the survival of the mankind and the protection of our climate. The share of renewable energy in total energy supply needs to grow by 2% per year in order to ensure future energy demand and to avoid regional and global crises. Although there's more than 100 years' supply of crude oil left in the ground, the resources that are "cheap and easy" to extract have for the most part already been discovered and adequate proportions of gas and oil resources should be reserved for human welfare in decades to come.

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Renewable and Green Energy Resources Technologies: Lessons Learnt In Sub-Saharan Africa (SSA)

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ABSTRACT

Since its introduction, renewable and green energy resources especially liquid biofuels were widely praised. So, many countries and especially those in Sub-Saharan Africa (SSA) embarked on it hopping that it could contribute to the reduction of both dependency of fossil fuels and reduction of huge foreign currency used to buy fossil fuels whose price is going up almost every day. There are several benefits of renewable energies especially in developing countries and these includes; job creation and diversification of the economy in rural areas, reliable market for agricultural produce especially for energy crops such as jatropha which had no economic importance to farmers. In some areas the community went further and got cheap energy from green resources for example some of milling machines for maize and cassava in rural areas are now driven by biofuels from energy crops cultivated in their community. In addition some villages in Sub Saharan Africa now are getting cheap electricity generated by renewable green resources. This paper reviews renewable and green energy resources technologies and lessons learnt in Sub-Saharan Africa (SSA) regarding lack of policy ,lack of appropriate technology and involvement of local community etc. in generaton and use of renewable energy .

Key words: Renewable energy, green energy resources , Sub-Saharan Africa (SSA)

INTRODUCTION

In terms of land mass, Africa has more land mass than the total area of Brazil, Japan, Australia, Europe and USA (Fig 1). The continent have 54 countries with approximately 14% of the world's population and occupying about 20% of the world's landmass, but it consumes only about 3% of the world total energy (Muhongo, 2012). It should be noted here that about 75% of the Sub Saharan population has no access to electricity.

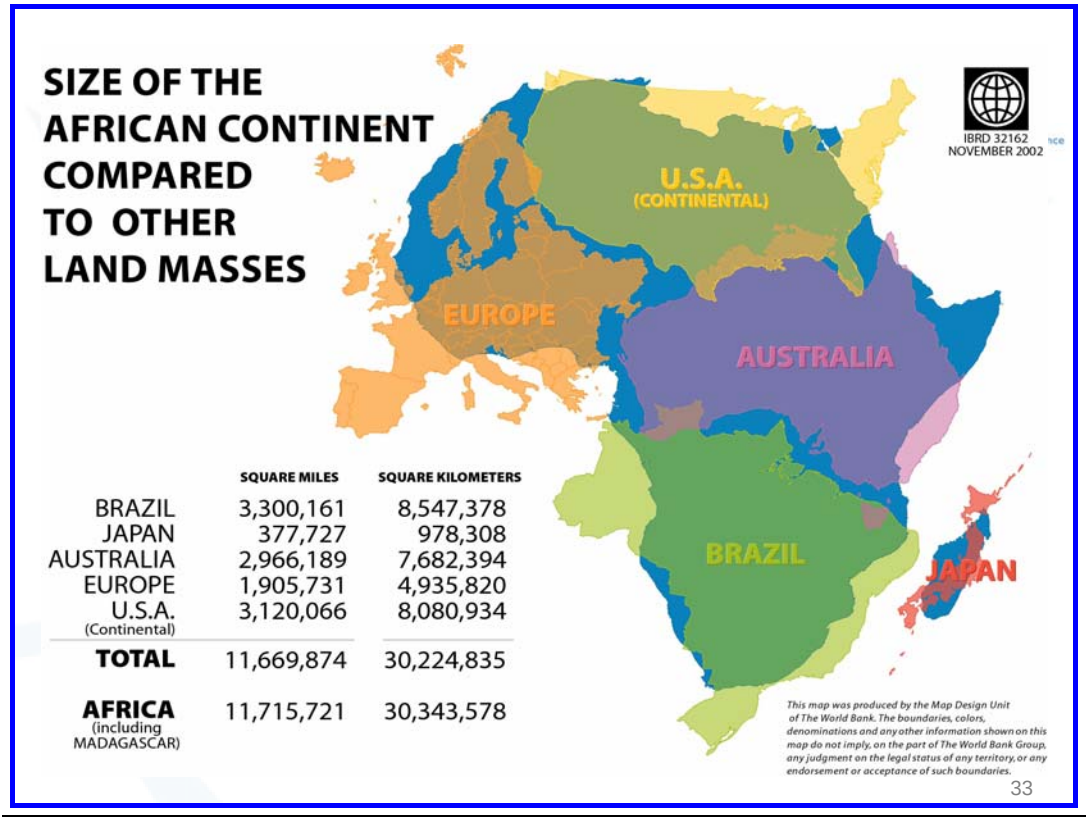

Fig. 1: Size of the African continent compared to other land masses

Since its introduction, renewable and green energy resources especially liquid biofuels were widely praised. So, many countries and especially those in Sub-Saharan Africa (SSA) embarked on it hopping that it could contribute to the reduction of both dependency of fossil fuels and reduction of huge foreign currency used to buy fossil fuels whose price is going up almost every day. It should be noted here that most countries in SSA adopted the idea of renewable energy production mostly because they thought that it could create jobs in rural areas, diversify the economy of the rural community, reduce the heavy bills of fossil fuels, etc. they had nothing in their minds about reduction of GHG and other bad effects of fossil fuels. But in recent years, mainly due to poor approaches in introducing renewable energy production systems, these positive hopes on renewable energy especially on liquid biofuels changed and now it is being blamed that this might be a major cause of food price increases in the world.

There are several benefits of renewable energies especially in developing countries and these includes; job creation and diversification of the economy in rural areas, reliable market for agricultural produce especially for energy crops such as jatropha which had no economic importance to farmers. In some areas the community went further and got cheap energy from green resources for example some of milling machines for maize and cassava in rural areas are now driven by biofuels from energy crops cultivated in their community. In addition some villages in Sub Saharan Africa now are getting cheap electricity generated by renewable green resources. Also as time went on appropriate feed stocks were identified in various areas in Sub Saharan Africa and

these were mostly sugar cane, jatropha and palm oil (Fig 2a, b, c). In addition sweet sorghum, soya bean and sunflower were added to the list. But the appropriate feed stock was chosen depending on the environment, climate and a real situation of the place in question.

A=Sugar cane B=Jatropha C= Palm oil

Fig. 2. Some of selected feed stocks in Sub Saharan Africa

CHALLENGES

The biggest challenges which most countries in Sub-Saharan Africa (SSA) is facing are two; technology and lack of policies on renewable energy.

Most of the countries in SSA accepted the idea of production of renewable and green energy without having appropriate technology. This is still a problem as most of the technologies imported are very expensive. It is therefore, argued to help the SSA countries in expanding the technology through various means including training the scientists from the SSA under whatever arrangements. This is very vital as without affordable technology renewable energy production will be either very expensive or not affordable. This might end up into SSA countries being producers of feed stocks and developed countries are the processors. For sure no country in SSA wants this to happen i.e. to remain feed stock producers for the developed countries.

On the other hand the other challenge is that most of SSA countries accepted the idea of introduction of renewable and green energy production systems while they were not prepared in terms of policies governing the whole production system. Here it was not clear how the small scale poor farmers will be involved, or how the large scale energy crop plantations should be introduced. In some areas this ended up into big conflicts. Many areas had land conflicts, some poor farmers their land was taken and given to big foreign investors for establishment of energy crop plantations. This was not accepted by most poor farmers and hence created many conflicts and in some cases farmers lost their life. In some areas there were conflicts of interests, for example there are cases where farmers were not willing to give their land for a crop which they were not interested in. Some areas rejected jatropha to be planted in their very fertile land even if the land was idle. Also there are some conflicts in some areas where farmers were very much used for rice production and rejected the palm oil production in their area. All in all what expired here was that there was lack of renewable and green energy production policy in these SSA countries although they had all reasons for being good renewable energy producers.

A third thing which had some effects in introduction of renewable energy production in SSA was that the first promoters gave wrong information to farmers at the onset of renewable energy

industry. In Tanzania some of biofuel promoters told farmers that they should go for cultivation of jatropha as it can grow anywhere and produce a lot of oil and one hectare of jatropha can produce more than eight tons of oil even in arid areas. They went further telling farmers that they can have their first crop (harvest) in two years time. Practically this was not true and some farmers came to realize this very late and hence were discouraged.

A bitter lesson in the issue of renewable energy especially on biofuels was a fight against it by the promoters (from developed countries). Experience show that some of the promoters came to realize that the main beneficiaries of biofuel industry are the tropical developing countries. These countries have all reasons of benefiting from biofuel industry as they have ample idle land especially in Sub-Saharan Africa, good weather for most of energy crops, cheap labour, etc. For capitalistic mode of production, this is not good news. So they started a new wave of fighting against biofuels. A Professor from Germany tried to highlight who are behind this anti biofuel campaign and he pointed out some of them being fossil oil producers, big oil business companies to mention a few.

Several weapons were used to fight renewable energy and in particular biofuel. These were; environmental factors, food insecurity, land use issues, etc. But what is the fact; FAO say that there is no hunger because of biofuels; they say there is more food per capita globally today than ever before. Experiences show that poor agricultural planning in most developing countries ended up into food deficit. There are 450 million smallholder farmers in developing countries that have been neglected by their governments. In 1973 Tanzania had a very big food shortage just due to the fact that they had poor production system, but definitely that year Tanzania did not produce even a single litre of biofuel. This is a good example that food shortage has nothing to do with biofuel production. If we look at it on the Tanzanian side, with 44 million ha of arable land and only 1% of this is needed to carter for sufficient biofuel for the whole country. Is it true that 1% of 44 million ha will take the country into food shortage? There are several examples which show that renewable energy and especially the biofuel have very little to do with food insecurity in most Sub-Saharan Africa if good approaches or methods are used in establishing it.

The fact remains that renewable energy in SSA can be of great benefit to most countries but care is needed in establishing the industry. One of the major steps to be taken should include; awareness campaign to both political leaders (decision makers) and local poor farmers, involvement of the local community in both choosing the type of the energy crops in their area and the site selection for growing such selected energy crops. In addition we should avoid the top bottom approach; we should share ideas with the local community to see how best the industry be established for the benefit of both the community and the promoters.

LESSONS LEARNT

Lack of Policy

Most countries in SSA came to realize that lack of policy on renewable energy production system in their country was one of the big setbacks. To avoid confusions and problems in production systems of renewable energy, some countries such as Tanzania has started working on the processes of getting a policy of renewable energy production system. In Tanzania for example "Guidelines for Sustainable Liquid Biofuels Development" have already been prepared.

Areas with sugar Sugar cane Jatropha Palm Sunflower *Croton*

Cane plantations potential areas *megalocarpus*

Fig. 3. Some of selected areas for production of renewable energies in Tanzania

Here Institutional Framework has been well stipulated, Application and Registration procedures for Biofuel Investment, Permit fees, Taxation and Incentives, Land Acquisition and Use, Contract Farming, Sustainability of Biofuels Production, Environment and Social Impact Assessment, Farming Approaches and Seed Management, Efficient Utilization of Biofuel Crops, Community Engagement, Processing of Biofuels, Storage and handling of Biofuels,

Transportation and Distribution, Quality of biofuels, Blending Ratios, Biofuel waste management are all well explained. So before an investor or promoter comes in they are well knowledgeable on where, what, how and when to do. Tanzania now is about to publish its renewable energy policy and reliable sources from the government show that by August 2012 Tanzania might have its policy in place. This will reduce some of unnecessary conflicts which the country has gone through in the early stages of introduction of renewable energy production system in the country. Fig 3 shows some of selected areas for investment of renewable and green energy production in Tanzania.

Lack of Appropriate Technology

Lack of appropriate technologies on renewable energy production system was and still is a big issue as most countries in SSA have no appropriate technology on the production of any chosen renewable energy. This made the production of most renewable energies to be very difficult or in some areas it was impossible. Most countries in SSA which are interested in producing renewable energies are now trying to sort out what type of technologies are required and from where should it be imported and under what conditions. This is due to the fact that if the technology is going to be very expensive, it is not going to work efficiently.

Involvement of Local Community

Most countries have learnt that involvement of local community in the production system of renewable energy is vital. The community will be in position to tell what sort of raw materials for the production system will be appropriate in their area.

The Top Bottom Approach

The top bottom approach in establishing the renewable energy systems has costed so many projects and some of them although were very fit in the area failed due to the top bottom approach.

Political Will

It was learnt that partial political will has been one of the problems in establishing a production system of renewable energy in a given area or country. So promoters should make sure that there is a full support of politicians of the renewable energy production system they want or intend to introduce in a given area or country.

Facts on the Early Stages

Local community should be told the truth or all the facts governing the whole production system, e.g. if it is a production of a feed stock, farmers should know exactly how long will it take from sowing or transplanting to first harvest, how much should they expect per unit area in terms of yields, what is the life span of the crop is it a perennial or an annual crop, etc. It was learnt that giving wrong information on the onset of the production system of renewable energy feed stocks discouraged the community and it costed some useful projects in some countries, for example the production of jatropha in Tanzania failed in some areas due to this..

CONCLUSION

- Renewable and green energy resources production in Sub-Saharan Africa will be of great benefit to poor farmers provided the approach is going to be social and democratic (involving the farmers right from planning to processing).
- Renewable and green energy resources production in SSA should be encouraged.
- Countries in the Sub-Saharan Africa should target renewable and green energy production for home market first and then gradually expand to external market.
- The government in the Sub-Saharan Africa should encourage partnership type of investment where the local people provide land and the investor provides the funding (But this might not be easily accepted by most foreign investors due to strong capitalistic mode of production in their mind).
- Our developing partners should know that the local populations play a great role in smooth and sustainable production in a given country. Ignoring this, Tanzania has experienced some of very potential investment ending into conflicts, this ended up in total failure of some profitable and useful planned investment.
- One of the problems faced by investors or promoters of renewable energy in Sub-Saharan Africa was lack of awareness. Most of senior government officers and mainly the decision makers as of today do not know the pros and cons of renewable energy. The lack of awareness has costed a lot of potential projects. When it started the promoters thought that the idea of renewable energy is easily understood by most decision makers. This was not the case and up to this moment most of decision makers don't know the role of renewable energy in the economy of their countries. There is a big gap and should be filled.

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Renewable Energy Applications in Denmark

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ABSTRCT

In order to massively reduce CO_2 emissions, there is a need to build a new energy system that is based on a greatly expanded use of renewable energies. Emphasis should be laid on to integrate the various forms of renewable energy, sometimes in combination with natural gas, in order to achieve the maximum utilization of renewable energy sources and supplies.

A persistent global attachment to the dominant fossil-fuel based energy system has limited the development of combined fluctuating solar and wind energies into coherent, autonomous systems. One consequence of this is, for example, that renewable energies, when generated in excess, remain unutilized, or even wasted. Wind turbines in regions with high shares of wind energy, for example, may be periodically shut down when the wind turbines produce too much power. Similarly, when combined heat and power production coincide with excess wind energy, an excess power capacity may occur. These problems will become increasingly frequent as more wind turbines feed power into the grid and more CHP systems are utilized. Electric boilers, however, have proved to be a low cost solution to capture excess energy, by using excess wind power in fuel-efficient heat and power systems. This paper critically examines various renewable energy options , their applications and integration to achieve higher efficiency .

Key words : Renewable energy , wind energy, solar energy, CO_2 emission

INTRODUCTION

The world's energy system is on the verge of a major transformation as a result of climate change and resource scarcity (Abramsky and Sparking, 2010). In order to massively reduce CO_2 emissions, there is a need to build a new energy system that is based on a greatly expanded use of renewable energies. It is almost certain that in 20 or 30 years time the world will have a very different energy system from the one that currently exists. In discussions of climate change, it is frequently stated that it is urgent to reduce CO_2 emissions by 40% below what were 1990 levels by the year 2020, and further still to 95% by 2050. Northern countries are undoubtedly the main emitters, which need to implement these reductions.

The technological building blocks for the transition to a sustainable energy future already exist in the form of decentralized cogeneration plants, wind turbines, large and small biogas plants, solar energy and various types of biomass for energy purposes. The primary task, therefore, is to integrate the various forms of renewable energy, sometimes in combination with natural gas, in order to achieve the maximum utilization of renewable energy sources and supplies(Bassam, and Maegaard, 2004).

BRIEF HISTORY

Denmark is well known internationally for its wind industry and the high share of electricity that is obtained from the wind(Danish Energy Agency, 2010). District heating together with the production of combined heat and power (CHP), may in the long term prove to be even more important. *This transition represents the single most important initiative to reduce CO_2 emissions in Denmark.* Moreover, the change to combined heat and power supplying up to 60% of electricity and 70% of the demand for heat has created the necessary infrastructure that gradually can be transitioned entirely to renewable energy.

By 2007 43% of the 36 TWh of electricity used in Denmark came from independent power projects (IPPs). Of the 43%, wind power accounted for 18-20% and local CHP around 25%. As a consequence the central power utilities (now owned by Vattenfall and DONG Energy) had their share of the electricity market reduced to little over 50% of the domestic demand.

It took only 10 years to dramatically shift almost half of the power production from inefficient, centralized, fossil fuel power supply to local, municipal or consumer-owned companies. Coincidently this is the amount of time it takes to build one nuclear power plant, or the equivalent of 1200 MW_{el}. Denmark has not and is not planning to build atomic power plants; this very problematic source of supply was ultimately withdrawn from national energy plans in 1985.

Denmark has succeeded in stabilising its primary energy supply during 30 years of economic growth. During this time, small CHP plants and renewable energy was introduced and supported by the state. In the period 1975 to 2000 fuel consumption for heating in households was reduced by 30%. In the same period, what was almost an 100% oil based primary energy supply in the year 1975, decreased the share of oil by means of diversification to 40%. The fuels used were a mixture of oil, coal, natural gas and renewable energy. During the whole period the national gross energy consumption had a level around 20 million tons of oil equivalents (TOE).

The combination of energy conservation and district heating based on CHP were the most important factors in improving overall energy efficiency. Insulation of buildings contributed to a 12% decreased heat demand from 1975 to 2000, while at the same time the heated areas increased by 46%. District heating increased by over 50% while CHP plants replaced boilers, which during the 25-year period, decreased the consumption for heating per m^2 by half. Approximately 40% of this decrease was attributable to the implementation of new building codes that were important for the energy conservation that was as a result of improved energy efficiencies and to new CHP for the balance.

During the 1990s, CHP plants were built in towns and villages as small as 150 households. The small Danish CHP plants are typically built in connection with district heating systems in towns and villages. The CHP plants contain one or more CHP units, peak load boilers and heat storage systems. The CHP units are either engines, gas turbines, or in some cases steam turbines or combined cycle plants.

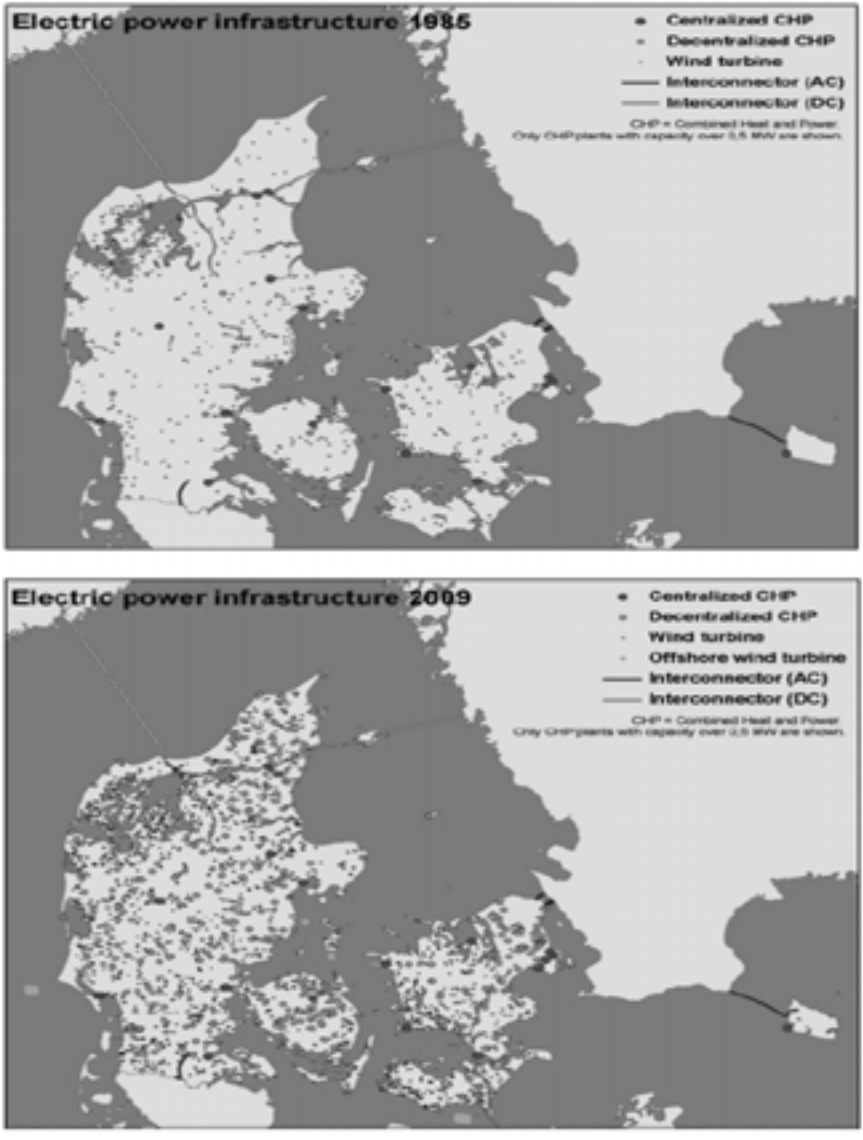

Figure1: In 1985 Denmark 14 central power stations and a small number of windmills covered the production of electricity in Denmark. By 2009, power production was decentralized with approximately 3,000 windmills and more than 700 CHP units over 0,5 MW_{el}. Together wind power and small CHP can deliver 45% of the annual demand for electricity.

CONSEQUENCES OF FLUCTUATING POWER SUPPLY

On days with a high demand for heat combined with high wind, the combined heat and power plants, CHPs, and the wind turbines together sometimes feed more power into the grid than needed by the consumers. The CHPs are at such occasions not operating to cover a need for power but to supply heat to the consumers through the district heating system and the production of electricity can be seen as residual. The wind turbines deliver their electricity production to the

grid in accordance to the prevailing wind speeds. CHP and the fluctuating wind and solar together feed their production into the same grid.

The early application of solar and wind to an existing power grid can be balanced without special problems. Once the share of wind energy exceeds 20% or more, however, initiatives have to be taken. With 20% of wind power at the annual basis there will be hours and even days when the wind power production can fully cover the actual need for power. In regions with a high concentration of wind power installations they can deliver most of the base load for power, but also periodically when wind speeds are high can even produce up to 300% of actual power needs. The structural and technological challenges involved in a transition to renewable energy are obvious when taking into account that in the transition away from fossil fuels and atomic energy, some countries have plans of 50% wind and solar in the supply of power.

Some of measures that can be taken to maintain a balance between supply and demand include:

- Store the electricity for use in periods with insufficient solar and wind
- Stop temporarily the operation of some of the wind turbines
- Export power to neighbouring countries
- Encouragement of demand side power consumption
- Find new applications of fluctuating electricity for industrial purposes and in the heating/cooling sector

In this article special focus will be made at the use of fluctuating power in the heating/cooling sector and the infrastructural changes that it requires. Storage of electricity will be discussed separately whereas discontinued operation of wind mills is considered non-acceptable during periods when fossil fuels are being combusted. Export of power to neighbouring countries involves heavy investments in long distance transmission lines and is not a long term realistic solution; periods with high wind speeds is a trans-border phenomenon and neighbouring countries are often expanding their wind power capacity as well. With tariff differentiation, industrial consumers and households may be encouraged to change the pattern of use of electricity by operating special machinery, doing the washing at night and charge-discharging future electric cars at periods according to the power supply situation. Experiences, however, indicate that change of consumer behaviour has its limits. Electric car owners for instance may prefer the benefits of leaving their home in the morning with a fully charged car instead of earning a few cents per kWh peak power delivered to the utility.

A future of renewable energy as a primary source for the world's energy is one that society can no longer continue to ignore. As fossil fuel supplies diminish and the cost of atomic energy continues to rise, while there is no solution to the deposition of nuclear waste, renewable energy can step in to provide feasible alternatives to energy demands. Renewables do pose some challenges, namely, in addressing the fluctuating power supply that is inherent in their nature. Robust, integrated solutions using available, mature technologies have proven to be the solution to the challenges that wind and solar energy pose. Denmark has in the past, and continues to be a leader in integrated renewable energy solutions. In 2010, Denmark with its 5.5 million inhabitants was still on the world top-10 list measured by accumulated wind power capacity. In particular, the use of combined heat and power systems and the implementation of district heating have proven successful for Denmark, and can be transferred elsewhere. This chapter seeks to explore questions

surrounding the implementation of sustainable integrated solutions very concretely in relation to energy in general and renewable energy in particular.

On days with both a high demand for heat and high winds, combined heat and power plants, CHPs, and wind turbines together sometimes feed more power into the grid than needed by power consumers. On such occasions, the very efficient CHPs are not operating to cover a need for power but to supply heat through district heating systems, while the production of electricity can be seen as residual. The wind turbines deliver their electricity production to the grid in accordance to the prevailing wind speeds. Together, CHP plants and fluctuating wind and solar feed their production into the same grid. Once the share of wind energy exceeds 20% or more, initiatives have to be taken. With 20% of wind power at the annual basis, there will be hours and even days when wind power production can fully cover the actual need for power. In regions with a high concentration of wind power, they can deliver most of the base load for power, but also periodically when wind speeds are high, they can even at the local level produce 300% or more of actual power needs. The structural and technological challenges involved in a transition to renewable energy are obvious when taking into account that in the transition away from fossil fuels and atomic energy, some countries have plans of 50% wind and solar in their supply of power.

Export of power to neighboring countries involves heavy investments in long-distance transmission lines and is not a long-term realistic solution; periods with high wind speeds is a transborder phenomenon and neighboring countries are often expanding their wind power capacity as well with a need to sell excess power to the neighbouring countries.

Supply and demand on windy days can be balanced with simple solutions such that excess wind and solar power can be used in electric boilers and heat pumps at combined heat and power stations. In the case of Denmark, with its many hundreds of CHP stations, it is possible to stop gas engines at periods when the wind and solar power is sufficient for both the actual supply of power, heat and hot water–based cooling. As the CHP stations already have large hot water storage tanks, additional excess power can be stored for some days of hot water supply with no electricity to water conversion loss. Electric boilers are cheap, costs around EUR 200,-/KW; the conversion loss is in principle 0%.

By combining and integrating CHPs with electric boilers, heat pumps, and hot water storage in combination with fluctuating energy forms of wind and solar, it will be possible to have much higher shares of solar and wind in the energy structure as a whole, without causing instability in the power system. With further integration of the mobility sector using cars with batteries, additional possibilities of handling fluctuating power will later become available.

Integration of fluctuating power production with the heating sector will gradually allow high future shares of wind and solar energy in the system because in a temperate climate the demand for heat exceeds the need for electricity by a factor of 3 or so. In areas with high shares of wind or solar availability, these energies will more and more be seen as a base load that covers the supply of power by 100% and often more. In the Thisted municipality with its 46.000 inhabitants, the wind power already covers the demand for electricity at 6 m/s. Later this may become the case for the whole region and even nation which means that the power produced at more than 6 m/s is available for other purposes. Here the heating sector is especially important.

Electricity storage (Boston Consulting Group, 2009) may later be an essential part of the integrated systems that see power supply, mobility, heating and cooling as a whole together with existing possibilities such as demand-side management. These systems should be affordable, sustainable and efficient. Costs of electricity storage solutions are in general prohibitive and with significant losses while the conversion of excessive power into heat is cheap and efficient. Furthermore the value of the excessive power will never be less than the fuel that it replaces in the heating sector.

Because biomass functions as an ideal long-term storage solution, and due to its limited availability, it is necessary that it be reserved for combustion in combined heat and power stations with efficiencies of 85% or more. As an overall strategy their primary function is for balancing by up-regulation when solar and wind energy cannot cover the demand loads. Besides an electricity grid, the future energy structure with extensive pipe networks for district heating and cooling will have ancillary functions.

Figure 2: Community biogas plant with CHP. The tanker truck (left) collects 400 tons of liquid waste from farms daily. In the 7.000 m^3 Bigadan digester (middle) the biogas is produced which the Jenbacher gas engine (right) converts into heat and electricity.

Due to their low efficiencies of 45% or less, conventional condensation power stations will not have an important role to play. With response time for change of capacity from start-up till close-down of 20 hours or more, large coal stations and atomic energy matches very poorly to fluctuating supply technologies from solar and wind. In contrast, gas engines can reach full load capacity within a few minutes after start-up.

In a new book that Springer Science will publish later this year, I am writing a chapter with more details of how to manage big shares of fluctuating power.

In a political perspective, due to the integration with the heating sector, the future energy structure basically must be decentralized. The Stadtwerke, municipal and consumer-owned companies will be especially important in this transition while the presently dominating big power companies are not needed. This will in itself cause fierce opposition to the change to solar and wind energy and the smallest hair in the soup will be searched for.

CONCLUSION

The reality of renewable energy is that it is necessary to combine and integrate technologies since no single renewable energy source can sufficiently stand-alone. A comprehensive future conversion to renewable energy requires mobilization of all forms of renewable energy installations, including both large and small plants. It is not enough to base development on technologies which are currently cheapest, as this could lead to a unilateral deployment of large wind turbines in particular.

A persistent global attachment to the dominant fossil-fuel based energy system has limited the development of combined fluctuating solar and wind energies into coherent, autonomous systems. One consequence of this is, for example, that renewable energies, when generated in excess, remain unutilized, or even wasted. Wind turbines in regions with high shares of wind energy, for example, may be periodically shut down when the wind turbines produce too much power. Similarly, when combined heat and power production coincide with excess wind energy, an excess power capacity may occur. These problems will become increasingly frequent as more wind turbines feed power into the grid and more CHP systems are utilized. Electric boilers, however, have proved to be a low cost solution to capture excess energy, by using excess wind power in fuel-efficient heat and power systems.

A lack of balance between supply and demand of power means that there may periodically be an increasing problem of excess power from the combined supply from wind turbines, solar power and CHP. The problem, however, needs not to exist but is caused by lack of political management and coordination. Appropriate forms of public management and control of supply seems best to solve problems associated with fluctuating and intermittent power production. What is required, are political solutions with incentives for the wise use of this so-called surplus power, avoiding selling at very low prices to neighbouring countries, the establishment of major new transmission lines and integrated systems to match with supply peaks when winds are strong. The various renewable forms of energy (solar, wind, biomass) can provide an alternative to fossil fuel when they are used in combination with one another. None of the renewable energy forms are capable of covering the need for electricity, heat and transportation if they used alone. There must be, however, a multiform effort involving many kinds of supply systems, energy storage and saving mechanisms, as well as appropriate user-management strategies.

The constant expansion of renewable energy not only provides realistic potential, but ultimately could lead to an end of the combustion of fossil fuels. The economic risk connected with investments in new conventional power plants will grow significantly, especially with increased uncertainties in the future of fossil fuel prices. Not least will be the growing risk of low utilization as their annual production is being marginalized by increased use of decentralized renewable energy forms.

Renewable energies will have the key role in the global push towards a carbon dioxide-free future of energy production. Due to their in principle unlimited potential, in comparison to the current global energy regime, they are treated in this article as the primary source of supply for meeting the future demand for electricity, heating and mobility, irrespective of their intermittent character. In areas with high shares of wind or solar availability, these energies will more and more be seen as base load that covers the supply of power by 100% and often more. Because biomass functions as an ideal long-term storage solution, and due to its limited availability it is

necessary that it be reserved for combustion in combined heating/cooling and power stations with efficiencies of 85% or more. Their primary function is for balancing by up-regulation when solar and wind energy cannot cover the base loads. Besides grid for electricity, in the future energy structure extensive pipe networks for district heating and cooling will have ancillary functions. Due to their low efficiencies of 40% or less conventional condensation power stations will not have an important role to play. Electricity storage will be an essential part of the integrated systems that see power supply, mobility, heating and cooling as a whole together with existing possibilities like demand-side management. These systems should be affordable, sustainable, and efficient. Some regions and even countries already have relatively high shares of fluctuating power supply. By 2010 Denmark has seen 22% of its demand for electricity from wind turbines which by 2015, will grow to around 35%. At low peak power demand and high wind speeds the wind power can currently fully cover the consumption of electricity; at the local level the share of wind power may even be 300% of actual consumption. Interregional compensation with strong connections to neighbouring countries still plays an important role for up-regulation and down-regulation; it may be a short term solution, however, as the present importers of excess power most likely in the future will be less interested in buying power as the deployment of fluctuating forms of renewable energy will only increase in neighbouring countries as well. The reality is that outlets for periodical overcapacities will be required globally. Currently there exists many different energy storage systems, but only a few are functional and commercially available. Moreover, these technologies need to be compared by their investment volume, their losses and their potential for centralized and decentralized applications. The storage solutions have to be discussed by their limits, environmental effects, geographical requirements, application focus, investment complexity, and efficiency. Furthermore storage technologies have to be optimized in terms of size and capacity, responding time and flexibility, as well as their cost-effectiveness. The following chapters will focus on increased applications of various forms of renewable energy, solutions for power balancing technologies with references to pioneering countries that are already facing the need for new kinds of power management and its opportunities. Besides storage technologies power production in combination with heating and cooling will be discussed as especially important ancillary solutions. Worldwide their role is still limited but with the expected significantly increased use of intermittent and fluctuating energy forms, structural aspects including CHP connected to district heating and cooling are indispensable. The supplies of water, electricity, gas, heat and energy for transportation have in common the fact that they are all daily necessities for domestic consumers, as well as for industry and public sector institutions. Therefore, it is the case in many countries that the same company, often a municipal company, may have supplied all these services for several decades, a process which has generally worked to everyone's satisfaction. This article will seek to explore these questions very concretely in relation to energy in general and renewable energy in particular.

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New Vistas in Renewable Energy Generation and Applications

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ABSTRACT

By 2030, the world is expected to use more than 678 quads of energy per year, nearly double the annual energy use just ten years ago. This increase in energy use is attributable to worldwide population growth and to economic development in countries such as China and India as they seek to achieve living standards comparable to those currently enjoyed by western nations. For example, by 2030, annual petroleum demand is forecast to be more than 25% higher. Conventional energy sources based on oil, coal, and natural gas have proven to be highly effective drivers of economic progress, but at the same time damaging to the environment and to human health. Renewable energy is energy which comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable (naturally replenished). The development and use of these sources can enhance diversity in energy supply markets, contribute to securing long term sustainable energy supplies make a contribution to the reduction of local and global atmospheric emissions provide commercially attractive options to meet specific needs for energy services particularly in developing countries and rural areas, and create new employment opportunities.

Key words: Solar energy, hydroelectric energy , geothermal energy, wind energy, biofuels

INTRODUCTION

Conventional energy sources based on oil, coal, and natural gas have proven to be highly effective drivers of economic progress, but at the same time damaging to the environment and to human health. Furthermore, they tend to be cyclical in nature, due to the effects of oligopoly in production and distribution. These traditional fossil fuel-based energy sources are facing increasing pressure on a host of environmental fronts, with perhaps the most serious challenge confronting the future use of coal being the Kyoto Protocol greenhouse gas (GHG) reduction targets. It is now clear that any effort to maintain atmospheric levels of CO_2 below even 550 ppm cannot be based fundamentally on an oil and coal-powered global economy, barring radical carbon sequestration efforts.

The potential of renewable energy sources is enormous as they can in principle meet many times the world's energy demand. Renewable energy sources such as biomass, wind, solar, hydropower, and geothermal can provide sustainable energy services, based on the use of routinely available, indigenous resources. Transition to renewable-based energy systems is looking increasingly likely as the costs of solar and wind power systems have dropped substantially in the

past 30 years, and continue to decline, while the price of oil and gas continue to fluctuate. In fact, fossil fuel and renewable energy prices, social and environmental costs are heading in opposite directions. Furthermore, the economic and policy mechanisms needed to support the widespread dissemination and sustainable markets for renewable energy systems have also rapidly evolved. It is becoming clear that future growth in the energy sector is primarily in the new regime of renewable, and to some extent natural gas-based systems, and not in conventional oil and coal sources. Financial markets are awakening to the future growth potential of renewable and other new energy technologies, and this is a likely harbinger of the economic reality of truly competitive renewable energy systems.

In addition, renewable energy systems are usually founded on a small-scale, decentralized paradigm that is inherently conducive to, rather than at odds with, many electricity distribution, cogeneration (combined heat and power), environmental, and capital cost issues. Maycock (2000) pointed in his study that as an alternative to custom, onsite construction of centralized power plants, renewable systems based on PV arrays, windmills, biomass or small hydropower, can be mass-produced "energy appliances" capable of being manufactured at low cost and tailored to meet specific energy loads and service conditions. These systems can have dramatically reduced as well as widely dispersed environmental impacts, rather than larger, more centralized impacts that in some cases are serious contributors to ambient air pollution, acid rain, and global climate change.

Renewable energy sources currently supply somewhere between 15 percent and 20 percent of world's total energy demand. Rothkopf (2007) concluded that the supply is dominated by traditional biomass, mostly fuel wood used for cooking and heating, especially in developing countries in Africa, Asia and Latin America. A major contribution is also obtained from the use of large hydropower; with nearly 20 percent of the global electricity supply being provided by this source. New renewable energy sources (solar energy, wind energy, modern bio-energy, geothermal energy, and small hydropower) are currently contributing about two percent.

Future Energy Needs of the World: this scenario shows a steady decline in the use of oil and coal, an increase in the use of gas in the early part of the century, then a decline after 2025, and a sharp increase in the use of new renewables and biofuels. This takes place in a very competitive environment characterized by the rise of new energy industries.

VARIOUS TYPES OF RENEWABLE ENERGY SOURCES

Renewable energy is energy which comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable (naturally replenished). Renewable energy is an alternative to fossil fuels and was commonly called *alternative energy* in the 1970s and 1980s. In 2009, about 16% of global final energy consumption came from renewables, with 10% coming from traditional biomass, which is mainly used for heating, and 3.4% from hydroelectricity. New renewables (small hydro, modern biomass, wind, solar, geothermal, and biofuels) accounted for another 2.8% and is growing very rapidly. The share of renewables in electricity generation was around 19.4%, with 16.1% of global electricity coming from hydroelectricity and 3.3% from new renewables.

Wind power is growing at the rate of 21% annually, with a worldwide installed capacity of 238gigawatts (GW) in 2011, and is widely used in Europe, Asia, and the United States. At the end of 2011, cumulative global photovoltaic (PV) installations surpassed 69 GW, an increase of almost

70%, and PV power stations are commonplace in Germany, Italy, and Spain. Solar thermal power stations operate in the USA and Spain, and the largest of these is the 354 megawatt (MW) SEGS power plant in the Mojave Desert. The world's largest geothermal power installation is The Geysers in California, with a rated capacity of 750 MW. Brazil has one of the largest renewable energy programs in the world, involving production of ethanol fuel from sugar cane, and ethanol now provides 18% of the country's automotive fuel. Ethanol fuel is also widely available in the USA.

Wind, water, and solar power using current technology can supply all of the world's energy by 2030, and has the advantage that consumption is reduced by 30%. Excess production would be used to produce hydrogen for use in ships and airplanes. It also has the advantage that it lasts for as long as we are on the planet, vs. less than a century for most of the non-renewable resources.

Wind

Wind power harnesses the power of the wind to propel the blades of wind turbines. These turbines cause the rotation of magnets, which creates electricity. Wind towers are usually built together on wind farms. Wind power is growing at the rate of 21% annually, with a worldwide installed capacity of 238 giga watts (GW) in 2009, and is widely used in Europe, Asia, and the United States.

At the end of 2011, worldwide nameplate capacity of wind-powered generators was 238gigawatts (GW). Energy production was 430 TWh, which is about 2.5% of worldwide electricity usage. Several countries have achieved relatively high levels of wind power penetration, such as 21% of stationary electricity production in Denmark, 18% in Portugal, 16% in Spain, 14% in Ireland, and 9% in Germany in 2010. By 2011, at times over 50% of electricity in Germany and Spain came from wind and solar power. As of 2011, 83 countries around the world are using wind power on a commercial basis.

Many of the largest operational onshore wind farms are located in the USA. As of 2012, the Alta Wind Energy Center is the largest onshore wind farm in the world, with a capacity of 1020 MW of power, followed by the Roscoe Wind Farm (781.5 MW). The Walney Wind Farm in the Irish Sea is the largest offshore wind farm in the world at 367 MW, followed by Thanet Wind Farm (300 MW) in theEnglish Channel.

Hydroelectric

In hydro energy, the gravitational descent of a river is compressed from a long run to a single location with a dam or a flume. This creates a location where concentrated pressure and flow can be used to turn turbines or water wheels, which drive a mechanical mill or an electric generator.

Solar

Solar power involves using solar cells to convert sunlight into electricity, using sunlight hitting solar thermal panels to convert sunlight to heat water or air, using sunlight hitting a parabolic mirror to heat water (producing steam), or using sunlight entering windows for passive solar heating of a building. It would be advantageous to place solar panels in the regions of highest solar radiation.

At the end of 2011, cumulative global photovoltaic (PV) installations surpassed 69 GW and PV power stations are common in Germany, Italy, and Spain. Solar thermal power stations operate in the USA and Spain, and the largest of these is the 354megawatt (MW) SEGS power plant in the Mojave Desert. China is increasing worldwide silicon wafer capacity for photovoltaics to 2,000 metric tons by July 2008, and over 6,000 metric tons by the end of 2010. Many solar photovoltaic power stations have been built, mainly in Europe. As of April 2012, the largest photovoltaic (PV) power plants in the world are the Charanka Solar Park (India, 214 MW), and the Golmud Solar Park (China, 200 MW).

Agricultural Biomass

Biomass production involves using garbage or other renewable resources such as corn or other vegetation to generate electricity. When garbage decomposes, the methane produced is captured in pipes and later burned to produce electricity. Vegetation and wood can be burned directly to generate energy, like fossil fuels, or processed to form alcohols. Brazil has one of the largest renewable energy programs in the world, involving production of ethanol fuel from sugar cane, and ethanol now provides 18% of the country's automotive fuel. Ethanol fuel is also widely available in the USA.

Vegetable oil is generated from sunlight, H_2O, and CO_2 by plants. It is safer to use and store than gasoline or diesel as it has a higher flash point. Straight vegetable oil works in diesel engines if it is heated first. Vegetable oil can also be transesterified to make biodiesel, which burns like normal diesel.

Geothermal

Geothermal energy harnesses the heat energy present underneath the Earth, and is capable of supplying all of our energy. Two wells are drilled. One well injects water into the ground to provide water. The hot rocks heat the water to produce steam. The steam that shoots back up the other hole(s) is purified and is used to drive turbines, which power electric generators. When the water temperature is below the boiling point of water a binary system is used. A low boiling point liquid is used to drive a turbine and generator in a closed system similar to a refrigeration unit running in reverse. There are also natural sources of geothermal energy: some can come from volcanoes, geysers, hot springs, and steam vents. The world's largest geothermal power installation is The Geysers in California, with a rated capacity of 750 MW. Geothermal power has the advantage that it is not variable, like most of the other renewable sources. There are four factors to consider in providing 100% of a country's energy from renewable sources - transmission when local resources are greater or less than needed, storage for the same reason, excess capacity to provide sufficient demand, and use of biomass or geothermal to fill in for when wind and solar are insufficient. Rother (2006) concluded that while the solutions are not fundamentally different from those used with conventional non-renewable sources, the technology is. For example, transmission lines and storage have been used almost since the beginning of electricity use, but as late as 2008 wind power and solar power provided less than 0.25% of total energy (1/400th). A study in Germany by the University of Kassel showed that a combination of wind, solar, storage, and biomass could supply all of Germany's electricity.

Tidal

Tidal power can be extracted from Moon-gravity-powered tides by locating a water turbine in a tidal current, or by building impoundment pond dams that admit-or-release water through a turbine. The turbine can turn an electrical generator, or a gas compressor, that can then store energy until needed. Coastal tides are a source of clean, free, renewable, and sustainable energy.

Fossil fuels

Fossil fuels sources burn coal or hydrocarbon fuels, which are the remains of the decomposition of plants and animals. There are three main types of fossil fuels: coal, petroleum, and natural gas. Another fossil fuel, liquefied petroleum gas (LPG), is principally derived from the production of natural gas. Heat from burning fossil fuel is used either directly for space heating and process heating, or converted to mechanical energy for vehicles, industrial processes, or electrical power generation.

Greenhouse gas emissions result from fossil fuel-based electricity generation. Currently governments subsidize fossil fuels by an estimated $500 billion a year.

Nuclear

Nuclear power stations use nuclear fission to generate energy by the reaction of uranium-235 inside a nuclear reactor. The reactor uses uranium rods, the atoms of which are split in the process of fission, releasing a large amount of energy. The process continues as a chain reaction with other nuclei. The energy heats water to create steam, which spins a turbine generator, producing electricity.

Stated estimates for fission fuel supply at known usage rates vary vastly, from several decades to billions of years; among other differences between the former and the latter estimates, some assume usage only of the currently popular uranium-235, and others assume the factor of a hundred fuel efficiency increase which would come from utilizing uranium-238 through breeder reactors. The Earth's crust contains around 40 trillion tons of uranium and 120 trillion tons of thorium, but, depending on assumptions, reserve figures can be millions of times less for the portion assumed affordable to extract in the future, for the amount of quality ores of far above average crustal concentration.

WAYS TO GO AHEAD

Renewable resources can represent a feasible model for sustainable energy strategies that enables the carbon dioxide emissions reduction and thus contribute to slow down of the global warming.

Strategy 1: Improve energy efficiency: 10 ways to increase energy efficiency

1. Orient the House for Energy Efficiency. Before you even think about Energy Star appliances, recycled-content products, or whiz-bang technologies, the first thing anyone building a house needs to do is position the structure for maximum benefit. It is, perhaps, the most important decision one can and should make. This is general knowledge but still so few builders actually do it or are unable because of how subdivisions are typically planned.
2. Place Windows Appropriately. Once the house is properly sited on the lot, the last thing you want to do is negate it with large windows in the wrong places. Let your geographical region and climate determine placement. ”If you want morning sunlight to spray across your

breakfast table, your breakfast room window should face east, Light from the south is bright and direct; solar houses are oriented to the south for maximum heat gain. South-facing windows are often located beneath eaves or roof overhangs to block the high, intense summer sun, but allow in the warmth of the lower winter sun."

3. Install a Radiant Barrier. Your house is sited properly and windows are in the right places, but now it's time to keep out the sun's heat. A radiant barrier installed on the roof deck or (in some cases, the attic floor) will help. A structural panel with a thin sheet of reflective material—usually aluminum—on one side, a radiant barrier is used as regular sheathing (with the reflective side down).
4. Properly Air-Seal the Structure. One of the most important factors in a house is preventing unwanted air infiltration. Builders can do this with an aggressive campaign to caulk all cracks and seal all pipes penetrating the building envelope, with diligent house wrap application, or with spray foam insulation or blow-in cellulose. "Number one with a bullet for us is rigorous air sealing," says Jesse Thompson, with Kaplan Thompson Architects in Portland, Maine.
5. Insulate. Insulate. Insulate. Siding and roofing will protect the house from bulk rain, and sealing stops the air flow, but a properly insulated house will keep its inhabitants comfortable. "A good, tight, well-insulated shell is about 70% of the solution,"
6. Remember the Attic. It's tempting to overlook this part of the house, but the attic is also an important part of an energy efficiency strategy. Simply put, "Properly insulating and air sealing your attic will help reduce your energy bills," reminds the Office of Energy Efficiency and Renewable Energy.
7. Install a Properly Sized Efficient Furnace or Boiler. The last thing you want to do after being diligent about the other energy efficiency strategies is blow it by installing an inefficient HVAC system. In 2006, DOE mandated that manufacturers cannot import or produce air conditioners with anything less than a 13 SEER. Shoot for ratings above that. Vigil adds that builders should avoid any mechanical system that is less than 90% efficient.
8. Choose an Efficient Hot Water System. In most houses, the refrigerator and the hot water tank are the two major appliances that are always on—always! In fact, water heating is the third-largest expense in the home after air conditioning and major appliances and accounts for 14% to 25% of a home's operating costs.
9. Choose Fluorescent-Friendly Fixtures. The Energy Star program says lighting in the average U.S. home accounts for about 20% of its electric bill. Switching out an incandescent lamp for a medium-based compact fluorescent bulb (CFL) will help will save about $30 over its lifetime and pay for itself in about six months. But there is a better way: Use fixtures designed for pin-based fluorescent bulbs instead.
10. Install Energy Star Appliances. No builder interested in efficiency should be installing anything less than Energy Star rated appliances.

Strategy 2: Renewable Energies: Renewable energy generation should be tripled to provide the equivalent of thousands megawatts of clean energy while continuing to produce safe, abundant, and affordable food, feed and fiber

Strategy 3: Sustainable Production of Biofuels: Biofuels, in the form of liquid fuels derived from plant materials, are entering the market, driven by factors such as oil price spikes and the need for increased energy security. Budny and Sotero (2007) elaborated that however, many of the

biofuels that are currently being supplied have been criticised for their adverse impacts on the natural environment, food security, and land use. Some plants that are used in different countries to make biofuels are sugarcane, jatropha, *Pongamia pinnata*, sweet sorghum, etc.

Strategy 4: Coal Liquefaction is the process of producing synthetic liquid fuels from coal. This can be done by various processes like Pyrolysis and carbonization processes and Hydrogenation processes .With its vast coal resources, India is uniquely positioned to develop a coal-to-liquid fuels industry that can serve as an engine for economic growth, while helping to reduce our dependence on foreign oil.

Strategy 5: Increase Gas Supply : Virtually all of the gas needs of India can be met by natural gas production augmented by synthetic natural gas produced by gasifying coal.

Strategy 6: carbon capture and storage: Carbon capture and storage (CCS), (**carbon capture and sequestration**), Jay and Hendricks (2007) refered to technology attempting to prevent the release of large quantities of CO_2 into the atmosphere from fossil fuel use in power generation and other industries by capturing CO_2, transporting it and ultimately, pumping it into underground geologic formations to securely store it away from the atmosphere. It is a potential means of mitigating the contribution of fossil fuel emissions to global warming. The process is based on capturing carbon dioxide (CO_2) from large point sources, such as fossil fuel power plants, and storing it where it will not enter the atmosphere. It can also be used to describe the scrubbing of CO_2 from ambient air as a geo engineering technique. Although CO_2 has been injected into geological formations for various purposes, the long term storage of CO_2 is a relatively new concept.

Strategy 7: Nuclear Power Stations use nuclear fission to generate energy by the reaction of uranium-235 inside a nuclear reactor. The reactor uses uranium rods, the atoms of which are split in the process of fission, releasing a large amount of energy. The process continues as a chain reaction with other nuclei. The energy heats water to create steam, which spins a turbine generator, producing electricity.

CONCLUSION

The development and use of these sources can enhance diversity in energy supply markets, contribute to securing long term sustainable energy supplies make a contribution to the reduction of local and global atmospheric emissions provide commercially attractive options to meet specific needs for energy services particularly in developing countries and rural areas, and create new employment opportunities. While fossil fuels will remain in the fuel mix for the foreseeable future, current high petroleum costs, transient or not, illustrate the degree of social and political ill-will (e.g. European gas shortages and protests) that energy insecurity can generate. Integration of renewable energy supplies and technologies into the mix can help to temper the cyclical nature of fossil fuel markets, and can give renewables a foothold from which they can continue to grow and compete.

To make sure we have plenty of energy in the future, it's up to all of us to use energy wisely. We must all conserve energy and use it efficiently. It's also up to those who will create the new energy technologies of the future. All energy sources have an impact on the environment. Concerns about the greenhouse effect and global warming, air pollution, and energy security have led to increasing interest and more development in renewable energy sources such as solar, wind,

geothermal, wave power and hydrogen.But we'll need to continue to use fossil fuels and nuclear energy until new, cleaner technologies can replace them. One of you who is reading this might be another Albert Einstein or Marie Curie and find a new source of energy. Until then, it's up to all of us. The future is ours, but we need energy to get there.

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Determining the Most Sustainable Woody Biomass Based Bioenergy System in The Western Cape, South Africa, Using Lca, Mcda, Mpb And Gis

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ABSTRACT

The new energy paradigm shift from fossil fuels to renewable energy sources is driven, among others, by a growing sustainability awareness, necessitating more sophisticated measurements in terms of a wider range of criteria. Technical efficiency, financial profitability, environmental friendliness and social acceptance are some of the factors determining the sustainability of renewable energy systems. The resulting complexity and conflicting decision criteria, however, constitute major barriers to processing the information and decision-making based on the information. Seeking to implement local bioenergy systems, policymakers of the Cape Winelands District Municipality (CWDM), South Africa, are confronted with such a problem.

Following a case study approach, this study illustrates how life-cycle assessment (LCA), multi-period budgeting (MPB) and geographic information systems (GIS) can aid the decision-making process by providing financial-economic, socio-economic and environmental friendliness performance data in a structured and transparent manner, allowing for a comparison of the magnitude of each considered criterion along the life-cycle. However, as the environmental impacts cannot readily be expressed in monetary terms on a cardinal scale, these considerations are given less attention or are omitted completely in a market economy. By measuring the various considerations on an ordinal scale and by attaching weights to them using the multi-criteria decision analysis (MCDA) approach, this study, illustrates how to internalise externalities as typical market failures, aiding policymakers of the CWDM to choose the most sustainable bioenergy system.

Following the LCA approach, 37 lignocellulosic bioenergy systems, encompassing different combinations of type of harvesting and primary transport, type of pretreatment (comminution, drying, and fast pyrolysis) and location thereof (roadside or landing of the central conversion plant), type of secondary transport from the roadside to the central conversion plant, and type of biomass upgrading and conversion into electricity, were assessed against five financial-economic criteria, three socio-economic potential criteria and five environmental impact criteria. The quantitative performance data were then, as part of the MCDA process, translated into a standardised 'common language' of relative performance. An expert group attached weights to the considered criteria using the analytical hierarchy process (AHP). The 'financial-economic viability' main criterion received a weight of almost 60%, 'socio-economic potential', nearly 25% and 'lowest

environmental impact', the remainder of around 16%. Taking the prerequisite of financial-economic viability into consideration, the preferred option across all areas of the CWDM (despite various levels of productivity) comprises a feller-buncher for harvesting, a forwarder for primary transportation, mobile comminution at the roadside, secondary transport in truck-container-trailer combinations and an integrated gasification system for the conversion into electricity.

Key words : Woody Biomass, bioenergy , South Africa, Lca, Gis

INTRODUCTION

The need for security and diversification of energy supplies as well as for less reliance on fossil fuels, the uncertainty surrounding oil prices, and increasing concerns over environmental degradation and climate change effects are some of the major social, political, and economic challenges that have prompted the international community to work harder at promoting renewable energy sources (Perimenis et al., 2011). However, this new energy paradigm has also demanded new ways of measuring the viability of energy sources. While in the past, the 'success' of energy carriers was mostly driven by financial considerations, leading to fossil fuels such as coal and oil being the preferred choices, the introduction of renewable energies has resulted in more of a sustainability driven approach, necessitating more sophisticated measurements of a wider range of criteria.

The financial-economic competitiveness still plays an important role, but medium- and long-term aspects need to be taken into account, especially when considering the growing scarcity of fossil energy carriers. A major feature of any renewable energy product is also the degree to which it can reduce environmental impacts, e.g. carbon dioxide (CO_2) emissions, associated with the use of the fossil energy that it will replace. Another important feature is the extent to which renewable energies can contribute to socio-economic potential. Bioenergy particularly is considered a local energy source, as it requires large areas to ensure a sufficient and sustainable supply, resulting not only in a change of current land-use patterns but also in significant employment creation, particularly in rural areas. In contrast, generating fossil-fuel-driven energy is considered a large-scale, capital-intensive operation that is limited to relatively small areas, resulting not only in significant environmental impacts locally (e.g. acidification, eutrophication, human health) and globally (e.g. climate change), but also in other social challenges such as limited employment creation, migration to cities, and infrastructure and food constraints.

Against this background, biomass is considered to be one of the most promising alternatives to conventional fuels and feedstocks, as it is the only renewable source of fixed carbon that can be converted to liquid, solid and gaseous fuels as well as to heat and power (Amutio et al., 2011). Moreover, biomass is considered 'carbon neutral' over its life cycle because the combustion of biomass releases the same amount of CO_2 as was captured during its growth. By contrast, fossil fuels release CO_2 that has been locked up for millions of years. Furthermore, biomass is considered the renewable energy source with the highest potential to contribute to the energy needs of modern society for both developed and developing economies world-wide (IEA, 2000, Bridgwater, 2002). Bioenergy has an almost closed CO_2 cycle, but there are greenhouse gas emissions (GHG) in its life cycle, largely resulting from the production stages: external fossil fuel inputs are required to produce and harvest the feedstocks, in processing and handling the biomass, in operating bioenergy plants and in transporting the feedstocks and biofuels (Cherubini et al.,

2009). In recent years, short- rotation woody crops such as willow, poplar and eucalyptus have turned out to be the biomass materials with the highest energy potential (Guerrero et al., 2005).

While significant progress can be seen in many European and North American countries, the implementation of renewable energies is still at an early stage of development on the African continent. South Africa relies on fossil fuels such as coal and oil to generate more than 90 percent of its electricity (ESKOM, 2010). While projections based on known reserves indicate sufficient coal for 114 years, pollution of the air, water and soil is causing serious environmental damage. Additionally, an outdated electricity infrastructure and low capacities of electricity generated have resulted in scheduled power cuts by the monopolistically acting national energy supplier, ESKOM, which has had a severe impact on South Africa's economic growth. This has prompted public decision makers of the Cape Winelands District Municipality (CWDM), South Africa, to investigate the possibility of implementing local renewable energy bioenergy systems aimed at improving energy security and reducing the dependency on ESKOM, while maximising all dimensions of sustainability. The promotion of more sustainable bioenergy systems thus called for an approach that identifies and evaluates potential bioenergy alternatives in terms of a wider variety of criteria.

The life-cycle assessment (LCA) approach, originally developed as an environmental assessment tool, has gained recognition as a tool that can provide environmental performance information to support decision-making in both the private and public sectors (Basson and Petrie, 2007). LCA can be understood intuitively as a tool that captures the environmental impacts along the entire life cycle of a product or a service (from its 'cradle' to its 'grave'). There is broad agreement in the scientific community that LCA is one of the best methods for evaluating the environmental burdens associated with biofuel and bioenergy production, as it identifies energy and materials used as well as waste and emissions released to the environment; moreover, it allows the identification of opportunities for environmental improvement (Cherubini et al., 2009). Due to its structured and systematic approach, LCA appears to be well suited to being integrated with other, complementary assessment methods such as multi-period budgeting (MPB) and geographic information systems (GIS). Widely accepted and applied, these methods could assist in covering the technical, financial-economic and socio-economic aspects along a product's life-cycle. However, while LCA and other complementary methods may be suitable methods for providing environmental, financial and socio-economic performance data, the main problem in finding the most viable/ sustainable alternative in a decision environment with multiple and often conflicting objectives persists (Azapagic and Clift, 1999).

To overcome this problem, an additional method is required to support decision-making that organises and synthesises the respective information, that is capable of integrating mixed sets of data (qualitative and quantitative), and that assists the decision maker to place the problem in context and to determine the preferences of the stakeholders involved. Multi-criteria decision analysis (MCDA) is an assessment tool aimed at aiding such a decision-making process. Based on a number of defined criteria, the goal of a decision maker is to identify an alternative solution that optimises all the criteria (Peremenis et al., 2011). However, in complex projects like bioenergy assessments, it is impossible to optimise all the criteria at the same time; therefore, a compromise solution needs to be actively sought by using subjective judgements of the considered criteria and by combining these as weighted scores to obtain an overall ranking of alternatives. Thus, MCDA could aid decision-making processes by integrating objective measurement with value judgement,

by making subjectivity explicit, and by managing this subjectivity in a transparent and reproducible manner.

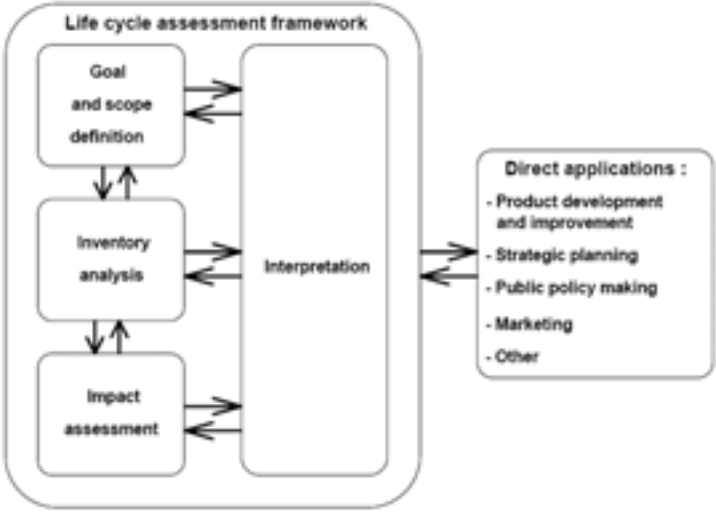

Figure 1: Phases of a life-cycle assessment (ISO 14040, 1997)

A variety of studies discuss the combined use of LCA and MCDA. However, while a variety of studies concur that environmental, financial- and socio-economic criteria need to be considered when seeking the most sustainable alternative, most of them fall short in their application, as they consider either only environmental aspects (in most instances solely LCA-based criteria) or they take a very limited number of financial and social aspects into account (e.g. only one for each aspect). The early development of complementary assessment methods, the data intensity, and the lengthy process of generating the respective information are given as explanations for omitting other sustainability indicators.

This study provides a more comprehensive, more sustainability-driven approach in determining the most sustainable lignocellulosic bioenergy system for the CWDM, using LCA and other complementary assessment methods, including MPB and GIS, to provide financial-economic, socio-economic and environmental performance data. The analytical hierarchy process (AHP) – one of the commonly applied and accepted MCDA approaches, characterised by its simplicity, and possessing the natural appeal of expressing relative importance by means of pairwise comparisons in ratio terms – was applied to integrate and evaluate the generated performance data, resulting in an overall ranking of the alternatives.

MATERIALS AND METHODS

Resource Baseline

Great variations in topology, climate and soil conditions characterise the 2.23 million hectares of the CWDM, which is located in the centre of the Western Cape Province and is shaped by a Mediterranean climate and a historically strong deterministic water supply (winter rainfall) from April to August. The south-western part of the CWDM is mainly frost free, but some areas

towards the interior regularly experience periods of frost during winter and droughts during summer. One of the main concerns for public decision makers in the CWDM is the unemployment rate. Almost 21% in the CWDM (mostly in the unskilled to semi-skilled category) are unemployed, creating a variety of socio-economic problems.

Based on a land availability assessment, around 175 000 hectares were identified as being suitable for the production of energy wood in a short-rotation coppice system. With the aim of limiting the impact on the environment (e.g. biodiversity) and to avoid competition between food and biomass production, GIS was used to exclude non-suitable areas, most importantly areas with water limitations and ecologically sensitive areas, thereby decreasing the number of considerations to be handled during the multi-criteria decision analysis discussed further on. The biomass availability assessment indicated that about 1.4 million tons of fresh biomass lignocellulosic biomass could be supplied annually, assuming medium productivity. In general, indigenous species (e.g. *Acacia karoo*) are expected to produce higher yields in the interior, low production areas in the north-east of the CWDM, while exotic species (e.g. *Eucalyptus cladocalyx*) grow better in areas with higher production potential compared with indigenous species.

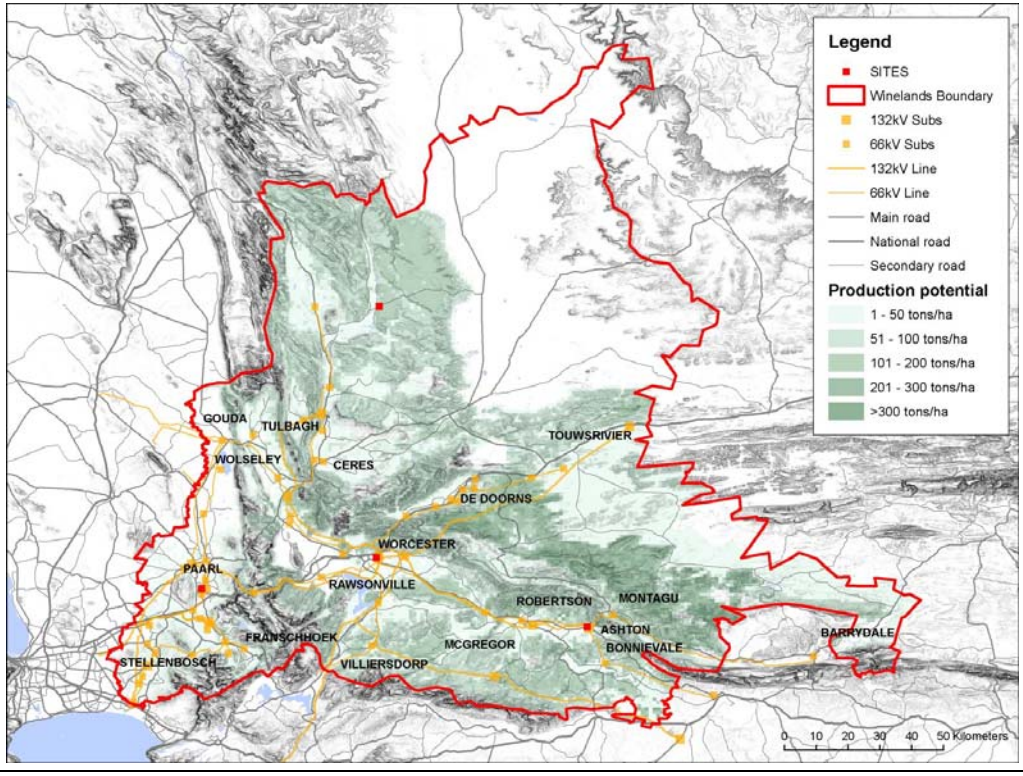

Figure 2: Lignocellulosic biomass availability of the CWDM, including main electricity grid and electricity substations, as well as potential sites for bioenergy conversion
Source: Van Niekerk and Von Doderer (2009).

Life-Cycle Assessment

Along the lines of the LCA method, the first LCA phase (goal and scope definition) provided the foundation by defining its goal and scope and by specifying the functional unit and the different dimensions of system boundaries. The functional unit was defined as 'impacts calculated for an average year's operation normalised to the electrical power produced per year', i.e. the electricity generated annually by a 5-MW system over 330 days of full production. As system boundaries a set of 37 lignocellulosic bioenergy systems (LBSs) was defined, which can be structured in five production phases and are characterised by different combinations:

i) Primary production of biomass in short-rotation-coppice (SRC) plantations,
ii) Type of harvesting and primary transportation of the biomass from in-field to the roadside (the latter is also referred to as forwarding or extraction),
iii) Type of pretreatment (comminution, drying, fast pyrolysis) of the biomass and location thereof (roadside or landing of the central conversion plant),
iv) Type of secondary transport of the bioenergy feedstock from the roadside to a central conversion plant, and
v) Type of biomass upgrading and conversion into electricity.

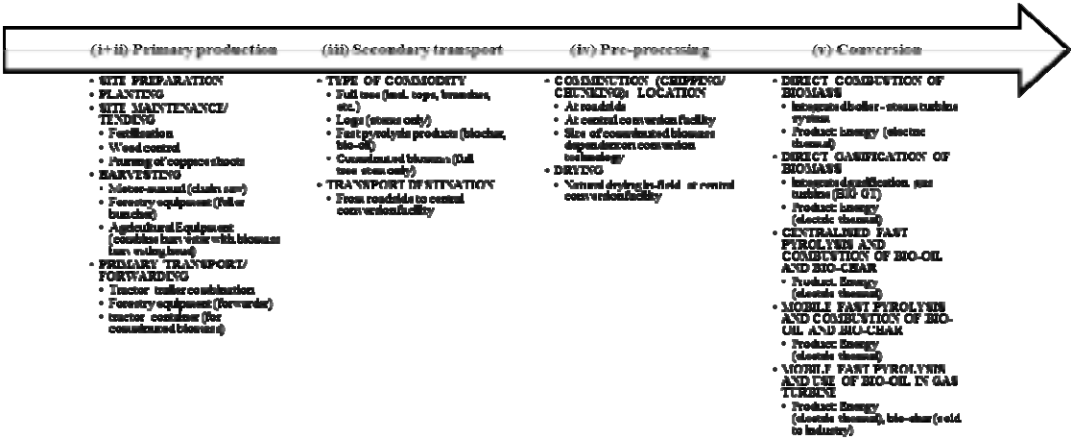

Figure 3: Life-cycle of the lignocellulosic bioenergy systems assumed for the CWDM

Four potential sites/biomass procurement areas (BPAs) within the CWDM were selected as geographical boundaries (Paarl, Worcester, Ashton and Rural Cederberge), based on their different site conditions and their different biomass productivity rates (relatively high, medium, low, very low respectively), which were estimated by experts taking available climate data into consideration. Other boundaries in relation to the natural system were specified by taking land-use change-related carbon stock changes for each of the BPAs into account.

During the second LCA phase, the life-cycle inventory (LCI), detailed information was gathered about all process-related inputs and outputs for each of the 37 lignocellulosic bioenergy systems. For each process, qualitative and quantitative data, i.e. machinery and equipment, was assumed, and the related productivity was specified, not only in terms of environmental input and

output flows, which are typical for an LCI, but also by considering related financial-economic (capital and operational expenditures, income from selling electricity and related by-products such as thermal energy, bio-char or carbon credits) as well as socio-economic (direct employment creation potential) data. Various sources including the GaBi 4.4 database, the literature, and industrial data were used to calculate the environmental impacts and financial-economic performance, assuming best operating practices for each process.

The third phase of an LCA, the life-cycle impact assessment is aimed at a better understanding of the environmental significance of a product system's life cycle by assessing its inventory results. This was achieved by translating the environmental loads from the inventory results of the 37 lignocellulosic bioenergy systems for each of the biomass procurement areas into environmental impacts, using the so-called CML 2001 method (normalisation factors from November 2009). CML 2001 is a collection of impact assessment methods that restricts quantitative modelling to the relatively early stages in the cause-effect chain, to limit uncertainties and to group LCI results into midpoint categories, according to themes. The environmental impact categories taken into account were abiotic depletion potential (ADP, measured in gigajoules), acidification potential (AP, t SO_2-equivalent), eutrophication potential (EP, t phosphate-equivalent), global warming potential ($GWP_{100years}$, t CO_2-equivalent), and photochemical ozone creation potential (POCP, t ethene-equivalent). The toxicity impact categories (human toxicity potential, as well as terrestrial, freshwater aquatic and marine aquatic eco-toxicity potentials) were not included in this study, due to a lack of consistency in the field of hazardous substances and heavy metals, as well as a lack of inventory data for emissions, creating data gaps, potentially resulting in incorrect conclusions stemming from inconsistent data. Other important environmental impact assessment methods not included in the LCIA, such as the *biodiversity intactness index* and the *water footprint* were also discussed, but were not included in this study, since they are not included in the commonly accepted LCIA methods. In addition, both environmental impacts have been dealt with a priori in the land availability assessment, by means of GIS.

Furthermore, using the LCA framework as a guideline, a set of financial-economic and socio-economic criteria was defined, against which the LBSs were assessed. By means of multi-period budgeting (MPB), financial-economic data was translated into key parameters describing the profitability and cost performance of each LBS, making them more comparable. Internal rate of return (IRR), expressed as a percentage, was used as a profitability indicator. Four cost indicators were considered important in terms of risk of investment: capital and operational costs of technology for biomass upgrading and conversion ($CAPEX_{conv.}$ and $OPEX_{conv.}$). The establishment of a bioenergy conversion system represents a capital-intensive venture, characterised by significant risks (e.g. sufficient supply of feedstock, continuity of production, reliability of the conversion technology and all ancillary systems, and a guaranteed market for the products produced) that are carried by either a single or a few private investors, a public investor, or a joint venture between public and private sectors. Costs other than conversion technology ($CAPEX_{other}$ and $OPEX_{other}$) include all expenses along the value chain prior to biomass upgrading and bioenergy conversion, i.e. from the land valuation, primary production of biomass, harvesting, forwarding, comminution and secondary transport, amongst others. In contrast with the costs of the conversion systems, the costs occurring during the other production phases are carried by a variety of investors, such as land owners and entrepreneurs (small business owners, contractors, etc.).

'Direct employment creation potential', subdivided into three income categories, was used as the socio-economic indicator, based on the productivity data of each production phase used in the MPB and LCA models. DECP I comprises the number of jobs created for unskilled to semi-skilled labourers (earning an income of less than R8 000 per month), including farm and forest workers, chainsaw, tractor, three-wheeler loader, and conversion plant operators, as well as assistants to truck drivers during secondary transportation. DECP II (earning an income from R8 000-R24 000 per month) includes all skilled labourers, such as operators of combine harvesters, feller-bunchers, forwarders, service technicians for the stationary comminution units, and truck drivers. Highly skilled labourers earning a monthly income of more than R24 000, such as engineers and managers for the conversion plant as well as for the supply chain, are aggregated in the category DECP III. Similar to the environmental impacts biodiversity and water balance, food security, another socio-economic impact was also briefly discussed.

The main driver for each criterion, whether it be of an environmental, financial-economic or socio-economic nature, is the overall conversion efficiency (OCE) of the biomass upgrading and bioenergy conversion system. The greater the OCE, the less biomass is required, resulting in fewer upstream activities and less land required for biomass production. In terms of the environmental impact of the lignocellulosic bioenergy systems, a greater OCE is desired, resulting in lower total emissions and, therefore, in lower impacts for each life-cycle impact category. Similarly, for the financial-economic viability of the LBSs, a greater OCE results in lower costs, both in terms of capital and operating expenditure, as well as in higher internal rates of return on the capital invested; the lower the OCE, the greater the direct employment creation potential, particularly for the unskilled to semi-skilled income category. Another important driver is the efficiency of the harvesting system, which has a similar effect to the OCE. The greater the degree of mechanisation and automation, the lower the environmental impact and the higher the cost-effectiveness and profitability, but also the lower the direct employment creation potential.

The Interpretation of the LCA Results Using the Analytical Hierarchy Process

The fourth LCA phase encompasses the interpretation of the results using the multi-criteria decision analysis (MCDA) method. Aimed at identifying the most sustainable lignocellulosic bioenergy system, the analytical hierarchy process (AHP), one of the most commonly applied MCDA approaches, was applied to support decision makers in der CWDM. The initial steps of the AHP included the development of a hierarchy of criteria (criteria value tree) and the translation and normalisation of the performance data provided in the previous chapter into a standardised common language of relative performance, i.e. into so-called scores. The aggregation of these scores for each LBS resulted in a ranking of the alternatives, with each criterion being equally important. Consequently, the decision-making problem persisted, as the conflicting nature of some of the criteria, the differing viewpoints of potential stakeholders, and the resulting trade-offs were not considered in this phase of the MCDA, requiring an additional phase in which the stakeholder preferences were taken into consideration, by attaching weights to the considered criteria. Thus, aimed at providing insight, a task team of experts, reflecting the broad section of potential stakeholders, was introduced during a workshop to the decision-making problem at hand, including the alternatives and their respective performances in terms of the predefined criteria. The experts were then requested to express the relative preferences for the criteria by means of pairwise comparisons using the AHP-based 'Expert Choice' software. No serious

conflicts of opinion between the participants were recorded during the discussions and the weighting procedure, resulting in consensus on a set of weights, where the main criterion 'financial-economic viability' received a preference of almost 60%, 'socio-economic potential', nearly 25% and 'lowest environmental impact', the remainder of almost 16%. The most important sub-criteria are 'best IRR' and 'direct employment creation potential (DECP) I', with cumulative weights of around 43% and 18% respectively.

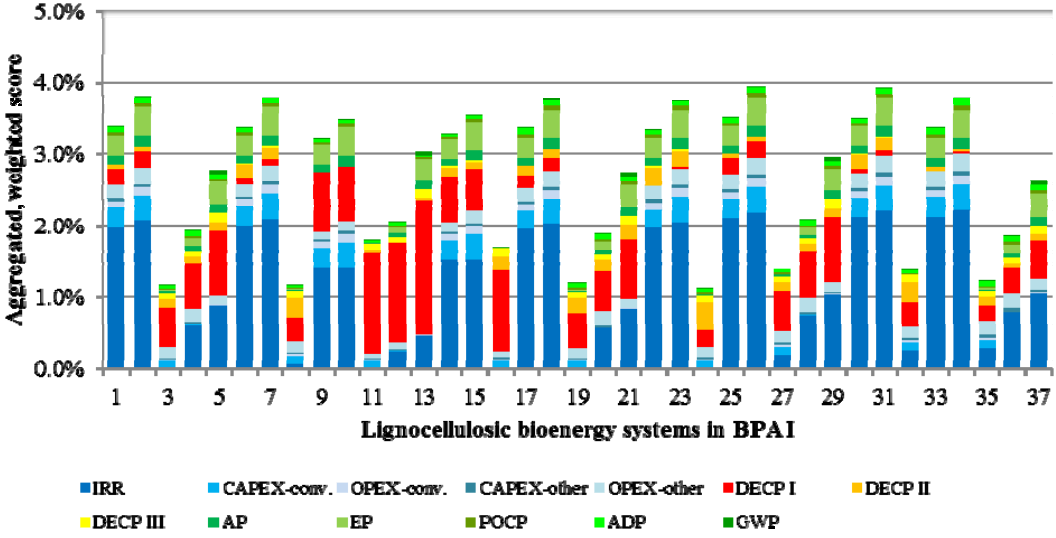

Figure 4: Aggregated, weighted scores of the lignocellulosic bioenergy systems for one of the biomass procurement areas

The aggregation of the weighted scores into a single indicator allowed a ranking of the lignocellulosic bioenergy systems. Taking the prerequisite of financial-economic viability into consideration, the top-performing alternative across all areas of the CWDM (despite various levels of productivity) comprises a feller-buncher for harvesting, a forwarder for primary transportation, mobile comminution at the roadside, secondary transport in truck-container-trailer combinations and an integrated gasification system for the conversion into electricity.Across all biomass procurement areas within the CWDM, most of the top-ten-ranked alternatives show similar profiles with around 70-75% of their aggregated, weighted scores being derived from its 'financial-economic viability', around 5-10% from its 'socio-economic potential' and 15-20% from its 'lowest environmental impact'. With few exceptions, all of them encompass a parallel series of integrated 450Nm^3/h gasifier-gas-turbine systems for biomass upgrading and bioenergy conversion, which is characterised by relatively low capital and operating costs, as well as by good conversion efficiencies. This again highlights the importance of the overall conversion efficiency, as it also has an effect on all upstream activities, with less biomass and, thus, less land being required, resulting in fewer upstream activities and, therefore, lower operational and capital costs, including for machinery, equipment and land.

CONCLUSION

As it was shown, the application of LCA proved to be an appealing and practical tool that provides environmental performance information in a structured and comprehensive way. It can be understood intuitively as a tool that captures environmental impacts along the entire life cycle. It further highlighted the widely accepted perception in the scientific community that LCA is one of the most effective methods for evaluating the environmental burdens associated with biofuel and bioenergy production. Due to its structured and systematic approach, LCA is well suited for integration with other complementary system assessment methods, such as multi-period budgeting (MPB) and geographic information systems (GIS). These widely recognised and applied methods generate additional performance data covering technical, financial-economic and socio-economic aspects along the bioenergy system's life-cycle.

In a broad context, the provided information aids public decision-making by illustrating the trade-offs of the different alternatives, as well as the respective opportunity costs when selecting one alternative over another. However, additional support for the decision-making process of identifying the most sustainable solution is required, as the barrier to implementing bioenergy projects in terms of the multiple, and often conflicting objectives, persists. The multi-criteria decision analysis (MCDA) approach can aid decision makers to overcome such a decision-making barrier. It has gained recognition to support decision-making as a tool that organises and synthesises the respective information, which is capable of integrating mixed sets of data (qualitative and quantitative), and which assists the decision maker to place the problem in context and to determine the preferences of the stakeholders involved. In essence, based on a number of defined criteria, the goal of a decision maker is to identify an alternative solution that optimises all the criteria. However, in complex projects like bioenergy assessments, it is impossible to optimise in terms of all the criteria at the same time; therefore, a compromise solution needs to be sought by using subjective judgements of the considered criteria and by combining these as weighted scores to obtain an overall ranking of alternatives. Thus, MCDA aids decision-making processes by integrating objective measurement with value judgement, by making subjectivity explicit, and by managing this subjectivity in a transparent and reproducible manner.

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Plant Biomass as a Renewable Energy Source

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ABSTRACT

Energy is a vital component of any society playing a pivotal role in the development. Post oil crises shifted the focus of energy planners towards renewable resources and energy conservation. Biomass is one such renewable, which accounts for nearly 33% of a developing country's energy needs. In India, it meets about 75% of the rural energy needs. Biomass (plant material) is a renewable energy source because the energy it contains comes from the sun. Through the process of photosynthesis, plants capture the sun's energy. When the plants are burnt, they release the sun's energy they contain. In this way, biomass functions as a sort of natural battery for storing solar energy. In general there are two main approaches for using plants for energy production: growing plants specifically for energy use (known as first and third-generation biomass), and using the residues (known as second-generation biomass) from plants that are used for other things.

Key words: Biomass energy, bioenergy plant species, biofuel

INTRODUCTION

Biomaterials and bioenergy have long been produced from plants. The development of oil from fossil fuel replaced many of these traditional uses during the twentieth century. The prospect of oil supplies being exhausted and concern about the impact on the atmosphere of adding the carbon in fossil fuels have resulted in renewed interest in the use of plants as direct sources of bioenergy and biomaterials. Although there are many current issues with biofuel production and use, the development of new biofuel crops and second generation biofuels attempts to circumvent these issues. Many scientists and researchers are working to develop biofuel crops that require less land and use fewer resources, such as water, than current biofuel crops do. One step to overcoming these issues is developing biofuel crops like Corn, Soybeans, Crop residues, Switch grass etc in each region of the world. If each region utilized a specific biofuel crop, the need to use fossil fuels to transport the fuel to other places for processing and consumption will be diminished. Firing biomass instead of coal led to a 148% reduction in GWP. Thus the plants adapted to a wide range of available production environments are needed.

What types of plants are required to produce these yields?

The next question we need to address is what species of plants we should have with yields that would allow production on a reasonable land footprint. The yields of crops used as biomass sources need to be achievable on a sustainable basis with minimal energy inputs for crop

production including cultivation, planting, nutrient production and application, harvesting and transport. This requirement limits the choice of crop species and production environments.

The biomass yield from plants varies enormously with environment. Consideration of yield potential under optimal conditions is a starting point. The following crops have been in use for biomass production for the last so many years allover the world:

- **Grass species** such as the major cereal crops provide yields of the order of 10 tonnes/ha/year of grain under favourable conditions. The higher biomass yield potential is around 20 tonnes/ha/year.
- **Switchgrass** (*Panicum virgatum*) has been widely evaluated as an energy crop option (McLaughlin et al., 1999).
- **Miscanthus** has been shown to deliver much higher yields than currently available switchgrass genotypes (Boehmel et al, 2008).
- **Sugarcane and related species** (Saccharum, Miscanthus and Erianthusspecies) are C4 plant and probably the grasses with the highest yield potential identified to date. Sugarcane has potential to yield in excess of 100 tonnes dry matter/ha/year (Bull and Glasziou, 1975).
- **Maize and sorghum** are potentially model genomes for research on the use of grasses as bioenergy crops (Carpita and McCann, 2008).
- Corn (*Zea Mays*) is a popular feedstock for ethanol production in the United States. Corn and other high starch grains have been converted into ethanol for thousands of years, yet only in the past century has its use as fuel greatly expanded.
- Soybean oil is currently a major feedstock for production of biodiesel (NBB). Numerous studies between 1980 and 2000 have shown the use of straight vegetable oil including soybean oil to cause carbon deposits and shorten engine life (Jones and Peterson 2002).
- **Woody** biomass options include species such as poplar and willow with yield potentials of about 15 tonnes/ha/year (El Bassam, 1998; Boehmel et al, 2008). Eucalypt species have the potential to yield more than 100 tonnes/ha/year (Ugalde and Perez. 2001), comparable to the best grasses such as sugarcane. More than 700 Eucalypt taxa have been described with hybrids between these species displaying enhanced growth performance (Henry, 2009). The poplar (Tuskan et al, 2006) and Eucalypts are the emerging model genomes for woody plant development as bioenergy resources.
- **Crop residues** left in the field after grain harvest has a large potential as a bioenergy feedstock. As a byproduct of grain production these residues have been called waste, yet research has shown their nutrient, erosion, and soil carbon characteristics have value that must not be overlooked. Crop residues of interest for bioenergy include; corn stover, corn cobs, wheat straw, soybean straw, and rice hulls (Shapouri, et al., 2002; Shapouri et al., 2004, John Hay, 2010).

Many different plant species may be selected for energy production to suit the varied production environments available globally. As it matures, bioenergy production may parallel food production with many species being used at least regionally and a smaller number adapted to more diverse or abundant environments becoming widely grown internationally.

FIRST, SECOND AND LATER GENERATION BIOENERGY FROM PLANTS

The first generation of biofuel production has been based upon the conversion of the storage carbohydrates (sugars and starch) in the plants into fuel e.g. bioethanol (Schubert, 2006). Oil from plants such as oilseeds has also been used, but the relatively low yields indicate that this is unlikely to be a sustainable source of fuel on a global basis. Engineering of improved oil composition (Graef *et al*, 2009) may make these plants more suited to biodiesel production. The use of storage carbohydrates from the edible parts of plants creates the potential for direct competition between food and fuel production. The second generation of biofuels under development is based on the conversion of the structural carbohydrates of the plant cell wall (Yuan et al, 2008). This avoids direct competition with food production and makes a much wider range of plants possible sources of biomass.

In 2010 worldwide biofuel production reached 105 billion liters (28 billion gallons US), up 17% from 2009, and biofuels provided 2.7% of the world's fuels for road transport, a contribution largely made up of ethanol and biodiesel (Morales, 2012). Global ethanol fuel production reached 86 billion liters (23 billion gallons US) in 2010, with the United States and Brazil as the world's top producers, accounting together for 90% of global production. The world's largest biodiesel producer is the European Union, accounting for 53% of all biodiesel production in 2010 (Kroldrup, 2010). As of 2011, mandates for blending biofuels exist in 31 countries at the national level and in 29 states/provinces. According to the International Energy Agency, biofuels have the potential to meet more than a quarter of world demand for transportation fuels by 2050 (Ren 21, 2011).

What is the likely efficiency of conversion of plant biomass to biofuel?

Another key part of the requirement is that we have plants that can be converted at a high enough efficiency to ensure the land footprint is not too great. The conversion process is critical but the composition of the biomass can also be optimized to make the process more efficient. Selection of material with a high carbohydrate content and a composition that is easily degraded to sugars is best for current biochemical conversion technologies. Conversion efficiencies are low for most second-generation technologies but current research should provide significant advances (Simmons et al, 2008).

SYSTEMATIC ANALYSS OF PLANT GENETIC RESOURCES

The proper utilization of available biomass as energy crops in specific environments requires an analysis of available species and their suitability in available production environments. A systematic analysis of plant options for food, energy, conservation and other uses should include all plant species. Selection of new plants for energy production or even diversified food production requires a systematic analysis of the available options. Many of the species currently being promoted for use as energy crops have not been a product of such analysis and are in many cases not good options. For example, many oil-producing species are promoted because of the ease of using the oil produced in the plant with minimal processing. However, the environmental cost (land and water requirements) of growing these species will often not compete with many other species with much greater potential for biomass production. Application of appropriate selection

criteria should focus attention on species with good potential for sustainable production. Following are some general criteria for use in selecting bioenergy crop species:

- high suitability for genetic improvement
- high biomass accumulation
- high water use efficiency and harvest index
- high bulk density and high N use efficiency
- high fraction of biofuel in harvested biomass
- harvested material able to be stored in the field
- large-scale potential production
- low cost of harvest

ROLE OF PLANT BIOTECHNOLOGY

Plant biotechnology provides tools that may allow rapid development of domesticated genotypes with growth and composition characteristics optimized for energy production (Yuan et al, 2008). Innovations that promote rapid biomass growth and development and engineering of cell wall biosynthetic pathways will be required. A high yield per unit of land area and high conversion efficiency are essential to the delivery of an environmentally sustainable biofuel production system. Replacing oil with plant biomass probably needs to be associated with efforts to improve the efficiency of use of liquid fuels and reduce that total demand. It may be a priority to use plants to replace oil in the production of biomaterials other than fuel especially if other alternative renewable energy sources can be developed to replace transport energy requirements. Engineering plants to assist conversion to fuel by expressing enzymes required for processing (Taylor et al, 2008) may make fuel production more efficient and economic. Developing plants to produce high value coproducts may also be necessary to provide an adequate economic return in production of biomass for energy. Plant biotechnology may contribute to the development of later generation biofuels that are more equivalent to current liquid fossil fuels such as gasoline or jet fuel (Tollefson, 2008).

Modern DNA analysis methods have greatly improved the rigour and utility of higher plant taxonomy. The variation in the composition of plants in relation to their utility can now be analysed against this taxonomy. For example, the distribution of the major components of plant biomass, the major structural and nonstructural carbohydrates in these families, deserves re-evaluation. A good example of how plant taxonomy and biochemical composition relate is found in the plant families reported to contain fructans (polymers of fructose that serve as reserve carbohydrates). Current DNA-based systematic analysis suggests many other related families that should be examined for the presence of fructans. The presence of nonstructural carbohydrates in the form of fructans has implications for food use and for energy production from these species. The type of structural carbohydrate (cell wall polysaccharides) can also be very important in determining the utility for food, feed or energy. The monocotyledonous plant families in the commelinoid group (including the grasses and related families) have cell walls rich in arabinoxylans and mixed linkage β-glucans (Henry and Harris, 1997). These cell walls are very different to those found in other higher plants and suggest very different processing requirements for conversion to biofuels. Comparative genomics allows the evolution of these different cell wall

compositions to be followed (Fincher, 2009a, b). The mixed linkage β-glucans appear to have evolved independently in the horsetails (Fry et al, 2008). Very specific plant selection and improvement targets might be developed for improving groups of plants such as the grasses as resources for biofuels. Phylogenetic analysis is an important guide in our analysis of plant cell wall diversity and resulting potential for a wide range of uses. Most plant families have not been adequately explored as bioenergy options. Conifers and related plants (Gymnosperms) are described by Hill (2005). Flowering plants (Angiosperms) are listed as defined by the Angiosperm Phylogeny Group (APG, 2003). Families that have been reported (Suzuki and Chatterton, 1993) to contain fructans are identified. The seed plants can be divided into five groups, four of which are gymnosperms, with the fifth being the flowering plants or angiosperms (Hill, 2005). The closest relatives to the seed plants are the ferns. The ferns and lower plants have limited food and other uses.

Many plants have been developed as food crops, and this suggests that we may need to domesticate many species to produce the biomass required to replace oil. Plants adapted to a wide range of available production environments are needed. The grasses (Poaceae) represent a major option having been domesticated for food production; they will probably repay screening efforts aiming to discover potential bioenergy crops. Many more plant families are probably able to contribute to the development of woody bioenergy tree crops. Some limited new options for domestication of food plants could also be identified by systematic analysis.

BIORESOURCE ENGINEERING

Bioresource engineering is related to the applications of chemical engineering and agricultural engineering usually based on biological and/or agricultural feedstocks. Bioresource engineering is more general and encompasses a wider range of technologies and various elements such as food engineering and processing, biomass, biological waste treatment, bioenergy, biotransformations and bioresource systems analysis, and technologies including aerobic methods, anaerobic digestion, microbial growth processes, enzymatic methods associated with thermochemical conversion technologies like combustion, pyrolysis, gasification, catalysis, etc. The impact of urbanization and increasing demand for land, food, and water presents engineers in a world with serious challenges. Little attention has been given to the interface between the biological world and traditional engineering in the past (Smithers, 2009). It is the job of bioresource engineers to fill that gap. Agricultural and bioresource engineers develop efficient and environmentally-sensitive methods of producing food, fiber, timber, bio-based products and renewable energy sources for an ever-increasing world population (Lee, 2009).

BIO_BASED PRODUCTS AS RENEWABLE ENERGY SOURCES

1. Bioalcohols.

Biologically produced alcohols most commonly **ethanol** and less commonly propanol and butanol are produced by the action of microorganisms and enzymes through the fermentation of sugars or starches or cellulose. Biobutanol (also called biogasoline) is often claimed to provide a direct replacement for gasoline, because it can be used directly in a gasoline engine (in a similar way to biodiesel in diesel engines). Ethanol fuel is the most common biofuel worldwide, particularly in Brazil. Ethanol can be used in petrol engines as a replacement for gasoline; it can be

mixed with gasoline to any percentage. In high altitude (thin air) locations, some states mandate a mix of gasoline and ethanol as a winter oxidizer to reduce atmospheric pollution emissions. Ethanol is also used to fuel bioethanol fireplaces. As they do not require a chimney and are "flueless", bio ethanol fires are extremely useful for new build homes and apartments without a flue.

Methanol is currently produced from natural gas a non-renewable fossil fuel. It can also be produced from biomass as biomethanol. The methanol economy is an alternative to the hydrogen economy compared to today's hydrogen production from natural gas.

Butanol is formed by ABE fermentation (acetone, butanol, ethanol) and experimental modifications of the process show potentially high net energy gains with butanol as the only liquid product. Butanol will produce more energy and allegedly can be burned "straight" in existing gasoline engines and is less corrosive and less water soluble than ethanol, and could be distributed via existing infrastructures. DuPont and BP are working together to help develop Butanol. *E.Coli* has also been successfully engineered to produce butanol by hijacking their amino acid metabolism (Jon , 2008)

2. Biodiesel

Biodiesel is the most common biofuel in Europe. It is produced from oils or fats using transesterification and is a liquid similar in composition to fossil/mineral diesel. Chemically, it consists mostly of fatty acid methyl (or ethyl) (FAMEs) (Knothe, 2010). Feedstocks for biodiesel include animal fats, vegetable oils, soy, rapeseed, jatropa, mahua, mustard, flax, sunflower, palm oil, hemp, field pennycress, pongamia, pinnata and algae. Pure biodiesel (B100) is the lowest emission diesel fuel. Biodiesel can be used in any diesel engine when mixed with mineral diesel. In some countries manufacturers cover their diesel engines under warranty for B100 use, although Volkswagen of Germany, for example, asks drivers to check by telephone with the VW environmental services department before switching to B100. B100 may become more viscous at lower temperatures, depending on the feedstock used. The emerging US biodiesel market is estimated to have grown 200% from 2004 to 2005 (ADM Biodiesel, 2010).

3. Green diesel

Green diesel, also known as renewable diesel, is a form of diesel fuel which is derived from renewable feedstock rather than the fossil feedstock used in most diesel fuels. Green diesel feedstock can be sourced from a variety of oils including canola, algae, jatropa and salicornia in addition to tallow. Green diesel uses traditional fractional distillation to process the oils, not to be confused with biodiesel which is chemically quite different and processed using transesterification.

4. Vegetable oil

Straight unmodified edible vegetable oil is generally not used as fuel, but lower quality oil can and has been used for this purpose. Used vegetable oil is increasingly being processed into biodiesel, cleaned of water and particulates and used as a fuel. Oils and fats can be hydrogenated to give a diesel substitute . The resulting product is a straight chain hydrocarbon with a high cetane number, low in aromatics and sulfur and does not contain oxygen. Hydrogenated oils can be blended with diesel in all proportions (US Dept. of Energy, 2012)

5. Bioethers

Bio ethers (also referred to as fuel ethers or oxygenated fuels) are cost-effective compounds that act as octane rating enhancers. Greatly reducing the amount of ground-level ozone, they contribute to the quality of the air we breathe. (The Council of the European Communities, 1985; Commission of the European Communities, Brussels, 2007)

6. Biogas

Biogas is methane produced by the process of anaerobic digestion of organic material by anaerobes (Redman, 2008). It can be produced either from biodegradable waste materials or by the use of energy crops fed into anaerobic digesters to supplement gas yields. The solid byproduct, digestate, can be used as a biofuel or a fertilizer. Biogas can be recovered from mechanical biological treatment waste processing systems. Landfill gas is a less clean form of biogas which is produced in landfills through naturally occurring anaerobic digestion. If it escapes into the atmosphere it is a potential greenhouse gas.

- Farmers can produce biogas from manure from their cows by using an anaerobic digester (Farmers Guardian , 2009)

7. Solid biofuels

Examples include wood, sawdust, grass trimmings, domestic refuse, charcoal, agricultural waste, non-food energy crops and dried manure (Urban and Mitchell 2011).A problem with the combustion of raw biomass is that it emits considerable amounts of pollutants such as particulates and PAHs (polycyclic aromatic hydrocarbons)(Cedric *et al*, 2008).

SECOND GENERATION BIOFUELS (ADVANCED BIOFUELS)

Second generation biofuels are biofuels produced from sustainable feedstock. Sustainability of a feedstock is defined among others by availability of the feedstock, impact on GH emissions and impact on biodiversity and land use (European Biofuels Technology Platform, 2011). Many second generation biofuels are under development such as cellulosic ethanol, algae fuel, biohydrogen, biomethanol, DMF, BioDME, biohydrogen diesel, mixed alcohols and wood diesel.

1. **Cellulosic ethanol** production uses non-food crops or inedible waste products and does not divert food away from the animal or human food chain. Lignocellulose is the "woody" structural material of plants. This feedstock is abundant and diverse, and in some cases (like citrus peels or sawdust) it is in itself a significant disposal problem. In 2009 scientists reported developing, using "synthetic biology", "15 new highly stable fungal enzyme catalysts that efficiently break down cellulose into sugars at high temperatures", adding to the 10 previously known. In addition, research conducted at Delft University of Technology by Jack Pronk has shown that elephant yeast, when slightly modified can also create ethanol from non-edible ground sources (e.g. straw) (Tnw.tudelft.nl- a,b, 2010)
2. The recent discovery of the fungus *Gliocladium roseum* points toward the production of so-called myco-diesel from cellulose. This organism (recently discovered in rainforests of northern Patagonia) has the unique capability of converting cellulose into medium length hydrocarbons typically found in diesel fuel (AFP, 2008). Scientists also work on experimental recombinant DNA genetic engineering organisms that could increase biofuel

potential. Scientists working with the New Zealand company Lanzatech have developed a technology to use industrial waste gases such as carbon monoxide from steel mills as a feedstock for a microbial fermentation process to produce ethanol (Fisher, 2007; Voegele, 2009).

3. **Algal biofuels.** From 1978 to 1996, the U.S. NREL experimented with using algae as a biofuels source in the "Aquatic Species Program" (Sheehan, *et al*.,1998). A self-published article by Michael Briggs, at the University of New Hampshire Biofuels Group, offers estimates for the realistic replacement of all vehicular fuel with biofuels by utilizing algae that have a natural oil content greater than 50%, which Briggs suggests can be grown on algae ponds at wastewater treatment plants (Michael, 2004). This oil-rich algae can then be extracted from the system and processed into biofuels, with the dried remainder further reprocessed to create ethanol. The production of algae to harvest oil for biofuels has not yet been undertaken on a commercial scale, but feasibility studies have been conducted to arrive at the above yield estimate. Many companies are pursuing algae bio-reactors for various purposes, including scaling up biofuels production to commercial levels (Green Fuel Technologies, 2008). http://www.greenfuelonline.com/technology.htm.,2008).
4. **Jatropha**. Several groups in various sectors are conducting research on *Jatropha curcas*, a poisonous shrub-like tree that produces seeds considered by many to be a viable source of biofuels feedstock oil (Divakara, 2010). Much of this research focuses on improving the overall per acre oil yield of Jatropha through advancements in genetics, soil science, and horticultural practices. SG Biofuels, a San Diego-based Jatropha developer, has used molecular breeding and biotechnology to produce elite hybrid seeds of Jatropha that show significant yield improvements over first generation varieties (Biofuels Digest, 2011). SG Biofuels also claims that additional benefits have arisen from such strains, including improved flowering synchronicity, higher resistance to pests and disease, and increased cold weather tolerance (SG Biofuels, 2012).
5. Plant Research International, a department of the Wageningen University and Research Centre in the Netherlands, maintains an ongoing Jatropha Evaluation Project (JEP) that examines the feasibility of large scale Jatropha cultivation through field and laboratory experiments (Plant Research International, 2012). The Center for Sustainable Energy Farming (CfSEF) is a Los Angeles-based non-profit research organization dedicated to Jatropha research in the areas of plant science, agronomy, and horticulture. Successful exploration of these disciplines is projected to increase Jatropha farm production yields by 200-300% in the next ten years (Biofuels Magazine, 2011).
6. **Fungi.** A group at the Russian Academy of Sciences inMoscow published a paper in September 2008, stating that they had isolated large amounts of lipids from single-celled fungi and turned it into biofuels in an economically efficient manner. More research on this fungal species; *Cunninghamella japonica,* and others, is likely to appear in the near future (Sergeeva *et al,* 2008). The recent discovery of a variant of the fungus *Gliocladium roseum* points toward the production of so-called myco-diesel from cellulose. This organism was recently discovered in the rainforests of northern Patagonia and has the unique capability of converting cellulose into medium length hydrocarbons typically found in diesel fuel (Strobel *et al,* 2008).

BIOFUELS BY REGION

There are international organizations such as IEA Bioenergy (2010) established in 1978 by the OECD International Energy Agency (IEA), with the aim of improving cooperation and information exchange between countries that have national programs in bioenergy research, development and deployment. The U.N. International Biofuels Forum is formed by Brazil, China, India, South Africa, the United States and the European Commission (United Nations Department of Public Information, 2007). The world leaders in biofuel development and use are Brazil, United States, France, Sweden and Germany. Russia also has 22% of world's forest (http://archive.greenpeace.org/comms/cbio/russia.html) and is a big biomass (solid biofuels) supplier.

Biofuels currently make up 3.1% of the total road transport fuel in the UK or 1,440 million litres. By 2020, 10 per cent of the energy used in UK road and rail transport must come from renewable sources – this is the equivalent of replacing 4.3 million tonnes of fossil oil each year. Conventional biofuels are likely to produce between 3.7 and 6.6 per cent of the energy needed in road and rail transport, while advanced biofuels could meet up to 4.3 per cent of the UK's renewable transport fuel target by 2020. The NFESC, with Santa Barbara-based Biodiesel Industries is working to develop biofuels technologies for the US navy and military, one of the largest diesel fuel users in the world (Future Energies, 2009). A group of Spanish developers working for a company called Ecofasa announced a new biofuel made from trash. The fuel is created from general urban waste which is treated by bacteria to produce fatty acids, which can be used to make biofuels (Lele.newsvine.com. 2008).

ADVANTAGES OF PLANT BIOMASS

Biomass can be used for fuels, power production and products that would otherwise be made from fossil fuels. In such scenarios, biomass can provide an array of benefits. For example:

- The use of biomass energy has the potential to greatly reduce greenhouse gas emissions. The use of biomass can reduce dependence on foreign oil because biofuels are the only renewable liquid transportation fuels available.
- Biomass energy can agricultural and forest-product industries. The main biomass feedstocks for power are paper mill residue, lumber mill scrap, and municipal waste. In the near future-and with NREL-developed technology-agricultural residues such as corn stover (the stalks, leaves, and husks of the plant) and wheat straw can also be used.
- Considering, the global warming potential (GWP), which is a combination of CO_2, methane (CH_4), and nitrous oxide (N_2O) emissions, and energy balance of the system need to be examined using a life cycle assessment. This takes into account the upstream processes which remain constant after CO_2 sequestration as well as the steps required for additional power generation.

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Bioenergy Crops from Different Agro-ecological Regions for Biofuel Production

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ABSTRACT

Bioenergy is renewable energy that can generate many additional benefits, the extent of which depends on a combination of factors including the types of feedstocks used, how they are produced and transported, and the efficiency of the technologies deployed to convert them to bioenergy. Bioenergy is produced from organic matter derived from plants or animals. It is generated from living, or recently harvested matter, as opposed to fossil fuel. Fossil fuels, although originally derived from organic matter, have been created over long periods through biological and geological processes and are essentially non-renewable. Specific types of organic matter used to produce bioenergy are called biomass or bioenergy feedstocks. Being a storage house of bioenergy, biomass can be considered to be nature's 'solar batteries'. The energy biomass produces can be converted into electricity, heat or biofuels. Bioenergy can be as simple as a wooden log fire or a complex refined transport fuel.

Keywords: Bioenergy, Biomass, Biofuel

INTRODUCTION

Bioenergy comes from any fuel that is derived from biomass - recently living organisms or their metabolic byproducts. Biomass can include matter such as cow manure. Unlike other natural resources such as petroleum, coal and nuclear fuels, bioenergy is a renewable energy source. Like all methods used to generate energy, the combustion of biomass generates pollution as a by-product. However, since the carbon in biofuels was recently extracted from atmospheric carbon dioxide by growing plants, the combustion of a biofuel does not result in a net increase of carbon dioxide in the Earth's atmosphere.

Most bioenergy can be traced back to energy from sunlight, making it a major renewable energy source. Bioenergy is the most widely used renewable energy in the world, providing around 10% of the world's primary energy supplies, mostly as thermal energy for heating and cooking. **(Fact Sheet Series 1.3 of Department of Primary Industries, 2012).**

As fossil fuel reserves dwindle, society has begun to search for renewable fuel alternatives. Biofuels (such as ethanol and biodiesel) are developed from plants, and researchers are experimenting with plants that grow well in otherwise unusable lands such as deserts. Using arid desert land saves space on agriculturally useful land, and as an added benefit, land that would normally waste away is put to productive use.

With focus on biofuel production, productivity can be increased by implementing agricultural practices such as adequate water and fertilizers, suitable cultivars or hybrids, crop rotation, pest management etc. (Reddy et al., 2005).

BIOENERGY CROPS

The genus **Jatropha (*Jatropha curcus*)** belongs to the tribe Jatropheae in the Euphorbiaceae family and contains approximately 170 known species. Euphorbiaceae is an ancient and diverse family in the large rosid order Malpighiales and in addition to Jatropha includes many familiar members such as rubber, cassava, castorbean, poinsettia, and leafy spurge (Wurdack, 2008).Jatropha is also known as Physic Nut can yield up to two tons of biodiesel fuel per year per hectare. In such quantities, Jatropha, like biofuels in general, cannot become a replacement for oil. But Jatropha requires minimal inputs, stablizes or even reverses desertification, and has use for a variety of products after the biofuel is extracted. Moreover, diesel fuel with biodiesel additives causes far less pollution. Jatropha is well adapted to arid and semi-arid climates with demonstrated molecular mechanisms for resistance to drought (Zhang et al., 2008). It can also grow on a large range of soils provided they are well drained and aerated (Kumar and Sharma, 2008).

Mahua (*Madhuca indica*) is one of the forest based tree-borne non-edible oils with large production potential of about 60 million tons per annum in India. *Mahua* is a frost resisting tree of the dry tropics and sub-tropics, common in deciduous forests and dry sal plain forests. The tree is usually found scattered in pastures and cultivated fields in central India. It is extensively cultivated near villages. The tree is culturally most identified with Indian life in the plains being the lifeline of tribal belt in central India.

Its flowers are sweet, delicious and are consumed besides tasty fruits and are used to make vinegar. The seeds yield fat known as *Mahua* butter used in cooking, adulteration of *Ghee*, manufacturing chocolates and even soaps, besides treatment of rheumatism and constipation. *Mahua* cake is insecticidal and also used for fishing. The *Mahua* tree belongs to the genus *Mahuca*. The tree, its seed and flowers have been very useful in Indian economy for a long time. The flowering season extends from February to April. It is rich in sugar (73 %) and next to cane molasses; it constitutes the most important raw material for alcohol fermentation. The yield of alcohol is about 405 litres from one tonne of dried flower. The kernel of the *Mahua* fruit contains about 50% oil. The oil yield is 34-37% by small expeller. The expelled cake is relevant to recover the residual oil. Fresh oil is yellow in color, while commercial oil is generally greenish yellow with disagreeable odour and taste. Considering *Mahua*'s potential as an oilseed feedstock for biodiesel CJP (Centre for Jatropha Promotion & Biodiesel) has the honor to establish this untapped resource as alternative source for Bio- Diesel industry of future.

Karanj (Derris indica), also known as *Pongamia pinnata* is a fast-growing evergreen legume tree which reaches 40 feet in height and spread, forming a broad, spreading canopy casting moderate shade. The natural distribution of ***Derris indica*** is along coasts and river banks in India and Myanmar. Native to the Asian subcontinent, this species has been introduced to humid tropical lowlands in the Philippines, Malaysia, Australia, the Seychelles, the United States and Indonesia. It has also been naturalized in parts of eastern Africa, northern Australia and Florida. Some of the

uses of the tree are shade, wind shelter, living fence, improved fallow, improved pasture, mulch, fodder, bee forage, fuel wood, timber, fiber, resins etc.

Its seeds contain oils and fatty acids suitable for biodiesel production. Small clusters of white, purple, and pink flowers blossom on their branches throughout the year, maturing into brown seed pods. The tree is well suited to intense heat and sunlight and its dense network of lateral roots and its thick, long taproot make it drought tolerant. The tree withstand temperatures slightly below 0°C to 50°C and annual rainfall of 5–25 dm and grows wild on sandy and rocky soils. Although all parts of the plant are toxic and will induce nausea and vomiting if eaten, the fruits and sprouts, along with the seeds, are used in many traditional remedies. Juices from the plant, as well as the oil, are antiseptic and resistant to pests. *Derris indica* is one of the few nitrogen fixing trees (NFTS) used to produce seeds containing 30- 42% oil which is an important asset of this tree having been used as lamp oil, in soap making, and as a lubricant for thousands of years. It is often planted as an ornamental and shade tree.

The *Derris indica* trees are regarded as a sure source of 2nd Generation Biodiesel and the foundation around which a profitable business plan can be built for its ability to provide large amount of oil and its pure hardiness and stress handling ability. The tree has enough credentials: a higher recovery and quality of oil than other crops, no direct competition with food crops as it is a non-edible source of fuel, and no direct competition with existing farmland as it can be grown on degraded and marginal land.

Kumar et al. (2003) covered a review on the insecticidal, antimicrobial, nematicidal and medicinal properties of compounds isolated from *Pongamia pinnata* and chemical composition of *P.pinnata.* Karanjachromene, C21H18O4 which is a fluorescent pyranoflavonoid was isolated from the seed oil of *Pongamia pinnata* by Naghmana et.al (2008). Such compounds have many interesting pharmacological and industrial applications**.**

Drumstick Tree *(Moringa oleifera)* is a very fast growing tree which commonly reaches four meters in height just 10 months after the seed is planted and can bear fruit within its first year. Its pods are triangular in cross-section (30 to 50 cm long) and legume-like in appearance. These pods have oil rich black and winged seeds, which can be crushed to produce biodiesel. *Moringa* could yield +3 ton oil per ha and that it could be used for food in times of shortages. The seeds contain 30 percent to 40 percent oil that is high in oleic acid. The meal yields about 61 percent protein. Biodiesel made from *Moringa* has better oxidative stability than biodiesel made with most other feedstocks the crop's multiple dimensions would make it attractive to farmers worldwide. Other than biodiesel, the pods can also produce edible (in fact, highly nutritious) seeds and leaves. Some parts of the plant have medicinal purposes, and the sap can potentially be used as a dye. *Moringa oleifera* is native of India, occurring wild in the sub-Himalayan regions of Northern India, and now grown world-wide in the tropics and sub-tropics. It is an important crop in India, Ethiopia, the Philippines and the Sudan, and is being grown in West, East and South Africa, tropical Asia, Latin America, the Caribbean, Florida and the Pacific Islands. Commonly known as the 'horse-radish' tree (arising from the taste of a condiment prepared from the roots) or 'drumstick' tree (arising from the shape of the pods), *M.oleifera* has a host of other country specific vernacular names, an indication of the significance of the tree around the world.

Cassava (*Manihot esculenta*), is a tuber widely cultivated in tropical and sub-tropical regions, and is currently one of the world's most cost-efficient biofuel feedstocks. It is more efficient

compared to other energy crops, such as sugar cane, sweet sorghum, corn and wheat. One hectare of farm land cultivated with cassava is able to produce on average 6,000 kg of ethanol. (Ghizan and Rajanaidu 2011) Ethanol made from cassava costs more than the molasses-based varieties. In contrast one hectare of corn only produces 2,050 kg of ethanol per year, a little over a third of the same area as cassava. (Dominick, 2012).

Woody crops are generally fast-growing plants like grasses or trees, which are cultivated for energy production, but can also be forestry or agricultural residues. Short rotation woody crops are fast growing hardwoods, planted at high density and generally harvested two to twelve years after planting. In case of arid and semi-arid climates, the rotation period is likely to be closer to the higher end of this range in order to allow for more efficient harvesting. The harvested wood is used for various energetic purposes such as direct use as fuel wood for cooking, heating and lighting, co-firing for electricity production, ethanol production via fermentation and biodesel via gasification/ Fischer-Tropsch process. In this study the focus is placed on wood used as fuel wood as this does not require major modification to current energy use in Africa while the other technologies are also not widely available yet in Africa. In order to make full use of the potential, it is important that fuel wood from dedicated bioenergy production is combined with more efficient stoves.

Guayule (*Parthenium argentatum*) offers many biofuel benefits. Guayule shrubs can be harvested as early as two years after planting, and are ready to harvest again in about another year and a half. Guayule thrives in hot, dry ecosystems where many other biofuel crops wouldn't grow well. The hardy shrub requires less fertilizer than other crops currently produced in the desert Southwest. Even though a few herbicides are needed while the plants are getting established, once that happens, there's no need for chemicals that target harmful insects, fungi, or worms called nematodes (McMahan 2009).

Bioenergy can be made from ground-up guayule stems and branches, left after their white, rubber-rich latex has been removed, McMahan noted. The leftovers-a soft, light brown sawdust-like material called bagasse, provide 8,000 to 9,000 Btu per pound, about the same as charcoal (McMahan 2009)

There are a variety of cultivated crops that could grow well in arid, desert lands and climates that could become bioenergy crops and also serve to make other products such as alternative feed for animals. *Salicornia*, *Sweet Sorghum* and *Amaranth* to some degree are well suited to desert environments in that some of them have special growth characteristics such as low water consumption or drought tolerance and are also well suited to high salinity water and soil conditions. Majority of these plants grow better in more favorable ecosystems and climate but have proven to have adapted well to desert soil, water and climate conditions.

Salicornia is a salt tolerant or halophyte energy crop that is beginning to gain more interest as an energy crop. *Salicornia* is one of the oilseed crops being considered to produce bio-derived jet fuel. It is considered as a healthy plant due to its high protein content with around 30% and a variety of healthy salts that can be sundried and used in foods. *Salicornia* has been known to have pharmalogical value with special medicinal properties and other plant properties which makes it ideal for other sustainable materials, alternative animal feed and soil remediation projects. *Salicornia* is so salt tolerant that it can be directly irrigated with seawater itself (Glenn et al 1997). It is therefore, ideal to use with saline types of irrigation water such as brackish water.

Sweet Sorghum has been shown to require half of what sugar beets need for crop production and one fourth of what sugarcane requires for water usage (Prasad et al 2007). Called the sugarcane of the desert, sweet sorghum is one of the most promising crops for biofuel. Sweet sorghum can be used as a feedstock for ethanol production under hot and dry climatic conditions (Almodares and Hadi , 2009).It can be used as a substitute not only to produce food (Anglani, 1998), but also energy (Reddy et al.,2005), feed(Almodares et al.,1999; Fazaeli et al.,2006) and fiber (Murray et al.,2008a,b).

A comparison of sugar production with sweet sorghum, sugarcane and sugar beet showed that sugar production from sweet sorghum is cheaper than both sugarcane and sugar beet (Blas et al., 2000). Thus it can be used as a supplementary sugar crop (Kualarni et al., 1995).

Amaranth (*Amaranthus)* known throughout the world to be a very healthy plant is another plant that grows in a variety of climates and conditions. There are many species or varieties of it. The leaves can be consumed by humans or livestock, the plant contains grains that can be converted into a type of bread or also used in fermentation to produce alcohol. The bread made from amaranth is beneficial to people who require gluten free bread with a lot of other health benefits. The protein content of amaranth is high for a plant source, being around 15 percent and it also contains amino acids that aren't present in other plant sources. Amaranth provides grain meal that can be fermented by a variety of microorganisms, one type named *Rhizopus oryzae* can produce ethanol plus other organic compounds from amaranth (Bramorski et al 1998). Certain species of Amaranth are known to grow quite well in dry, arid desert lands such as Palmer Amaranth.

Pencil Tree *(Euphorbia tirucalli)* is a tropical to subtropical plant commonly known as milkbush. According to Calvin (1980), as cited by Purdue University, the plant is capable of producing between 10 to 50 barrels of oil (biodiesel) per acre. The plant also produces latex, and its wood can be used as framing lumber if the plants are allowed to grow tall enough.

Algae have a lot of promise as a biofuel producer. According to Thomas (2006), microalgae can produce between 5,000 to 15,000 gallons of oil per acre per year. Desert land is ideal for the large ponds' space requirement, but one of the major drawbacks is that shallow ponds must be filled in, and the only way this is possible is by piping in water to desert areas.

Soybean (*Glycine max*) is a major crop throughout much of North America, South America and Asia. Soybean acreage is much greater than other oilseed crops leading to substantial soybean oil production and its availability as a biofuel feedstock. Soybean oil is currently a major feedstock for production of biodiesel. The most common method of biodiesel production is a reaction of vegetable oils or animal fats with methanol or ethanol in the presence of sodium hydroxide (which acts as a catalyst). The transesterification reaction yields methyl or ethyl esters (biodiesel) and a byproduct of glycerin.

Crop residues left in the field after grain harvest has a large potential as a bioenergy feedstock. As a byproduct of grain production these residues have been called waste, yet research has shown their nutrient, erosion and soil carbon characteristics have value that must not be overlooked. Crop residues of interest for bioenergy include; corn stover, corn cobs, wheat straw, soybean straw and rice hulls.

CONCLUSION

The sustainable production and use of energy in the form of biofuels can offer significant benefits to both the urban and rural sectors. Bioenergy produced from non conventional energy sources such as desert plants is the future power of automobiles, homes, industries and agriculture. Using deserts for bioenergy production would definitely help to alleviate the problems associated with land-use and biodiversity as far as biofuel production is concerned.

The projects undertaken to produce biofuels from desert plants would definitely help to improve the economy and environment at local and global levels. However numerous questions remain unanswered as far as the best suited plant for biofuel production is concerned .Lot of research needs to be done in search of bioeconomic prosperity and sustainability

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Wheat and Triticale Crops as Source of Biofuel

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ABSTRACT

The demand for ethanol is increasing in recent years because of its wide use in chemical, potable and motor-fuel industries. Biofuel is now becoming one of the fastest growing markets within the food and agriculture sector. Increased public concern about global warming and over-reliance on foreign petroleum oil has led to the development of renewable and clean energy in many countries. Governments worldwide recognize the environmental and economical potential that biofuels have to offer. It can produce up to 70% fewer carbon emissions than petrol; if bioethanol replaced just 5% of the petrol in the UK, the carbon reduced would be equivalent to taking one million cars off the road. It can be easily blended with conventional grades of petrol (5% bio ethanol, 95% petrol) and dispensed through normal unleaded petrol pumps, without the need for modification of conventional petrol cars. Grains, for example corn, wheat, barley, triticale and sugarcane are all raw materials for bio fuel production. This paper examines significance of biofuel for energy purposes, possibility of selecting small grain cereals like wheat and triticale for biofuel production and genomics and biochemical process involved in build of grain starch.

Key words: Wheat, Triticale , biofuel,

INTRODUCTION

The demand for ethanol is increasing in recent years because of its wide use in chemical, potable and motor-fuel industries. Biofuel is now becoming one of the fastest growing markets within the food and agriculture sector. Increased public concern about global warming and over-reliance on foreign petroleum oil has led to the development of renewable and clean energy in many countries. Governments worldwide recognize the environmental and economical potential that biofuels have to offer. It can produce up to 70% fewer carbon emissions than petrol; if bioethanol replaced just 5% of the petrol in the UK, the carbon reduced would be equivalent to taking one million cars off the road. It can be easily blended with conventional grades of petrol (5% bio ethanol, 95% petrol) and dispensed through normal unleaded petrol pumps, without the need for modification of conventional petrol cars. Ethanol blended gasoline burns more efficiently and can contribute to reduction in greenhouse gasses emission (Wang *et al*. 1999). The Energy Policy Act of 2005 established annual goals via a renewable fuels standard that would have increased production of ethanol and biodiesel to 7.5 billion gallons by 2012. That bill was superseded by the Energy Independence and Security of Act of 2007, which increased usage targets and specified performance standards for ethanol and other biofuels with maize as the major feedstock for fuel ethanol production. Grains, for example corn, wheat, barley, triticale and sugarcane are all raw

materials for bio fuel production. Behl,and Molla(2010) suggested about selection of wheat and triticale genotypes as a source of biofuels. This paper examines the current status of wheat and triticale production in various countries , how agronomy, potential selection traits and starch metabolism aspects can be used to select appropriate wheat and triticale genotypes

CEREALS FOR BIOFUELS : WHEAT AND TRITICALE

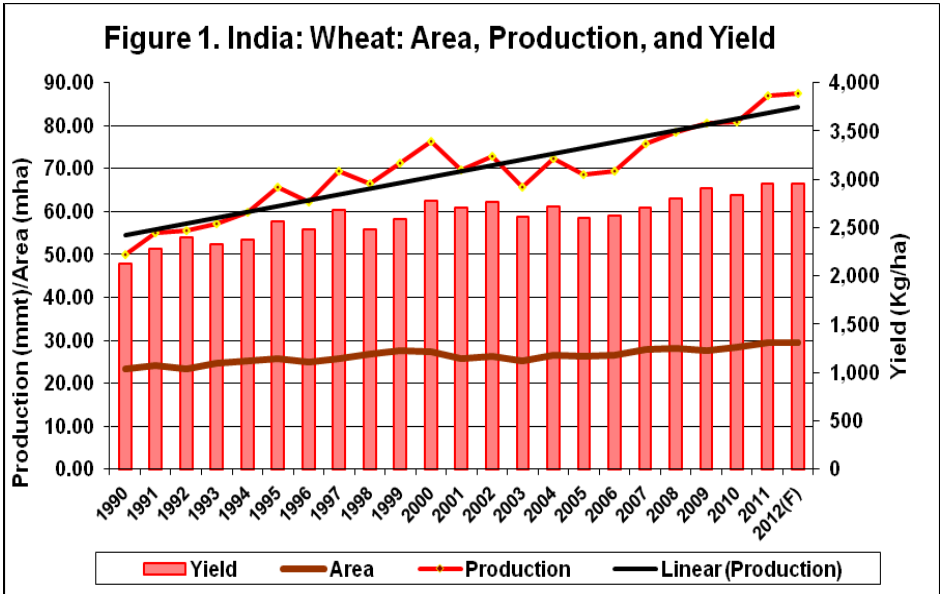
Wheat (*Triticum* spp.) is a worldwide cultivated grass from the Levant area of the Middle East. Globally, wheat is cultivated on about 218.60 million hectares. The top ten wheat-producing countries also contain nearly 70% of the wheat area (144 M ha) in the world (Table 1). This percentage has been consistent since the end of the USSR in the early 1990s. Since 1995, wheat area has increased most in Russia (2.7 M ha), Australia (1.6 M ha), and India (1.2 M ha) although there can be quite large changes in area planted between years due to seasonal and financial conditions.As reported by Food and Agriculture Organization (FAO) the wheat production, area, and yield in top 20 countries is as follows (Table 1) (FAOStat, 2012; IFADATA 2012).

Table 1. Production, area and yield of the top 20 wheat-producing countries in the world. (FAOStat 2012; IFADATA 2012).

Countries	Production (M t)	Area (M ha)	Yield (t/ha)
China	112.10	23.90	4.69
India	87.50	29.60	2.77
United States	58.70	20.32	2.89
Russian Federation	52.26	24.18	2.15
France	36.73	5.31	6.92
Canada	24.79	9.25	2.67
Germany	23.71	3.17	7.47
Pakistan	22.57	8.75	2.58
Turkey	19.06	8.15	2.34
Ukraine	18.30	6.31	2.86
Australia	17.92	13.04	1.36
United Kingdom	14.83	1.93	7.66
Kazakhstan	13.83	12.98	1.07
Islamic Republic of Iran	13.40	6.47	2.05
Argentina	12.68	4.69	2.70
Poland	8.79	2.26	3.87
Egypt	7.87	1.26	6.27
Italy	7.29	2.00	3.65
Spain	5.80	1.89	3.06
Romania	5.35	2.05	2.59
World	647.30	218.60	2.96

In India, wheat (principally *Triticum aestivum* Em.Thell) has recorded for the fifth consecutive record wheat harvest this summer on a marginal increase in the planted area and optimal growing conditions in the major growing areas so far. With normal weather conditions

through harvest (April), Post currently forecasts marketing year (MY) 2012/13 wheat production expected to increase to a record 87.5 million tons from 29.6 million hectares compared to 86.9 million tons from 29.4 million hectares last year. The government's preliminary 2012 wheat production estimate is higher at 88.3 million tons on slightly optimistic yield expectations as high temperature during harvest may temper yield prospects. The average national wheat (grain) productivity is about 2.77 t/ha whereas average productivity (grain) in Punjab and Haryana states is above 4 t/ha. Field trails at research stations and well managed farmers field under high input have envisaged much higher potential total biomass (above 10-12 t/ha) and grain yield (5 to 6 t/ha). After tottering below the production linear trend line for most of the last decade, India's wheat production has pulled above the trend line in the last two years on record planting and yields owing to government's steady increase in MSP and favorable growing conditions. Nevertheless, wheat yields across the major growing states show large variation owing to status of irrigation facilities and technology adoption. Wheat yields in the largely irrigated traditional growing areas of the north (Punjab, Haryana and Western Uttar Pradesh) are above 4.0 metric tons per hectare, while yields in central and western states (Rajasthan, Gujarat, Madhya Pradesh, Bihar) are relatively low (around 2.0 metric tons per hectare) due to inadequate irrigation facilities, poor seed replacement rate, and low input use (Figure 1).



Source: Ministry of Agriculture, GOI; and FAS/New Delhi estimates for MY 2012/13

Wheat grain is a staple food used to make flour for leavened, flat and steamed breads; cookies, cakes, breakfast cereal , pasta , juice , noodles and coscous; and for fermentation to make beer, alcohol, vodka, or bio fuel. Wheat is planted to a limited extent as a forage crop for livestock, and the straw can be used as fodder for livestock or as a construction material for roofing thatch.

While winter wheat lies dormant during a winter freeze, wheat normally requires between 110 and 130 days between planting and harvest, depending upon climate, seed type, and soil conditions. Crop management decisions require the knowledge of stage of development of the

crop. In particular, spring fertilizer applications, herbicides, fungicides, growth regulator are typically applied at specific stages of plant development

Grains from cereals should continue to serve as a major source for food and feed. Cereal straw combined with rice straw and maize husks constitutes one of the principal biomass sources arising from present agricultural activities in Europe. This represents a large potential resource for utilization as energy feed-stocks. Although there are some plans to use cereals as an energy source, the main justifications are overproduction of cereals and advanced technology in seed production, tillage, sowing, harvesting, baling and storage. Cereal crops that are whole crop harvested may be used under certain circumstances as energy crops. As per estimates provided by Food Corporation of India (FCI) huge quantities of cereal grains are getting spoiled every year due to unfavourable climatic conditions and become unfit for human and animal consumption and these are very cheap. There are about one million tonnes of damaged grains lying unutilised in FCI stores (Suresh *et al* 1999). The damaged includes discoloration, broken, cracked, attacked by fungi, insect damage, chalky, partially softened by being damp, dirty and bad smell etc. The damaged grains used for ethanol production are ten times cheaper than fine quality.

Triticale:

Triticale production increased to cca. 3.5 million ha worldwide at beginning of new millennium. Beside, this crop has the exceptional ability to get satisfactory yield under tough conditions and triticale is a promising species in the sustainable production systems. In the area, winter triticale can be grown in the place of wheat, barley, oat and rye and the spring one can be grown in the place of maize and spring barley. Share of winter triticale is dominant with its 90-95% over spring one; however, there is a growing interest towards the later one, too in the area. In a five-year period, triticale had over yielded wheat and rye except in one year where it had lower yield than wheat at our sandy soil station in Hungary (Bona, 2007). On-farm data also proved that on the areas where triticale is grown, it has an advantage over wheat (in terms of yield stability). Growers appreciate the crop that can produce satisfactory yield without higher rates of fertilizers, pesticides and intensive tillage. The average grain yield on the extremely poor areas varies between 2.5-4.5 t/ha. However, fertilizer-studies revealed that even in the above infertile acidic sandy soils in northeast Hungary, triticale can produce up to 8 t/ha yield, if properly fertilized with N, P, K, Ca and Mg (Kádár *et al.,* 1999). Small grain variety performance tests have been conducted at National Variety Field Tests network proved the excellence of triticale within small grain cereals. In a five-year period triticale had over yielded wheat and rye except in one year where it had lower yield than wheat.

Its utilization has tremendous prospects both as animal-feed and food for human race. Moreover, it will be one of the most promising non-food small grain cereals for industrial production (i.e. bio-fuels (ethanol), organic and industrial chemicals, paper-, building and plastic industry and beverage). Triticale has yet to achieve its appropriate market position and image in Europe. At this time, this crop is not on the EU-list of the fascinating cereal species that can take advantage of government's subsidy. Throughout the world - including Mid-Europe - there is an extremely strong force on costs and benefits. Triticale has run a short period in its history: from the time of the first hexaploid triticale released (Kiss, 1966), the modern hexaploid triticale cultivars today have got the highest yield potentials within small grain cereals. Prospects, however, are promising for triticale because its strong yielding ability, high level of adaptation and

also the possibility to use this species as energy crop in the future years (Green, 2002). In a field trial at Haryana Agricultural University, Hisar, India, it was observed that biological yield in elite tall type triticale was 102 gram per plant as against only 58 gram in standard check wheat variety. This was mainly due to plant height being 184 cm in triticale and 106 cm in wheat (Behl, 1980)

ENERGY GRAIN (WHOLE CROP TRITICALE, WHEAT)

Wheat (*Triticum spp.*) is the second most important winter cereal in India after rice. Bread wheat contributes approximately 95% to total production while another 4% comes from durum wheat and *dicoccum* share in wheat production remains only 1%. Wheat crop contributes substantially to the national food security by providing more than 50% of the calories to the people who mainly depend on it. In areas of cool weather and short growing season, where crops like maize can't be produced in large quantity, alternative feed stocks need to be explored for fuel ethanol production. There is an abundant but underutilized supply of agricultural residues and herbaceous grasses available in different wheat and barely growing areas. In 2006, for example, Montana produced 5.2 million tons (t) of wheat and 0.9 million t of barley. Over 9 million t of residues were left behind as a by-product of these crops. The annual and/or perennial grasses and cereal forage crops may serve both as livestock feed and lignocelluloses' feedstock for fuel ethanol production. Suresh *et al* (1999) reported production of ethanol by utilizing gelatinized starch from damaged wheat grains. The simultaneous saccharification and fermentation was used to produce ethanol from raw starch of damaged wheat grains by utilizing crude amylase preparation from *B. subtilis* VB2 and an amylolytic yeast strain *S.cerevisiae* VSJ4. Various concentrations of damaged wheat starch were used and 25% was found to be optimum for damaged wheat starch yielding 4.40% V/V ethanol.

The two main types of liquid bio fuel are biodiesel and bio ethanol. Biodiesel can be blended with diesel and bio ethanol is primarily blended with petrol. Currently the majority of vehicle engines are designed to run on blends of at least 5% biofuel. At present, the main vegetable oil used for biodiesel comes from oilseed rape, and bioethanol is produced from sugar beet or cereal grains. In future it may become possible to produce sugar, hence alcohol, from plant biomass, which is much cheaper and more plentiful. Using crops to produce fuel will help to meet targets for reducing greenhouse gas emissions such as carbon dioxide (CO_2). The production of cereals for combustion or for fermentation may be done like for production for food or fodder use. For fermentation use high grain yields must be obtained, while for combustion a high total yield is aimed at, as both grain and straw are used.

GROWING CROPS FOR BIOFUELS

Ethanol production depends upon the yield of starch and the ease with which it can be processed. For wheat use of varieties with good starch/distilling properties should be considered. Crop inputs, except nitrogen, should be applied at economically optimum amounts for yield. Nitrogen increases grain protein at the expense of starch, so N applications should be made earlier and at a slightly lower rate than for other markets. Processors may pay a premium for grain giving higher alcohol yields, which can be maximized through variety choice and nitrogen management.

The nitrogen fertilization rate could be 50% of the normal rate for grain cereals because most of the nitrogen needed by cereals is for grain production and to improve the protein content of the grain. This is not needed in whole crop harvesting for energy feedstocks.

- The whole crop harvesting procedure will involve cutting and collecting the unfractionated crop from the field.
- Harvesting should take place earlier than for grain cereals.

This system will prevent conflicts with the production of food cereal grains.

Harvest is done in Europe in August and yields vary between 7 to 10 t.ha^{1}. The crop needs about 250 kg N. ha^{1} (on average 3 kg N per 100 kg grain) of which about 160 kg from mineral fertilisers. Due to the nature of European agriculture high yield is a must. In the last decades yields have increased at an annual rate of about 0.15 t. ha^{1}. The straw produced at an average yield of 4.5 t. ha^{1}. The crop needs about 250 kg N. ha^{1} (on average 3 kg N per 100 kg grain) of which about 160 kg from mineral fertilisers. crop needs about 250 kg N. ha^{1} (on average 3 kg N per 100 kg grain) of which about 160 kg from mineral fertilisers.

The harvesting in Indian sub continent is done in April-may and the total biomass including grains and straw ranges between 8-10 t.ha^{1} in major whet growing areas. The fertilizer application varies from place to place and ranges between 120-150 Kg N ha^{1}. The protein content of Indian wheat's is relatively lower as compared to western hemisphere.

BIOFUEL POTENTIAL OF WHEAT AND TRITICALE

Triticale has potential in the production of bread and other food products, such as cookies, pasta, pizza dough and breakfast cereals. The protein content is higher than that of wheat, although the glutenin fraction is less. The grain has also been stated to have higher levels of lysine than wheat. Assuming increased acceptance, the milling industry will have to adapt to triticale, as the milling techniques employed for wheat are unsuited to triticale. Sell *et al.* (1962) found that triticale could be used as a feed grain, and later researchers found that its starch was particularly readily digested. As a feed grain, triticale is already well established and of high economic importance. It has received attention as a potential energy crop, and research is currently being conducted on the use of the crop's biomass in bioethanol production.

In Germany wheat, Triticale and rye are investigated. Wheat has the highest yield potential on good soils, while rye produces better on poor soils. Triticale performs intermediate and attracts interest for energy purpose. A mean total yield of 12 odt/ha (5.5 odt/ha of grain) is expected under German conditions and in Denmark total mean yields of 10.9 odt/ha at commercial conditions. In Austria total yields of about 10 odt/ha were obtained and in France yields of 10-14 odt/ha.

Cereals are highly developed crops due to their use for food production, and the knowledge of production is widespread among farmers. Therefore, energy grain production can easily be implemented in agriculture and high and stable yields can be expected.

BREEDING WHEAT FOR BIOFUEL PRODUCTION

To meet society's needs with renewable biopolymers, biochemicals and energy, we have to develop the potential wheat and Triticale genotypes. Known agronomic attributes including the

highest grain and biomass yield, high starch content, and genotypes having a favorable net energy balance, and resistance to biotic and abiotic stresses. Some of these preferred characters make triticale and specific wheat genotypes crops of choice for industrial and energy end-uses.

In recent decades, plant breeding activities have made good progress in increasing grain yields and improving the genetic make up of crops to increase their physiological efficiency to produce higher biomass through enhanced and prolonged photosynthesis , improve their adaptability for wider environmental conditions and better input (nutrients and water) use efficiency. In post green revolution era the jump in grain yield in wheat has been achieved mainly through improving harvest index (the ration of grain to straw) to almost 0.5 or even higher and better agro-technology and agronomical production package. The total biomass has been influenced very little by breeding activities. However, a kind of yield plateau is now being witnessed on further increase in yield. Therefore increasing biomass coupled with high harvest index is needed. Breeders should try to produce cultivars with higher straw proportion as energy cereal crops. This would minimize the inputs and decrease environmental damage. There are already attempts to breed cereals, especially barley, with higher enzyme contents that enable efficient fermentation and ethanol production from the grain.

Cereals as energy crops on set aside or non traditional stress prone areas may need attention of wheat /triticale breeders to develop Suitable genotypes which will have high biomass with a low harvest index to produce considerably more straw than grain and /or high biomass coupled with higher harvest index to produce higher total tonneage of produce. Tall type local Wheat genotypes of pre green revolution era have been by and large replaced with semi-dwraf high yielding high varieties with retailored grain to straw ratio while total biomass remain almost same. The breeders should involve the tall types, land races and, wild types having robust root system in crossing programme so as to further enhance biomass through selection among recombinants. In sizeably small areas local tall types are still grown for quality grains or stress tolerance. Such local types have around 30-35% harvest index (2.5:1 straw: grain ratio). The biomass in such genotypes can be further enhanced through crossing among tall types. In general, crosses between winter and spring wheat and wheat x triticale exhibit luxuriance for biomass and resilience for adaptability in segregating generations. In such crosses, selection for high seedling vigour, fast and appropriate vegetative growth to support reproductive phase and development, higher plant height, more number of tillers, broad leaves with stay green trait would be worthwhile to develop genotypes with higher biomass (about 8-9 tonnes/ha, with more straw and less grain) even under medium input. There is therefore, an urgent need to develop new and more efficient wheat-breeding methods to complement existing techniques, as well as to identify new traits to drive faster yield gains by exploiting the true biological yield potential of wheat. Various research activities in the world whose main aim was to capitalize on promising new techniques, based on morpho-physiological and biochemical criteria, which could be used for selecting high-yielding wheat varieties for breeding, have shown promising results.

Assessing the potential of genetic sources of variation in some physiological traits, such as high biomass production, longer rapid spike growth phase, or large kernel size, and stay green characters is very important. In addition, the evaluation of germplasm should also focus in producing lines with high starch and more amylose content together with potential yield gains. Selection for high biomass yield should bring about positive improvements in biomass yield, grain yield, effective tiller number, and number of kernels per spike. As yield improvements due to

increased partitioning of biomass to grain yield reaches its theoretical limit (Austin *et al*., 1980), breeding for larger total biomass becomes increasingly necessary if further genetic gains in yield potential are to be realized. Higher biomass may be achieved by: 1) increased interception of radiation by the crop; 2) greater intrinsic radiation use efficiency (RUE) throughout the crop cycle, and 3) improved source-sink balance permitting higher sink demand and, therefore, higher RUE during grain filling. Increased light interception could be achieved *via* early ground cover or improved "stay-green" at the end of the cycle. Improved RUE may be achieved, for example, by decreasing photorespiration or photoinhibtion (Loomis and Amthor, 1999), or through improved canopy photosynthesis related to factors such as canopy architecture. Better source-sink balance may result from increased partitioning of assimilates during spike development so that grain number is increased; this improves RUE during grain filling as a consequence of increased demand for assimilates.

WHEAT STARCH AND WHEAT FLOUR WITH HIGH AMYLOSE CONTENT

Wheat starch having high amylose content may be prepared by isolating starch from wheat seed lacking SGP-1 (Starch Granule Protein-1) according to any appropriate method known in the art. Wheat starch and wheat flour of the US invention are believed to be novel materials characterized by having a high level of apparent amylose content which has not been previously known in the art. Such wheat starch and wheat flour may be useful in various industrial and food applications. Moreover, it may be useful as a breeding material for developing wheat which produces starch having an amylose content as high as that of maize (60%-70%).

Example: - Production of Wheat Lacking SGP-1 (Starch Granule Protein-1 Null Wheat)

To produce a wheat which lacks SGP-1 (SGP-1 null wheat), the following four parental wheat (*Triticum aestivum* L.) cultivars were used: Chousen 30 (C 30) and 57 (C 57) lacking SGP-A1; Kanto 79 (K 79) lacking SGP-B1 and Turkey 116 (T 116) lacking SGP-D1. First, T 116 and K 79 were crossed to obtain F_1 seeds. F_1 plants which grew from the F_1 seeds were self-pollinated to obtain F_2 seeds. Starches were purified from the distal half of the F_2 seeds. SDS-polyacrylamide gel electrophoresis (SDS-PAGE) was performed using the purified starches so as to examine the presence or absence of SGP-D1 and -B1 As a result, F_2 seeds lacking both SGP-D1 and -B1 from cross K 79/T 116 were selected. Purification of the starches and SDS-PAGE will be described in greater detail below. F_2 plants which grew from the selected F_2 seeds lacking both SGP-D1 and -B1 were pollinated by either of C 30 and C 57, both lacking SGP-A1, to obtain new F_1 seeds. New F_1 plants grown from the new F_1 seeds were self-pollinated to obtain new F_2 seeds. Starches were purified from the distal half of the new F_2 seeds. SDS-polyacrylamide gel electrophoresis (SDS-PAGE) was performed using the purified starches so as to examine the presence or the absence of SGP-A1, -B1 and -D1. As a result, from the cross (K 79/T 116) F2//C 30 or C 57, variant progeny (new F_2 plant) lacking SGP-1 was selected.

STARCH STRUCTURE AND BIOSYNTHESIS IN RELATION TO BIOETHANOL

Carbohydrates contribute fifty to eighty percent of seed dry weight in cereals (*Chibbar et al*., 2003). Starch is the major grain carbohydrate accounting for two-thirds to three-quarters of grain

dry weight (Hucl and Chibbar, 1996). Starch is a complex glucan polymer consisting of linear α (1→4) glucan linkage which is branched by α (1→6) glucan linkage. Starch is present as discrete water insoluble granules, which are made up of one-quarter amylose, a poorly branched glucan polymer, and three-quarters of amylopectin, a heavily branched glucan polymer. Amylose is a relatively small molecule with a degree of polymerization (dp) ranging from 800 in maize to 4500 in potato. Amylopectin is a much larger molecule (dp 10^5 to 10^7) and more complex glucan polymer composed of hundreds of short α (1→4) glucan chains joined by α (1→6) linkages with approximately 5% of the residues having both types of linkages. The ordered nature of the (1→6) linkages, glucan branch chain length, and their branching pattern results in clustering of branches with in an amylopectin molecule. Three main types of glucan chains: short A-chains, intermediate B-chains and the long inter-cluster C chains provide a unique and highly ordered structure of amylopectin which is essential for starch granule formation and its physical and functional properties. Starch granules in the Triticeae tribe are synthesized in two size classes: the large lenticular A-type and the small spherical B-type granules. The two granule types have distinct chemical and physical attributes (Peng *et a*l. 1999) and end-uses (Chibbar *et al* 2007).

Basic steps in starch biosynthesis is fairly well described based on studies utilizing natural mutants (Ball and Morell, 2003; Zeeman *et al*., 2007). There is a general consensus that ADP-glucose pyrophosphorylase (AGPase), soluble starch synthases (SS), starch branching enzymes (SBE), starch debranching enzymes and possibly disproportionating enzyme catalyze the final steps leading to amylopectin synthesis. Several of the enzymes exist in different isoforms, some of which vary in sub-cellular distribution, enzyme specificity, temporal activity and interaction with other enzymes, making the starch synthesis pathway highly complex. The biosynthetic enzymes are known in some detail (Morell and Myers, 2005).

Recent increase in the demand for renewable fuels has resulted in the revaluation of all biological sources of carbohydrates as feedstock for bioethanol production. Although increase in grain starch concentration is the most obvious to increase bioethanol production, but it has been recently recognized that starch structure also impacts the efficiency of bioethanol production. For example in maize it has been shown that for bioethanol production waxy or hetero-waxy varieties (grain starch with increased amylose concentration) have higher fermentation efficiencies than on-waxy starches (Wu *et al*., 2006).

Cereal grains are a rich source of carbohydrates and starch is a most sought after raw material for bioethanol production. Therefore, there is a renewed interest in increasing grain starch concentration and modification of starch structure for enhanced bioethanol production (Smith, 2008). Various strategies have been deployed to increase grain starch concentration and their structure. In planta modified starches have been produced both by utilizing natural variation or created genetic variation in starch biosynthetic enzyme genes or by transgenic technology to express starch biosynthetic genes in target plants (Jaiswal *et al* 2010).

Increase in storage starch has been demonstrated by modulating the activity of highly regulated ADOP glucose pyrophosphorylase (AGPase). In potao (var. Russet Burbank) approximately 30% increases in tuber starch concentration was obtained by expressing an unregulated AGPase encoded by *E. Coli* glgC16 (Stark *et al*., 1992). In another strategy, site-specific mutagenesis was used in maize to generate a Pi insensitive variant AGPase large subunit. In this mutant line starch concentration did not change, but an 11-18% increase in seed dry weight was observed (Giroux *et al*., 1996). Similar to maize results, transgenic expression the same variant

large AGPase subunit in wheat produced AGPase with reduced Pi sensitivity, but did not have an increased grain starch concentration. However transgenic wheat had a 38% higher seed yield and a 31% increase in total plant biomass (Smidansky *et al.*, 2002). Similarly, in rice transgenic expression of Pi insensitive AGPase large subunit did not increase grain starch concentration, but by 11-18% increase in seed weight was observed (Sakulsingharoj *et al.*, 2004). These observations suggest a biological limitation to starch accumulation in cereal grains. However, the amount of carbon flowing in to grains is increased as shown by increase in seed weight. This increase in seed weight can potentially result in increased bioethanol production per unit area.

Increased amylopectin concentration has been shown to increased efficiency of starch hydrolysis for bioethanol production. Granule bound starch synthase I (GBSSI) is the major enzyme related to amylase synthesis. GBSSI is encoded from the waxy *(wx)* locus and mutations at this locus have been reported from most of the cereal crops (maize, rice, barley, sorghum wheat) resulting in amylose free (waxy) or reduced amylose (near waxy or heterowaxy) starches (Chibbar and Båga, 2003). Amylose free or reduced amylose starches have been produced in several cereal grains such as maize, rice, sorghum and wheat (Jaiswal *et al.*, 2010) which are desirable for bioethanol production (Wu *et al.* 2006). Another interesting feature of amylose reduced starches in polypolid species the amount in amylose reduction depends upon the genomes with waxy mutation. For example in hexaploid wheat GBSS1 produced by the three A, B and D genomes have differential enzymatic activities in the order B>D>A (Miura and Sugawara 1996). Therefore, wheat grain starch with varying amylose concentrations between the normal (25%) and waxy with undetectable amylose concentration combinations has been observed depending upon the number of GBSSI null alleles at different genomes. A wheat line deficient in GBSSI from B and D genomes produced partially waxy starch (12% amylose) (Demeke *et al.*, 1999).

Another interesting feature is that amylopectin architecture has been shown to influence starch enzymatic hydrolysis (Zhang *et al.*, 2008). In a recent study in barley, in vitro enzmyatic hydrolysis of starch is also associated with starch granule type and amylopectin architecture (Asare *et al.*, 2011).

In conclusion, starch hydrolysis for bioethanol production is influenced starch composition and structure. Most of the research has been focused on developing cereal grains with increased starch concentration. However, for increased efficiency starch granule composition and amylopectin structure should also be studied for optimal enzymatic hydrolysis for efficient bioethanol production. Advances in starch biosynthesis and genomics techniques should allow detection of natural starch variants which can improve the efficiency of bioethanol from plant feedstocks.

CONCLUSION

Currently, there exists little information on bio-ethanol yield advancement from wheat and Triticale. In order to achieve this we need to set several objectives which included the development and optimization of analytical protocols for determining grain starch content and structure, fermentable sugar levels, and ethanol yield. The establishment of correlations between grain ethanol yield and agronomic characteristics would be logical, to use these in order to quantify genetic variability of available germplasm, both local and international. A prebreeding program for genetic enhancement for desirable plant traits for biofuel production based on

morpho-physiological and marker assisted recurrent selection (MARS) should be established Exploring use of molecular(DNA) for use in marker assisted selection (MAS) deserves a priori consideration to complement conventional plant breeding methods .. Some research activities at molecular levels have already been initiated in some developed countries and promising results are awaited. However, a global network is needed in this direction so as to make the venture environmentally sustainable and economically profitable. Based on initial success, we can conclude that both possibilities, and technical feasibilities exist for genetic and management options to produce agro-technology for cereal production for biofuels.

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Sorghum : A Potential Source of Biofuel in Arid and Semiarid Regions

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ABSTRACT

Sorghum is an annual C_4 crop in the grass family, having high photosynthetic efficiency with considerable variability in growth characteristics. It contains both cultivated and wild races and possesses a significant amount of genetic diversity for traits of agronomic importance and has the potential to be an excellent diversified bio-fuel crop which is able to fill the needs of multiple bio-energy conversion process. Critical factors in utilizing biomass as an alternative energy source will be the ability of the plant to achieve high biomass yields, grow in diverse climates under various environmental conditions, and be economically converted into a bio-based product. Sorghum cultivars possess readily available fermentable sugars; therefore enzymatic conversion of starch to sugar is not necessary which gives sorghum an economical advantage over starch based crops. The juice from sorghum can be converted to alcohol using currently available, conventional fermentation technology. The fuel ethanol from sorghum is the best choice to be implementing under hot and dry climatic conditions regarding both economic and environmental considerations. Because, sweet sorghum has higher tolerance to drought, water logging and salt, alkali and aluminium soils; It may be harvested 3 - 4 months after planting and planted 1 - 2 times a year (in tropical areas); Its energy output / fossil energy input is higher than sugarcane, sugar beet, corn, wheat etc. especially in tropical areas like India. Sorghum juice is assumed to be converted to ethanol at 85% theoretical, or 54.4 L ethanol per 100 kg fresh stalk yield. Ethanol production directly from juice is about 3000 l/ha. Sorghum has high amount of sucrose and invert sugar which are easily converted to ethanol, therefore, it seems that Sorghum is the most suitable crop for biofuel production in arid regions of the world.

Key words: Sorghum, ethanol, biofuel

INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) is one of the main coarse cereal crops of India. India is Second largest producer of sorghum in the world with production of about 10–11 million t from a total area of 12 million ha. This crop is ideally suited for semi-arid agro climatic regions of the country and, it gives reasonably good yield with minimal requirement of irrigation and fertilizers. On the other hand, cereals such as wheat (*Triticum aestivum* L.) and rice (*Oryza sativa* L.) cannot withstand the harsh semi-arid climates. These crops also require fair amount of water and other inputs such as fertilizers and pesticides. Therefore, sorghum is one of the few cereals, which can be grown in semi-arid regions. However, demand for sorghum for human consumption is decreasing with enhanced socioeconomic status of population in general and easy availability of preferred

cereals in sufficient quantities at affordable prices. Since sorghum must be cultivated in the semi-arid regions for fodder to feed the large cattle population of the country, industrial applications for this grain are needed so that sorghum cultivation becomes economically viable for marginal farmers, in India The development of bio-based products from renewable resource as an alternative to petroleum has been one of the approaches to address these concerns. From a government perspective, the goal for bio-based industry is to provide at least 25% of the 1994 levels of organic carbon-based industrial feedstock chemicals and 10% of liquid fuels by the year 2020, and to provide 50% of liquid fuels by the year 2050 (National Research Council, 2000). These targets have stimulated research to increase the use of biomass and to develop bio-based products. Sugar sources, such as starch and cellulose are potential candidates for production of ethanol, biodiesel, and organic chemicals.

Grain sorghum (*Sorghum bicolor* (L.) *Moench)* is an important commodity crop for the semiarid regions of the world. In the United States, sorghum is one of the most important crops in the Midwest regions. Sorghum is a starch-rich grain with similar starch content to maize. However, sorghum has been underutilized for bio-based products and bio-energy. The major barriers to promoting sorghum utilization are the poor wet-milling properties and potentially lower digestibility of sorghum starch, which is about 90–95% that of corn (Leeson and Summers, 1997). Several factors have been suggested to be responsible for the low starch digestibility. First, some sorghum starch granules are imbedded in a protein matrix (Hoseney et al., 1974; Taylor et al., 1984) that could restrict starch gelatinization (Chandrashekar and Kirleis, 1988) and enzyme accessibility (Waniska et al., 1990). Second, a high content of dietary fiber in sorghum might decrease starch digestibility (Bach Knudsen et al., 1988) as there has been a highly negative correlation reported between starch digestibility and resistance starch formation. Third, the presence of phenolic compounds such as tannin in the sorghum might inhibit enzyme activity (Leeson and Summers, 1997). High levels of tannin, a polyphenol, can result as much as a 10% reduction in starch and protein digestibility (Ratnavathi and Sashidhar, 2000)

MATERIAL AND METHODS

Ethanol production from grain involves milling of grain, hydrolysis of starch to release fermentable sugars, followed by inoculation with yeast. Chemically starch is a polymer of glucose (Peterson 1995). Yeast cannot use starch directly for ethanol production. Therefore, grain starch has to be completely broken down to glucose by a combination of two enzymes, viz., amylase and amyloglucosidase, before it is fermented by yeast to produce ethanol. The biochemical reactions and process involved in starch hydrolysis and fermentation. Alcohol so produced is distilled from fermented broth. The remaining stillage is processed to produce DDGS (Distiller's dried grain and soluble's), (fig. 2).

Juice extraction:-

Juice is extracted by series of mills (Almodares et al., 2008e). The juice coming out of milling section is first screened, sterilized by heating up to 100°C and then clarified (Quintero et al., 2008). The muddy juice is then sent to rotary vacuum filter and the filtrate juice is sent to evaporation section for concentration (syrup to ethanol). The juice can also be directly sent to fermentation section (Figure 2) (juice to ethanol). Depending on the scheme selected the juice can be concentrated using evaporators to attend various brix. In case of juice to ethanol (no syrup), it

is advisable to partially increase the concentration of juice to 16 - 18 brix. The syrup which needs storage for using during off season needs to concentrate to minimum 65 brix (normally 85 brix).

Fermentation:-

Fermentation is a multidisciplinary process based on the chemistry, biochemistry and microbiology of the raw materials. Juice or syrup is converted into ethanol by the yeast *Saccharomyces cerevisiae*. Sugar is converted to ethanol, carbon dioxide and yeast biomass as well as much smaller quantities of minor end products such as glycerol, fuel oils, aldehydes and ketones (Jacques et al., 1999).

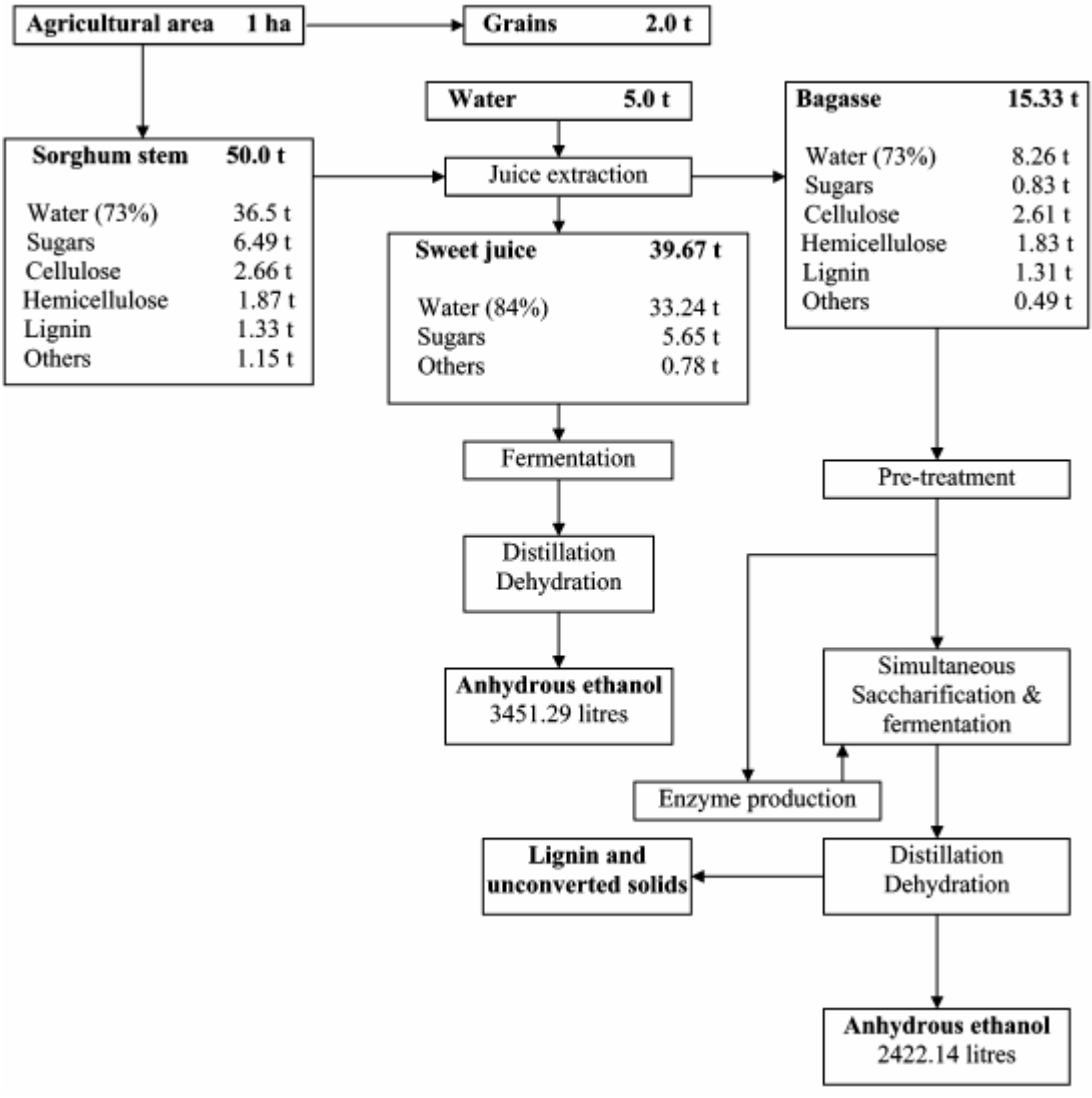

Figure-1. Mass balance of sweet sorghum juice extraction and ethanol production (Prasad et al., 2007).

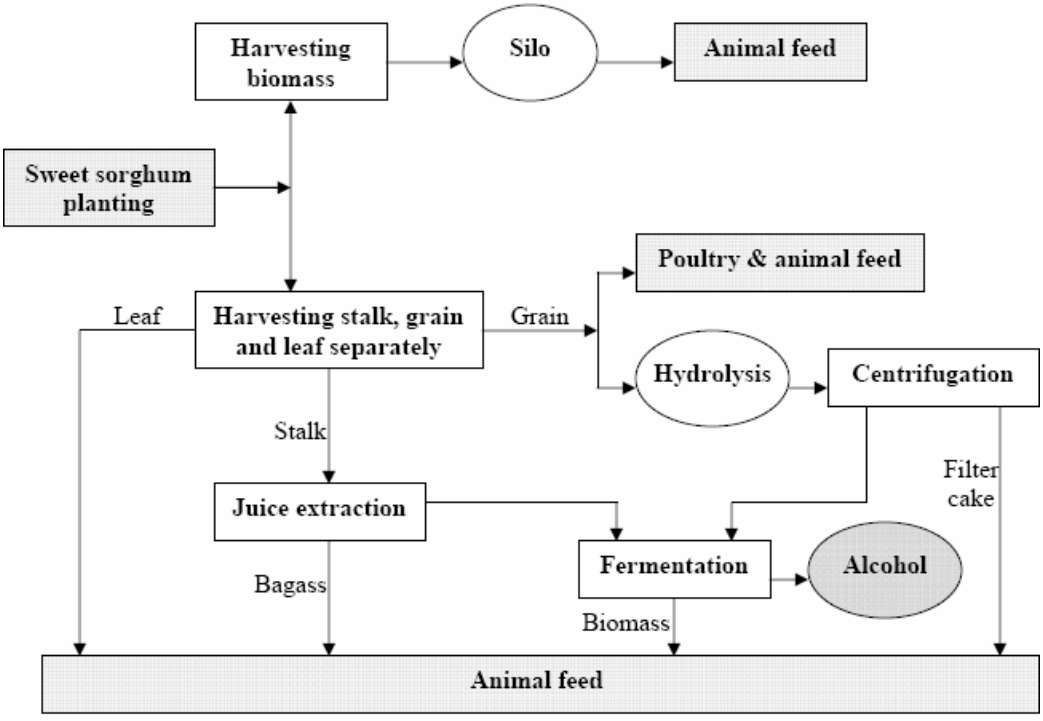

Figure 2. Proposed layout for ethanol production and by-product from sweet sorghum. (A.Almodares and M.R.Hadi,2009)

Distillation and dehydration:-

In the distillation section, alcohol from fermented mash is concentrated up to 95% v/v. This is further concentrated to produce ethanol with 99.6% v/v (minimum) concentration. The treatment of vinasse generated in the distillation section can be done using following option: Concentration of part of vinasse to 20 to 25% solids followed by composting using press mud available and concentration of rest of the vinasse to 55% solids and use as liquid fertilizer. Since Iran has dry and hot climatic conditions (Almodares, 2000) therefore sweet sorghum has emerged as a leading candidate for liquid sugar (Almodares and Sepahi, 1997) and biofuel production (Nahvi et al., 1994a) with minimum inputs (Almodares and Sepahi, 1997).

Processing ethanol production from sweet sorghum grain:-

The ethanol production processing from sweet sorghum grain (Figure 2) is similar to corn and it can be described according to Quintero et al. (2008). After washing, crushing and milling the sweet sorghum grains, the starchy material is gelatinized, liquefied and saccharified using amylase and glucoamylase enzymes to produce glucose. Fermentation, distillation and dehydration processing of grain sorghum are similar to the sweet sorghum stalk. However, the byproducts of grain is not similar to the stalk because DDGS (dried distillers grains with solubles) as a coproduct of the ethanol production process from grain is a high nutrient feed valued which is used by the livestock industry.

CONCLUSION

Bio-diesel is the name of a clean burning alternative fuel, produced from domestic, renewable resources such as soybeans, sunflowers, canola, waste cooking oil, or animal fats. Bio-diesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a bio-diesel blend. It can be used in compression-ignition (diesel) engines or oil-fired boilers or furnaces with little or no modifications. Bio-diesel is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics.

One method to reduce air pollution is to oxygenated fuel for vehicles. MTBE (Methyl tert-butyl ether) is a member of a group of chemicals commonly known as fuel oxygenates (Fischer et al., 2005). It is a fuel additive to raise the octane number. But it is very soluble in water and it is a possible human carcinogenic (Belpoggi et al., 1995). Thereby, it should be substituted for other oxygenated substances to increase the octane number of the fuel. Presently, ethanol as an oxygenous biomass fuel is considered as a predominant alternative to MTBE for its biodegradable, low toxicity, persistence and regenerative characteristic (Cassada et al., 2000). Like most biofuel crops, sweet sorghum has the potential to reduce carbon emissions (fig. 1). In addition, among the plants, sweet sorghum has the following characteristics (Almodares et al., 2008e):

i) It is an efficient converter of solar energy, as it requires low inputs and yet, a high carbohydrate producer.
ii) As a drought-tolerant crop with multiple uses.
iii) It has a concentration of sugar which normally varies between 12 - 21%, directly fermentable (that is, no starch to convert).
iv) It can be cultivated in temperate, subtropical and tropical climates.
v) All components of the plant have economic value - the grain from sweet sorghum can be used as food or feed, the leaves for forage, the stalk (along with the grain) for fuel, the fiber (cellulose) either as mulch or animal feed and with second generation technologies even for fuel.
vi) Its bagasse, after sugar extraction, has a higher biological value than the bagasse from sugarcane, when used as feed for animals.
vii) Its growing period is shorter (3 - 5 months) than that of sugarcane (10 - 12 months), and the quantity of water required is 1/3 of sugarcane.
viii) It has some tolerance to salinity.
ix) It can produce large quantities of both readily fermentable carbohydrate and fiber per unit land area. Therefore, based on the above characteristics, it seems that sweet sorghum is the most suitable plant for biofuel production than other crops under hot and dry climatic conditions.

The fuel ethanol from sweet sorghum is the best choice to be implementing under hot and dry climatic conditions regarding both economic and environmental considerations. Because, sweet sorghum has higher tolerance to drought (Tesso et al., 2005), water logging and salt (Almodares et al., 2008, 2008a), alkali and aluminum soils; It may be harvested 3 - 4 months after planting and planted 1 - 2 times a year (in tropical areas); Its energy output / fossil energy input is higher than sugarcane, sugar beet, corn, wheat and etc... specially in temperate areas; It is more water use efficient (1/3 of water used by sugarcane at equal sugar production); Its production can

be completely mechanized and Its bagasse has higher nutritional value than the bagasse from sugarcane, when used for animal feeding. Use of sorghum for ethanol fermentation will use up to 10–15% of the mold-damaged grain which will help farmers realize a good price for their produce. Ethanol producing companies, research institutions, and the Government can coordinate with farmers to strategically develop value-added utilization of sorghum.

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Brassica - A Potential Source of Renewable Energy

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ABSTRACT

Brassica crops are important sources of animal feed, vegetable oil for human consumption and are increasingly used globally as renewable energy. The role of bio-energy is significantly emphasized due to the continuous rise in oil price and environmental problems. Owing to concerns about energy security and because of increased environmental awareness, the biofuel industry is expanding worldwide. Three processes are possible to obtain biodiesel: cracking, tranesterfication or esterification, having glycerin as a derivate. *Brassica* oil is most suitable for transesterification process for bio-diesel production due to its low price compared to other vegetable oils. Due to the high content of oleic acid and low levels of both saturated and polyunsaturated acids, the oil is the ideal raw material for combustion, due to its characteristics (oxidative stability and cold temperature behavior). Bio-diesel from *Brassica* oils present comparable characteristics to diesel oil concerning viscosity, setting point, carbon residue and cetane number. The calorific value varies according to the species but they are close to the heating value of the diesel. These characteristics made brassica oil as the best renewable energy source to substitute partially or totally for diesel oil. Glycerol produced as by-product from biodiesel production could be upgraded into an important raw material for the production of various chemicals through microbial bio-conversions or enzymatic bio-transformations. The use of bio-fuels can contribute in a significant way to reduce the pollution from an important productive sector such as transport.

Biomass as one of the renewable resources of energy has a potential in utilization, especially in obtaining various forms of energy (heat, electrical energy, gas). Usage of coal in Brick Kiln has been replaced with *Brassica* straw (lignocellulosic biomass) in India, which is more economical. Furthermore, there is great scope for replacing coal for the production of electricity in thermal power plants. It can efficiently replace fossil fuel energy resulting in reduction of greenhouse gas emissions. Moreover, in Europe *Brassica* plant biomass has recently become major interest as substrate for biogas production. There is need to improve production and processing traits of *Brassica* grown for bio-fuel production.

Key words: Brassica, biodiesel, renewable energy,biomass

INTRODUCTION

Brassica is the most important oilseed crop of semi-arid and arid regions of India spreading over Western Rajasthan, North Gujarat, South-West Haryana and Punjab, some parts of Andhra Pradesh, West Bengal and Karnataka. It is an important source of animal feed, vegetable oil for

human consumption and increasingly used globally as renewable energy (Liu et al., 2010). With its ability to adapt to diverse agro-ecological conditions, *Brassica* may have unique position in the world agriculture as oilseed crop. Brassica can be grown successfully with one or two irrigations only. During drought conditions, farmers of these areas generally grow brassica with conserved moisture. Owing to concerns about energy security and because of increased environmental awareness, the biofuel industry is expanding worldwide (Stephenson et al, 2008). The European Union is giving significant attention to the diffusion of renewable energy sources because of the continuous increase of energy consumption, the necessity to differentiate energy sources in order to reduce the dependence on fossil sources and the conditions given from Kyoto agreement about environmental protection (Bezzi and Venturi, 2007). The production of oil crops for biodiesel chain such as sunflower, rapeseed and soyabean, is increasing because of the EU policy on giving incentives to energy crops. Nevertheless, there are still large possibilities of improvement for the whole chain, in fact, to improve competitiveness, local productions should be encouraged and imported raw materials should be less considered. It is necessary to improve the efficiency of the production cycle to reduce the price of raw materials and obtain a better balance of biodiesel chain. Finally, the better use of byproducts from oil extraction and transesterification can contribute to optimize the production cycle making the chain even more competitive (Bezzi and Venturi, 2007).

The petroleum dependence and the pollution generated by its use are the big disadvantages of this fuel, which demands to look for another source of energy. Biodiesel is the fuel obtained from vegetables oils or animal fat, which can substitute petroleum diesel, total or partially. Three processes are possible to obtain biodiesel: cracking, tranesterfication or esterification, having glycerin as a derivate (Silva and Freitas, 2008).

According to some research that have considered various factors such as breed, productivity, production costs and levels of technology, the most feasible bio-ingredients are rape and barley. By means of the benefit-cost analysis, rape has positive values in the net profits when considered with indirect benefits. Also, it is estimated that rape is feasible when produced in place of barley for double-cropping (Lee and Han, 2008). There is need to improve production and processing traits of brassica for biofuel production. Therefore, increasing oil content of oilseed crops is of importance economically in both food and oil industries.

BIODIESEL PRODUCTION FROM *BRASSICA* OIL

Biodiesel fuel as renewable energy is an alternative that can reduce energy dependence on petroleum as well as avoid air pollution. The several advantages of using biodiesel fuel are that it may be an alternative renewable energy or a biodegradable nontoxic fuel; and that there is a reduction in air pollution from particulates, CO_2, SO_2 emissions, and recycling of CO_2 in short periods. Several processes for the production of biodiesel fuel have been developed. Fatty acid methyl esters (FAMEs) show large potential applications as diesel substitutes, also known as biodiesel fuel. Brassica oil is most suitable for transesterification process for bio-diesel production due to its low price compared to other vegetable oils (Dulf, 2008). Due to the high content of oleic acid and low levels of both saturated and polyunsaturated acids, the oil is the ideal raw material for combustion, due to its characteristics (oxidative stability and cold temperature behavior, Dulf, 2008). Transesterification, called alcoholysis, is the displacement of alcohol from an ester by another alcohol in a process similar to hydrolysis. Transesterification process, which is the

chemical reaction of the triglycerides with alcohols (methanol or ethanol) using a catalyst (NaOH) (Silva and Freitas, 2008). Transesterification processes under alkali catalysis with short-chain alcohols give high yields of methyl esters in short reaction times. Jeong et al, (2004) investigated transesterification of rapeseed oil to produce the FAMEs. The conversion ratio of rapeseed oil was enhanced by the alcohol:oil mixing ratio and the reaction temperature.

The immiscibility of canola oil in methanol provides a mass-transfer challenge in the early stages of the transesterification of canola oil in the production of fatty acid methyl esters (FAME or biodiesel). To overcome or rather, exploit this situation , a two-phase membrane reactor was developed to produce FAME from canola oil and methanol. The transesterification of canola oil was performed *via* both acid- or base-catalysis. Runs were performed in the membrane reactor in semi-batch mode at 60, 65 and 70 degrees C and at different catalyst concentrations and feed flow rates. Increases in temperature, catalyst concentration and feedstock (methanol/oil) flow rate significantly increased the conversion of oil to biodiesel. The novel reactor enabled the separation of reaction products (FAME/glycerol in methanol) from the original canola oil feed. The two-phase membrane reactor was particularly useful in removing unreacted canola oil from the FAME product yielding high purity biodiesel and shifting the reaction equilibrium to the product side (Dube et al., 2007). Vargas (2007) reported that vegetable oils from groundnut, sunflower, soybean, Brassica, palm oil, coconut and avocado are having comparable characteristics to diesel oil concerning viscosity, setting point, carbon residue and cetane number. These characteristics made vegetable oil as the best renewable energy source to substitute partially or totally for diesel oil.

Study of the vegetable oils used as fuel for heating shows that viscosity of vegetable oil limits the use of blends up to 40% of them, and the oxygen present in their structures contributes to an efficiency gain (San et al., 2008). Glycerol produced as by-product from biodiesel production could be upgraded into an important raw material for the production of various chemicals through microbial bioconversions or enzymatic biotransformations (Koutinas et al., 2007).

After the extraction of rape seed oil from seeds, the remaining substance makes up the rape seed meal. From the viewpoint of vegetable oil technology, it is as valuable as the oil itself and is evaluated as animal feeds (Appelqvist and Ohlson, 1972; Kramer et al., 1983; Raps-Forderungs-Fonds, 1987; Patterson, 1989). There is no specific evaluation field for the straw and stalk obtained from rapeseed plant cultivation, and these are used up along with other kinds of hay and straw in similar ways.

BIOENERGY FROM BIOMASS

Biomass has been defined as the amount of living organisms, stated in terms of the weight or volume of organisms per unit area or volume in a particular area, of the environment (Karaosmanoglu et al., 1999). Early scenarios envisaged plant biomass as a supplement to coal on the solid fuel market for electricity and heat production, as currently practiced in Europe (Heaton et al., 2008). Biomass as one of the renewable resources of energy has a potential in utilization, especially in obtaining various forms of energy (heat, electrical energy, gas) (Spevak and Havlicek, 2008). All forms of biomass represent an indirect form of solar energy and is a renewable energy source. Some potential biomass energy crops can be renewed as frequently as two or three times

per year, depending upon location, while other materials such as trees have a renewable cycle of several years.

Among biomass sources, the straw stalk part oil seed plant has an important position. Karaosmanoglu et al. (1999) reported that oil seed straw stalk contains 75.43% holo-cellulose, 50.83% alpha-cellulose, 19.34% lignin, and small amounts of extractive matters. It consists of 5.87% ash, 75.55% volatile matter, and18.58% fixed carbon. It is rich in carbon and contains considerable amount of oxygen and trace amounts of sulphur and nitrogen. The lower heating value of the oil seed stalk is 16.37 MJ/kg (Karaosmanoglu et al., 1999).

Bioenergy consumption is greatest in countries with heavy subsidies or tax incentives, such as China, Brazil, and Sweden. Conversion of forest residues and agricultural residues to charcoal, district heat and home heating are the most common forms of bioenergy. Biomass electric generation feed stocks are predominantly forest residues (including black liquor), bagasse and other agricultural residues. Biofuel feed stocks include sugar from sugarcane (in Brazil), starch from maize grain (in the US), and oil seeds (soy or rapeseed) for biodiesel (in the US, EU, and Brazil). Of the six large land areas of the world reviewed (China, EU, US, Brazil, Canada, Australia), total biomass energy consumptions amounts to 17.1 EJ (Wright, 2006).

The use of plant biomass as substrate for biogas production has recently become of major interest in Europe. Winter *Brassica rapa* produces high early biomass and could be grown as a pre-crop harvested early in the year followed by a second crop such as maize (Ofori and Becker, 2008). To meet the increasing need for bioenergy several raw materials have to be considered for the production of bioethanol and biogas. Petersson et al. (2007) studied three lingo-cellulosic raw materials i.e. winter rye straw (*Secale cereale* L), oilseed rape straw and faba bean straw (*Vicia faba*). Employment of the whole plant for energy purposes is an important alternative.

POLLUTION CONTROL

The role of bio-energy is significantly emphasized due to the continuous rise in oil price and environmental problems. The ability of biofuels to contribute efficiently to the replacement of fossil energy and to the reduction of greenhouse gas emissions has been a matter of debate. Hence, there is a need to assess accurately the energy balance of biofuels and their ability to reduce greenhouse gas emissions, in order to evaluate and to improve the benefit for society. In rapeseed, the energy ratio (energy produced per unit of non-renewable energy input) is well above 2 whatever the method of calculation (Flenet et al., 2007). Biogenic emissions of carbonaceous greenhouse gases and N_2O turn out to be important determinants of life cycle emissions of greenhouse gases linked to the life cycle of biodiesel from European rapeseed and Brazilian soybeans.

The use of biofuels can contribute in a significant way to reduce the pollution from an important productive sector such as transport. Biodiesel fuels produced from renewable sources have characteristics such as low viscosity, volumetric heating value, cetane number and flask point similar to diesel (Lang et al., 2001). The biodiesel is biodegradable nontoxic fuel and has the advantages of reduction in air pollution from particulates, CO_2, SO_x emissions (Graboski and McCormick, 1998; Shahid and Jamal, 2008; Guarieiroa et al., 2009). Moreover, the biodiesels are considerably less volatile than the conventional diesel fuels (Lang et al., 2001). However, it has a higher cost production than petroleum diesel and the energy balance is less favourable, although it

can vary with the system production used (Silva and Freitas, 2008). Glycerol produced as by-product from biodiesel production could be upgraded into an important raw material for the production of various chemicals through microbial bioconversions or enzymatic biotransformations (Koutinas et al, 2007).

CONCLUSION

The goal of this revision was to discuss the advantages and disadvantages that biodiesel production can bring for agriculture and environmental and the competition that could occur for natural resources between food and fuel production (Silva and Freitas, 2008).Biodiesel is a good alternative to substitute partial or totally petroleum diesel, but the environmental and agricultural advantages depend on studies in every link of its production chain (Silva and Freitas, 2008).Karaosmanoglu et al., 1999)Furthermore, the performance of the crop could be improved, thus increasing the energy and environmental benefits. Further studies are required to define the oil quality need and the real cost of vegetable oil produced for carburant use.

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Castor Bean (*Ricinus Cummunis*): A Potential Plant Species for Biodiesel Production In Fragile And Marginal Environments

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ABSTRACT

The world is confronted with the twin crises of fossil fuel depletion and environmental degradation. The indiscriminate extraction and consumption of fossil fuels have led to a reduction in petroleum reserves. Petroleum based fuels are obtained from limited reserves. These finite reserves are highly concentrated in certain region of the world. Therefore, those countries not having these resources are facing a foreign exchange crisis, mainly due to the import of crude petroleum oil. Hence it is necessary to look for alternative fuels, which can be produced from materials available within the country. Castor Bean does not compete with food crops, as Castor Bean can be grown on marginal lands, which are not competitive with food production lands. Castor Bean is not competing with food grade oils. It's toxicity is sensed by animals and therefore not foraged on. It is high yielding, yielding as much as 350-650 kg of oil per hectare when no maintenance is applied to the crop i.e. fertilizers etc, to a high end yield where annual rainfalls happen at the right times, (1000 liter per hectare) (Anonymous, 2010). It has a very high oil content of approximately 50%. The seeds are collected by hand, by picking the ripe pods from the plant. It requires only moderate rainfall (approx. 600mm only) and can withstand long periods of drought, but will thrive under higher rainfall. It is an uncomplicated crop that requires little attention during its growing periods. Due to its low demand on soil fertility, it is ideal to replant marginal lands to prevent desertification and erosion. An unintended but important advantage to a castor bean project is that the plants absorb carbon dioxide, thereby reducing greenhouse gas accumulations in the atmosphere. The estimated carbon dioxide absorption level of castor bean plants is 34.6 tonnes per hectare, with two growing cycles per year. Production of castor oil worldwide is 0.5 million tonnes per annum. Consumption of petro diesel per day is approximately 10 million tonnes. If the entire petro -diesel is to be replaced by castor biodiesel it needs to produce 7000 times the castor oil that is being produced today. It has a lot of industrial usages and therefore market is already in existences. The biodiesel prepared from castor oil has certain properties that are attractive particularly for cold climate. It may be mentioned that it has flash point of 190.70C which is much higher than petro diesel and other vegetable oil biodiesel. The oil is stable at low temperature and makes it an ideal combustible for region of extreme seasonal weather.

Key words: Castor bean, castor oil, biodiesel,

INTRODUCTION

India has enjoyed a period of intense economic growth in last several years. Securing future energy supplies in a shrinking energy market is vital if this is to continue. After a decade in which oil reserves have shown a pronounced drop, it has become necessary to find new sources. However, the chances of finding oil wells of considerable size are becoming more and more limited. The benefits of growth however, have failed to filter down to the many millions of its population still living in rural poverty. Despite the reforms which went some way to open up the economy India still considers it as a welfare state with development planning taking a key role. In its approach to biodiesel production we can see the state's attempt to address both the issue of energy security in relation to liquid fuels, and its obligations to provide for the rural poor (Encyclopedia Britannica. 2010). This paper examines potential of Castor Bean (*Ricinus cummunis*) as a plant species for biodiesel production in fragile and marginal environments.

CASTOR (*RICINUS COMMUNIS*) : OIL PLANT

Ricinus communis is a species that belongs to the Euphorbiaceae family and it is commonly known as castor oil plant, and Palma Christi. This plant originates in Africa but it is found in both wild and cultivated states in all the tropical and subtropical countries of the world. In wild conditions this plant is well-adapted to arid conditions and is able to stand long periods of drought (Duke, 1983).

Ricinus communis plants can present precocious, median and delayed cylces . The precocious cycle is that in which flowering occurs about 45 days after sowing. The median cycle presents flowering at an intermediate time between the precocious and delayed cycle, which has a flowering time of 90 to 120 days after sowing.

Castor Oil

Castor oil is extracted from the seeds of castor seed. Seeds contain approximately 46% oil. This oil is highly viscous, its coloration ranges from a pale yellow to colorless, it has a soft and faint odour and a highly unpleasant taste. Castor oil dissolves easily in alcohol, ether, glacial acetic acid, chloroform, carbon sulfide, and benzene. It is made up of triglycerides: 91-95% ricinoleic acid, 4-5% linoleic acid, and 1-2% palmitic and stearic acids. Besides being used as a laxative, castor oil is widely used in the industrial field because of its many properties (Dove BIOTech Ltd., 2005). In the textile industry, castor oil is used for moisturizing and removal of grease in fabrics, and for the manufacturing of waterproof fabrics. In the steel industry, it is used in cutting oils and lubricants for steel lamination at high temperatures and it is also used in other liquids that are necessary for steel work. The automotive industry uses castor oil for the production of high performance motor oil and braking fluids. Moreover, it is also employed as a softener in the tanning industry and in the production of fluids for hydraulic devices, artificial leather, varnish, paint, linoleum, insulators, powder, fatty acids, enzymes, as a moisturizer for stationary and insecticides; additionally it can be used as a raw material for the fabrication of plastics.

What is Biodiesel?

Biodiesel is the name of a clean burning alternative fuel, produced from domestic, renewable resources such as soybeans, sunflowers, canola, waste cooking oil, or animal fats. Biodiesel

contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend. It can be used in compression-ignition (diesel) engines or oil-fired boilers or furnaces with little or no modifications. Biodiesel is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics.

Objectives of biofuel production

Feedstocks are produced on small farms and processed in on-site or nearby small-scale facilities to generate electricity, biogas for cooking or liquid biofuels for running machinery or vehicles. Of the liquid fuels, biodiesel and vegetable oil are conducive to small-scale production, whereas ethanol processing is generally characterized by significant economies of scale. Objectives for this system include improving local fuel availability (fuel security) and generating income through additional crops.

Conservation implications -

In this system, feedstocks are grown on small plots, in interstitial spaces in the landscape, or as part of integrated land use systems such as agroforestry or woodlots managed with coppicing. Because biomass crops are grown alongside other agricultural and non-agricultural land uses, the landscape is highly heterogeneous. If incorporated into a well designed landscape mosaic, biofuel production areas can provide benefits such as windbreaks, restoration of degraded production areas, habitat for native species and a range of ecosystem services (Tongoona, 1992).

Livelihood implications -

For the two billion people worldwide who rely on traditional biomass fuels, this system offers a clean and sustainable energy source, which can contribute greatly to livelihood improvement. Traditional biomass fuels cause significant indoor air pollution that is blamed for 1.6 million deaths per year – more deaths among women and children. However, when small farmers grow feedstocks for large processing facilities, economic pressures may cause them to intensify, reduce on-farm diversity and put uncropped areas into production.

Why Castor Bean should be use-

Castor bean (*Ricinus communis*) has been widely accepted as an agricultural solution for all subtropical and tropical locations that addresses the need for commercial crops with low input costs and at the same time provides traditional farming with a viable income from current non productive lands (Koutroubas, 2000):

- Castor bean does not compete with food crops, as it can be grown on marginal lands, which are not competitive with food production lands.
- Castor bean is not competing with food grade oils.
- It's toxicity is sensed by animals and therefore not foraged on.
- It is high yielding, yielding as much as 350-650 kg of oil per hectare when no maintenance is applied to the crop i.e. fertilizers etc, to a high end yield where annual rainfalls happen at the right times, (1000 liter per hectare).
- It has very high oil content, approximately 50%.
- The seeds are collected by hand, by picking the ripe pods from the plant.

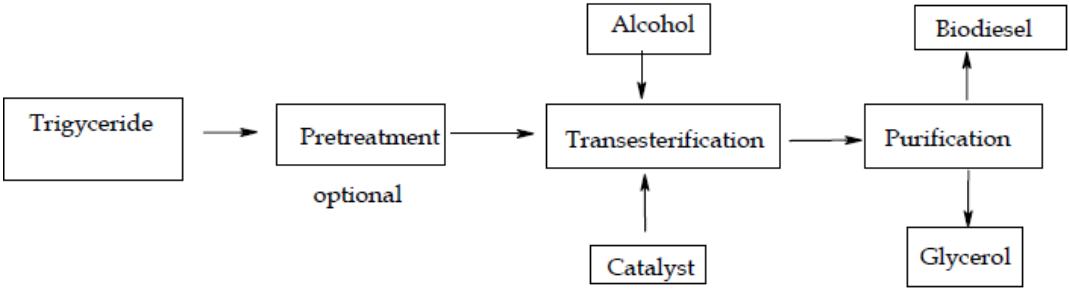
- It requires only moderate rainfall (approx. 600mm only) and can withstand long periods of drought, but will thrive under higher rainfall.
- It is an uncomplicated crop that requires little attention during its growing periods.
- Due to its low demand on soil fertility, it is ideal to replant marginal lands to prevent desertification and erosion.

Growing a crop for renewable energy provides the answer for long term prosperity. It is generally accepted that no matter how much oil seed is produced, there will not be an oversupply for many decades to come.

PRODUCTION AND PURIFICATION METHODS FOR BIOFUEL

Oil Production from Castor bean seeds : Oil is extracted from castor bean seeds using Soxhlet extraction apparatus (1000 ml) and hexane is used as solvent. The dried castor bean seeds (4 x 36 g) are placed into a cellulose paper cone and extracted with 600 ml hexane for 5 h. The solvent is removed through a rotary vacuum distillation at 40 °C. The residue is filtered. The castor bean oil is stored at 20 °C.

Reaction Conditions and Equipment : A glass pilot reactor with a 1000 ml volume is used for a transesterification reaction. It is equipped with mechanical stirrer, cascade heater system, contact thermometer and condenser with a guard tube to prevent moisture entering into the system. 400 g of neutral *Ricinus Communis* oil (crude grade) is added to the reactor and heated up to 60 °C with stirring. After sodium methoxide addition (80 ml methanol and 4 g NaOH), stirring condition (600 rpm) and the reaction are continued for two hours at constant temperature (Goswami, et al, 2007)



Purification of the Produced Biodiesel : All the products of the transesterification reaction in this study are allowed to settle overnight so as to enhance separation. Two distinct liquid phases are formed during separation in such a manner that the crude ester phase presented at the top and the glycerol phase at the bottom. The glycerol phase is removed and the methyl esters layer is then washed with warm diluted acetic acid at 60 °C repeatedly until the residual became clear. The excess methanol and water in the ester phase are then removed by heating the product to 110 °C.

The primary purpose of the biodiesel washing step is to remove any soaps formed during the transesterification reaction. In addition, the warm diluted water with acetic acid provides neutralization of the remaining catalyst and removes product salts. The use of warm water prevents precipitation of saturated fatty acid esters and retards the formation of emulsions with the use of a gentle washing action. Slightly acidic water eliminates calcium and magnesium

contamination and neutralizes remaining base catalysts. Gentle washing prevents the formation of emulsions and results in a rapid and complete phase separation

Properties of Biodiesel from Castor Oil:

The biodiesel prepared from castor oil has certain properties that are attractive particularly for cold climate. It may be mentioned that it has flash point of 190.7°C which is much higher than petrodiesel and other vegetable oil biodiesel. The oil is stable at low temperature and makes it an ideal combustible for region of extreme seasonal weather. From cost point of view although 100% biodiesel from castor oil (B100) seems to be expensive its 10% (B10) or 20% (B20) blending with petrodiesel show good flow properties and further lowers the cloud and pour point. Further, due to its ability of displaying as a solvent, sedimentation does not occur which could otherwise potentially obstruct pipes and filters. However, the oil is sensitive to contamination by ferrous salts and rusts particles. Its higher cooling capacity is a key factor in the conservation of engine components. Considering the technical features, castor oil biodiesel is advisable taking into accounts its renewable resources. Because of its biodegradability and lower emissions, it presents a favourable impact on the environment. Moreover, it could be used as a crop substitution program turning it into a factor that promotes growth in many regions affected by several economic problems. Awareness is there in recent times for cultivation of castor plants boosting rural economy by government and private agencies by establishment of transesterification plant with million tonnes capacity per day.

CONCLUSION

Although castor is probably indigenous to Eastern Africa but today castor is distributed worldwide. Castor establishes itself easily as a "native" plant and can often be found on wasteland, near rail roads and has recently also been used extensively as decorative plant in parks etc. Castor seed contains between 40% - 60% oil, which is rich in tryglycerides, mainly ricinolein and provides a great natural resource for biodiesel production.

Global castor seed production is around 1 million tons per year. Leading producing areas are India, China, Brazil and the former USSR. There are several active breeding programmes for castor.

Castor Bean in arid or semi arid regions using local varieties, can provide a valuable resource for biodiesel production. Holistic agricultural approach provides the regional farmers and local biodiesel industry with two strategic benefits;

1. For the regional farmers the planting and harvesting of local varieties of castor bean on marginal lands provides the farmers with additional income. Also it provides stabilization of marginal lands that are susceptible to erosion either through water or wind.
2. The local biodiesel industry benefits in that they are guaranteed a continuous supply of raw material for the production of biodiesel which in turn, gives viable economics to the local biodiesel industry overall.

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Exploiting Coriander (*Coriandrum sativum* L.) for Biomass and Biofuel

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ABSTRACT

Biomass resources are potentially the world's largest renewable energy source. Biomass conversion to biochemicals' is an important alternative to replace oil and coal. Potential plant species as sources of liquid hydrocarbons have been identified as a substitute for liquid fuels. There is a need to increase the biomass of these plants and conversion of their hydrocarbons into petroleum fractions. Coriander (Coriandrum sativum L.) seed oil methyl esters (CSME) has been prepared and evaluated as an alternative biodiesel fuel and has been found to have excellent fuel properties as a result of its unique fatty acid composition containing petroselinic (6Z-octadecenoic; 68.5 wt %) acid which is the principle component in biodiesel fuels. This paper aims to highlight the importance of coriander as an alternative annual crop for biofuel production.

Key words : Corriander, biomass, biofuel

INTRODUCTION

Energy is neither created nor destroyed, it's converted from one form to another" stands true in relatively all aspects and has been proved many times by many scientists. Nature has tremendous amount of potential energy stored in one or the other form. As for example the solar energy is converted into biomass by photosynthesis in all green plants, may it be forest trees, shrubs, herbs or agricultural crops. This biomass is further used as fuel from millions of years. This green energy or biomass has been the prime material which got converted in fossil fuels; it took thousands of years to take a shape of available energy source in form of coal, petrol, diesel etc.

Significance of biomass in form of energy is well understood, and with the advancement of technologies and our understanding, many milestones have been achieved in creating and utilizing energy sources. The non-renewable energy source will get vanish with the coming times, and simultaneously the population load on the earth surface will also increase (Sheehan *et. al*, 1998). No doubt, the energy requirement will also get increased; therefore, looking to the challenges ahead on human race, the concept of biofuel came up. In the past decade tremendous work has been done on the quality, production technology, and commercialization of biofuels (Kralova and Sjoblom, 2010) which can be a substitute to present source of energy.

Agriculture is the main source of hydrocarbons, from the agricultural produce the most important components available in form of energy are biomass and oil. Biomass can be biochemically degraded to develop ethanol or 'bioethanol', which can be used to blend petrol

with no engine modification, this can save significant amount of petrol (Demiras, 2008, 2009). Biomass conversion to fuel and chemicals is an important alternative to replace oil and coal. Using biomass instead of fossil energy carriers helps in (1) reducing CO_2 emissions (2) reducing climate change (3) reducing the anticipated resource scarcity of fossil fuels (4) providing rural job opportunities and stimulating new economic opportunities (5) better management of waste material. Vegetable oils are also used to make biodiesel, but due to their high viscosity they can't be used directly, the methyl esters present in vegetable oils are commonly referred as biodiesel (Demiras, 2002). Based on the quality of vegetable oil specific to crops it is taken up for biodiesel production.

The present paper highlights some significant findings made very recently emphasizing the potentiality of coriander as an alternative crop for production of biofuel.

CORIANDER AS A BIOFUEL

Coriander (*Coriandrum sativum*), a native to southern Europe and North Africa to southwestern Asia is an annual herb in the family Apiaceae. Its seeds and leaves are used as spice for curry preparation, chutney flavouring etc. India is the largest producer of coriander in the world, mainly cultivated in States of Rajasthan, Andhra Pradesh, Gujarat and Madhya Pradesh. Rajasthan contributes 40 % of the total production of the country. As a bioenergy source coriander biomass and oil both can be used. Bio-ethanol production from agricultural biomass has taken pace in recent times (Demiras, 2008, 2009). Looking to the importance of biofuels, horticultural crops have been evaluated for the quality of oil they contain as per the requirement of biodiesel production; coriander oil has been found to have high potential for biodiesel production. (Steven *et. al*, 2009 and Moser and Vaughan, 2010),

Biomass: Conversion of agricultural residue to bioethanol by enzymatic treatments is done in many crops (Chen *et. al.,* 2007). India is the largest producer and consumer of coriander in the world. A coriander crop residue in India is estimated to produce 188.3 kT/Yr biomass having 22 MW power potential and 5.2 Mcal/sec. calorific potential. This calorific value can be converted in bio-ethanol. Coriander is cultivated both for leaf as well as for seed; biomass in form of leaf of young plant is consumed, whereas the crop residue of the seed purpose coriander is left as an agricultural waste. The general practice adopted by farmers for management of that residual waste is using it for composting, or it is being burnt in the fields as it is not preferred by animals for feeding. Conversion of this biomass to bio-ethanol can be an opportunity for making biofuel. Biomass is coriander is highly variable as per the variety sown, production technology adopted, nutrient application, and environmental condition.

Coriander Oil: Coriander seeds contain nearly 18 % oil, the content may vary as per climate, production technology and genotype adopted. Of this 18 % percent , 0.3-0.4 percent is the aromatic/volatile oil which is of high commercial value. The fatty oil of coriander contains very high level of unusual petroselenic acid (68.5 wt %), which is a principal component of biodiesel. This petroselenic acid ($C_{18:1}$) is split to produce C_6 (adipic acid) and $C_{12:0}$ (lauric acid) molecules. This can be helpful in displacing C_{12} oils from coconut and palm kernel oils and can also be a source for production of adipic acid from fossil sources. Coriander biodiesel has been found to

have higher unsaturated fatty acid levels, with favourable cold flow properties, excellent lubricity values, and compared to soy biodiesel it had higher oxidative stability which is the predominant factor for biodiesel production (Steven *et al*., 2009). The other properties of coriander oil like its acid value, free and total glycerol content, iodine value, sulphur and phosphorous content are acceptable as per declared biodiesel standards. Hence, coriander oil can be a potential source for biodiesel production in future (Moser and Vaughn, 2010)

Coriander oil is having high export value both for its oleoresins and essential oil. Oleoresins contain nearly 90% of fatty acid, and 5 % of volatile oil. Can it happen that, production technologies be modified as per need and we can extract essential oil, oleoresins and remaining part of the oil be used for making biodiesels.

Production of biodiesel is not a game to be taken up by concentrating on a single commodity; rather it will come up as a cumulative production done from various sources of vegetable oils. In this strategy, coriander oil can also be one crop, as the quality of oil it has, is most favorable for production of biodiesel.

ROLE OF PLANT BREEDING, BIOTECHNOLOGY AND GOVERNMENT AGENCIES

These two component traits *viz.,* biomass and oil of coriander can be considered as potential source of bio-energy. Being highly heritable traits, it offers plant breeders to breed new varieties for commercial importance and simultaneously their utilization for biodiesel production. The studies done on coriander oil have given an idea for developing lines having high petroselenic acid. Ames 23620 (subspecies *indicum*), Ames 24923, PH 74130, Ames 13900 (subspecies *microcarpum*) Ames 26817 (subspecies *sativum*) are the accessions identified for high fatty acid content while Ames 13900, Ames 25169, Ames 26820 (subspecies *microcarpum*), Ames 26819 and Ames 26822 (subspecies *sativum*) have been identified for high petroselenic acid yield (Lopez *et al*., 2007). Studies has also been done on production of petroselenic acid from cell suspension cultures of coriander (Parthasarathy *et.al*., 2008). This shows that biotechnological intervention can also play a vital role in exploiting coriander as bio-fuel crop.

Evaluation of available genetic resources of coriander for total oil and petroselenic acid content under varied environmental condition can help us to identify genotypes suitable for bio-energy production. Conversion of biomass to bio-ethanol also needs to be standardized as per coriander biomass quality. At the same time, the efforts of scientists and extension agencies should be complimented by clear cut policies like mandated renewable fuel standards, minimum support prices for biofuel crops etc. which provide adequate incentives for industry and agriculturists to undertake the necessary investments for deployment of such technologies. Fiscal incentives for biodiesel such as reductions in feedstock and processing costs and tax exemptions will be the key tool for enhancing the use of biodiesel as an alternative fuel for transport in the near future.

CONCLUSION

Exploiting coriander as a bio-fuel crop is a new concept; the available biomass is potential source for bio-ethanol production. The quality of coriander oil due to presence of petroselenic acid makes it an excellent source for biodiesel production. Breeding coriander for biomass and oil

quality as per the requirement of biofuel production can make coriander an alternative crop for generating bio-energy for future.

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Mass Multiplication of Jojoba for Bio-Fuel Production

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ABSTRACT

Jojoba (pronounced as "ho-ho-ba") is a multi-purpose, medicinal and oil yielding species in the family Simmondsiaceae. The most valuable product of jojoba seed is the liquid wax or jojoba oil which is used extensively in the cosmetic and bio-fuel industry. An efficient *in vitro* regeneration protocol for Jojoba (*Simmondsia chinensis*); an important bio-diesel species has been developed. Maximum number of shooting response was obtained from nodal explants on MS medium. The regenerated plantlets have been acclimatized and transferred to soil for normal growth under field conditions with 70-75% success.

Key words: Micropropagation, jojoba, hardening, bio-fuel

INTRODUCTION

Increasing demand and limited sources of fossil fuels attract researchers to discover alternate renewable energy sources including plant species that could be produced on un-cultivated land. More than 90 species of plants in India have been identified to bear seeds, which can be exploited commercially for extraction of oil. According to an estimate our country has potential to produce 30 lakh tones of vegetable oils from non-traditional, minor oil seeds and other sources. With ever increasing prices of petroleum products and uncertainties of supplies, there is a renewed interest worldwide in these plant based oils as alternative sources of energy/fuels. Biodiesel is a green, carbon-neutral fuel that can be produced in farms and has the potential of partially substituting mineral diesel if the national bio-diesel program is implemented properly. India is a country blessed with agro-climatic diversity. *Simmondsia chinensis* commonly known as 'Jojoba' is the sole species in the family 'Simmondsiaceae' and is an admirable source of biodiesel.

Jojoba (*Simmondsia chinensis*) is a crop with considerable potential for semi-arid regions. It is naturally well adapted to saline soils and also to high temperature environments. Jojoba seeds store lipids in the form of liquid wax that makes up 40-60% of their dry weight. This wax has similar properties to sperm whale oil, and it is used as an industrial lubricant because of its superior lubricating ability and uniform viscosity over a wide range of temperature (Low and Hackett, 1981; Wang and Janick, 1986a). This has lead to increased interest in agricultural production of jojoba but it requires further research and development to improve quality and consistency of yield (Lee, 1988).

The advantage of using asexual propagules in commercial jojoba plantations is that they provide uniform and predictable plant growth and yield (Lee, 1988). Furthermore, jojoba is dioecious and cannot be sexed until flowers appear (usually 2-4 years from seed). Clonal propagation of elite individuals of known sexuality is necessary to ensure that commercial plantation will be productive (Chaturvedi and Sharma, 1989). Vegetative propagation can be achieved by rooting semi-hard wood cutting (Low and Hackett, 1981; Lee, 1988), however, this procedure yields only limited number of propagules as it depends on size of plant, time of year etc. Whereas, micropropagation offers opportunities for the production of thousands of elite plants from the selected stock plant (Lee, 1988). Jojoba plants from tissue culture grow more vigorously than both seedling and rooted cutting, and are significantly larger after the first of growth (Birnbaum *et al.,* 1984). Commercial-scale production can be achieved by using micropropagated clones of selected individuals that have proved their superiority in experimental plots (Mills & Benzioni, 1992). However, during micropropagation a large number of somaclonal variations/genetic aberrations occur. Therefore, development of commercial micropropagation systems for rare and industrially important plants with proven true to type nature is a necessity in order to meet industrial needs as well as for conservation of superior germplasm to prevent the plants from becoming endangered or extinct.

Jojoba (*Simmondsia chinensis*), pronounced as "hohoba", is a woody, evergreen, dioecious shrub, averaging 2-5 feet tall and wide sometimes to 10 feet with leathery, grayish green leaves. Plant life span is up to 200 years and it is native to Sonora Desert of south-western United States of America, north-western Mexico and Baja California (Benzioni, 1997). The pale green female flowers of this dioecious species are borne singly at each leaf node. The yellowish-green male flowers are borne in clusters. Plants bloom in winter and female plants ripen their acorn shaped and sized seeds in summer. Seeds are up to 1" long that is green in beginning and turns brown with age. Fruit set is usually in March and seed maturation is in July/August. Fresh seeds give 80-90 per cent germination and older seeds lose viability with age (Harsh *et al.,* 2001). Jojoba "beans" contain more than 40 per cent oil. The jojoba oil is non-toxic, biodegradable, and quite stable. It has promising physical properties, such as high viscosity index, high flash and fire points, high dielectric constant, and high stability and freezing point, and can be used in various industries. It does not get damaged by repeated heating to temperature above 285°C. The viscosity index of jojoba oil is much higher than that of petroleum oil, and it is therefore, being used as a high pressure lubricant in heavy machinery. In addition to this, it is also being used in transformer oil, detergents, in leather and plastic industries, and in pharmaceuticals as well as cosmetic industries all over the globe (Benzioni, 1997).

It has 30-37 per cent protein, along with rich content of carbohydrates and fibers (Mills *et al.,* 1997). Stability of jojoba oil makes it attractive to electronic and computer industries. This oil can also be used as an antifoam agent in antibiotic production , as a treatment of skin disorder, for cooking, hair care and for medical treatments such as poison ivy, sores, wounds, colds, cancer and kidney malfunction. The oil is chemically very similar to human sebum. Jojoba oil is also used as a replacement for sperm whale oil. The ban on importing whale oil to US in 1971 led to the discovery that it is in many regards superior to sperm oil for application in the cosmetics and other industries. Jojoba oil is also edible which is acaloric. Due to its digestibility by human it is frequently used as dietic oil substitute. Shelf-life studies indicated that up to months, there is no significant change in physico-chemical properties of oil (Gupta, 2001). Owing to all these

properties, Jojoba oil is claimed as one of the nature's gift to human race or liquid gold from desert.

Further, jojoba is a dioecious plant and in such plants gender influences economic values, breeding schemes and opportunities for commercial harvest. Several constraints have been faced with jojoba cultivation by its growers: (1) It is a slow growing and has male biased (6:1; Male: Female) population, (2) the waiting time from planting to harvest is very long, and (3) It does not flower or produce seeds until 3-4 years after transplantation. Realizing these inherent problems, it is imperative that a commercial protocol for micropropagation of this important bio resource is developed and true to type material of desired sex is multiplied.

MATERIAL AND METHODS

The nodal explants were obtained from mature plant of *Simmondsia chinensis* growing in Department of Plant Breeding, CCS Haryana Agricultural University. Young and small shoots segments were excised and washed thoroughly in running tap water to remove the superficial dust particles. Nodal explants (1 cm long) excised from the shoots were treated with 2% (v/v) Teepol solution for ten minutes with constant stirring followed by washing in running tap water. The explants were surface sterilized with 0.1% (w/v) aqueous solution of mercuric chloride for 3-5 minutes and rinsed five times with sterile double distilled water. The surface sterilized nodal explants were trimmed at their edges aseptically and inoculated immediately to prevent the drying of the cut edges of the explants.

Nodal segments were cultured on MS (Murashige and Skoogs, 1962) medium (containing analytical grade chemicals and 3% w/v sucrose and 0.8% w/v agar) and supplemented with various concentration of cytokinins, viz. BAP, Kn, Zeatin and/or Auxins, viz. 2,4-D, IAA and NAA alone and in combination. The pH of the medium was adjusted at 5.8 using 1N NaOH or 1N HCl, before autoclaving at 121°C, 1.2 kg cm^{-2} pressure for 15 minutes. The effect of different treatments was quantified on the basis of the percentage of explants showing response and the number of regenerates per node after 5 weeks. Each treatment consisted of 15 culture bottles containing 2-3 explants each. All the cultures were incubated at 25±2°C under white fluorescent light with a photoperiod of 16h light (intensity of 2000 lux) and 8h of darkness.

The 4-week-old axillary shoots proliferating from the nodal segments were harvested and used for further multiplication on culture initiation medium (MS + BAP 2.0 mg/l + NAA 0.1-0.5 mg/l). At the end of five weeks of subculture, total numbers of developing shoots were counted. The growth of shoots was assessed by measuring the longest shoots in the cluster.

In vitro raised shoots (4-5 cm or longer) were excised from the cluster and cultured on MS basal and MS (solid or liquid) medium supplemented with various auxins, viz. IAA, IBA and NAA to induce rooting. Plantlets with well-developed roots were taken out from the culture vessels and the roots were thoroughly washed in running tap water by using fine brush and were transferred to small pots containing sterilized sand. These pots were supplied with half strength MS salt solution and covered with polythene bags to maintain high relative humidity. These were placed in growth chamber at 25±2°C under 16h photoperiod. After two weeks, polythene bags were removed gradually (3-4 h daily) for their acclimatization to natural humidity and sun light. After 6 weeks plantlets were transferred along with sand to the pots filled with garden soil and kept in greenhouse for the normal growth.

RESULT AND DISCUSSION

An efficient *in vitro* regeneration protocol for obtaining plants from nodal explants of *Simmondsia chinensis* (Link) Schneider; an important multipurpose species has been developed. Maximum number of shoots with high frequency of shooting response (98.9 %) was obtained from nodal explants on MS medium fortified with 2.0 mg/l BAP with 0.5 mg/l of NAA (Fig. 1A). Caulogenic effect of BAP was found to be significant compared to Kn. The excised shoots (3-4 cm or longer) were cultured on MS medium with various concentrations of auxins for rooting. Maximum number of healthy rootlets with 78 % rooting response was observed on half strength MS medium supplemented with 2.5 mg/l IBA. The regenerated plantlets have been acclimatized and transferred to soil for normal growth under field conditions with 70-75% success (Fig. 1B). Continuous trials using explants from mature plant throughout the year showed that the period between August to November was the best season for explants source for rapid and mass multiplication of axillary buds.

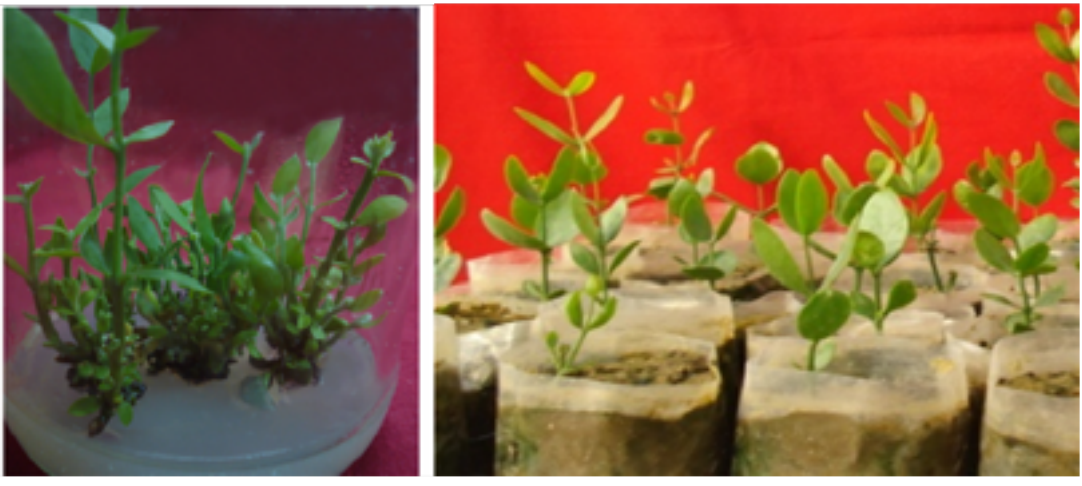

Fig. 1. (A) *In vitro* raised multiple shoots in Jojoba (B) Hardened plants of Jojoba after 3 months of transplantation

During plant tissue culture, a morphogenetic response to a stimulus that results in the production of organs, embryos or whole plant is said to be regeneration. The present study has revealed that the differentiation was found to be dependent on appropriate concentration of auxins and cytokinins in the medium. Under the same environmental conditions explants responded differently to different types of growth regulators and also to various concentration of same growth regulator. The direct regeneration of shoots is because of the proliferation of pre-existing axillary/lateral buds in the node and shoot apex. The proliferation of the buds in to shoots might be due to the supply of adequate amount of cytokinin in the nutrient medium which nullify the effect of apical dominance and enhance the proliferation of lateral buds from the axil (Hu and Wang, 1983).

So, on the basis of present investigation, it may be concluded that cytokinin was responsible for shoot multiplication, and not the auxin, which alone either gave poor number of shoots or no

shoot per explants and there was a definite correlation between concentration of cytokinin (BAP) in medium and number of shoots produced per explant.

In the present study, we used first four nodes from the tip of branch and it was found that 2nd and 3rd nodes were best for rapid and increased multiplication of shoots, which suggested that multiplication potentialities of these buds may be due to high level of auxins or because these buds are physiologically and biochemically more active. Using nodal explants from the mature tree every month throughout the year showed that the period between August-October was the best season for the explant source for rapid and increased multiplication of shoots. Shoot initiation was lower from November to April than in the periods preceding and following. The increase in number of shoots from May onward and good response in early winter may be due to initiation of lateral buds. Similarly, Sharma (1983) has observed that in nature the plant shows flowering in the months of February and March with poor vegetative growth. Due to burst of dormancy in the month of August onwards the plant shows initiation of lateral axillary buds.

It is well known that auxins are required for root induction (Rai *et al*., 2010). In the present study, MS basal medium, MS basal medium with NAA (2.0 mg/l), half strength MS basal medium with IBA (1.0 and 2.5 mg/l) and half strength MS liquid medium with auxins (IBA or IAA) were used with pulse treatment of half strength MS semi-solid medium for differentiation of roots. Half strength MS agar-agar solidified medium with IBA (2.5 mg/l) was found to be the best for rooting in which 2-5 thick roots per shoot were obtained. Which suggest that there is a requirement of high concentrations of auxins for root induction. Any further increase in auxin concentration inhibited root formation which may be due to the imbalance of endogenous auxin present in plantlets.

In the present study, the rooted plantlets were acclimatized by gradual shifting to pre-sterilized soil and sand mixture (3:1) under high humidity and subsequently to natural light and temperature.

Gradual hardening and acclimatization of plants was done because the plants raised under *in vitro* on synthetic carbohydrate supplemented medium under artificial light fail to acclimatize abruptly to rigidity of natural environment. So, a careful transfer of plants in the soil after acclimatization was fully accomplished in the present study.

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Pongamia pinnata (Karanja): An admirable Source of Bio-energy

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ABSTRACT

Depleting oil reserves, increasing oil prices, lack of availability of the mineral oil and the problem of environmental pollutions have prompted research worldwide into alternate fuels for internal combustion engines. While the world encountered with near crisis situation on non-renewable fossil fuels, the prospects for alternative sources of energy from oil-bearing plants have not been explored. The requirement is to search for an alternative to the natural resources of fossil fuel that could be of plant origin and that should be produced on un-cultivated land. Pongamia [*Pongamia pinnata* (L) Pierrre] is a leguminous deciduous tree, commonly known as Indian Beech, Pongam, Honge and Karanj, grows about 15-25 m tall and is well-adapted to semi-arid and humid zones. *Pongamia* is indigenous to the Indian subcontinent and has been successfully introduced to humid tropical regions of the world as well as parts of Australia, New Zealand, China and the United States.

The tree is known for its multipurpose benefits and as a potential source of biodiesel. A thick yellow-orange to brown oil is extracted from seeds. Yields of 25% of volume are possible using a mechanical expeller. Pongamia oil is non-edible due to the presence of toxic flavonoids like karanjin, pongapin and pongaglabrin. The seeds contain 30 to 40% oil, which can be converted into biodiesel (fatty acid methyl esters; FAMEs) by esterification with methanol in the presence of KOH or straight vegetable oil (SVO) is also used as fuel in diesel generator sets. The oil is also used as a lubricant, water-paint binder, pesticide, and in soap making and tanning industries. Research, development and conservation of oil-bearing plant resources can significantly uplift the economic conditions of rural farmers while contributing to the national economy. There is a good scope to improve the supply and quality of planting material of this species for the promotion of oil-bearing plant-genetic resource as an alternative energy to fossil fuel.

Key words : *Pongamia pinnata*, Karanja , bio-energy

INTRODUCTION

The country has been hit hard by the increased cost and uncertainty and so is exploring other energy sources occurring bio-diesel extracted from trees is one such alternative under consideration. Bio-diesel would be cheap to produce as it can be extracted from certain species of tree that are common in many parts of India. Among varieties of non edible oil seeds crops, only 10-12 varieties are most important for the biodesel production (Table 1). In India, Jetropha, Karanja and Mahua trees has great potential for production of bio-fuels like bio-ethanol and biodiesel. The annual estimated potential is about 20 million tones per annum. In India, out of

cultivated area, about 175 million hectares are classified as waste and degraded land, We can cultivate these crops very easily on this land.

Pongam commonly known as Karnja (Leguminoceae, subfamily Papilionoideae) is a medium sized tree that generally attains a height of about 8 meters and a trunk diameter of more than 50 cm. The trunk is generally short with thick branches spreading into a dense hemispherical crown of dark green leaves. The bark is thin gray to grayish-brown, and yellow on the inside. The tap root is thick and long, lateral roots are numerous and well developed. The alternate, compound pinnate leaves consist of 5 or 7 leaflets which are arranged in 2 or 3 pairs, and a single terminal leaflet. Leaflets are 5-10 cm long, 4-6 cm wide, and pointed at the tip. Flowers, borne on racemes, are pink, light purple, or white. Pods are elliptical, 3-6 cm long and 2-3 cm wide, thick walled, and usually contain a single seed. Seeds are 10-20 cm long, oblong, and light brown in color. *Pongamia Pinnata* trees are normally planted along the highways, roads and canals to stop soil erosion. Billions of trees exist all over India. If the seeds fallen along road side are collected, and oil is extracted at village level expellers, tousands of tons of oil will be available for Lighting the Lamps in rural area.

Karanja is widely distributed in tropical Asia and it is nonedible oil of Indian origin. It is found mainly in the Western Ghats in India, northern Australia, Fiji and in some regions of Eastern Asia. .The plant is also said to be highly tolerant to salinity and can be grown in various soil textures viz. stony, sandy and clayey. Karanja can grow in humid as well as subtropical environments with annual rainfall ranging between 500 and 2500 mm. India is a tropical country and offers most suitable climate for the growth of karanja tree (Scott *et al*., 2008; Kumaran *et al*., 2003).

The seeds are crushed in expeller to get the oil. Karanja oil has been reported to contain furanoflavones, furanoflavonols, chromenoflavones, flavones and furanodiketones which make the oil non-edible and hence further encourages its application for biodiesel production (Vivek and Gupta 2003).

Karanja (Pongamia pinnata) is an underutilized plant which is grown in many parts of India. The main production area for the Karanja oil is in the village level and villagers use this oil in some of their daily activities. Karanja oil is one of the potential oils with yearly production of 200 t (metric ton), out of which 6% is being presently utilized. The karanja oil contains primarily eight fatty acids viz. palmitic, stearic, oleic, linoleic, lignoceric, eicosenoic, arachidic and behenic. Of these, the four which are commonly found in most oils, including Pongamia, are the saturated acids, palmitic and stearic and the unsaturated acids, oleic and linoleic (Karmee and Chanda, 2005). The freshly extracted Karanja oil is yellowish orange to brown and rapidly darkens on storage. It has a disagreeable odor and bitter taste. The presence of toxic Xavonoids makes the oil non-edible (Meher *et al*., 2006). Different properties of Karanj oil are given in Table 2 & 3.

Table 1: IMPORTANT CROPS FOR BIODIESEL PRODUCTION

Non Edible Crops	Edible crops
Jatropha curcus	Sunflower
Pongomia pinnata	Soybean
Calophyllum inophyllum	Rapseed
Hevea brasiliensis	Pam oil

Calotropis gigantia	Linseed (SPAIN)
Euphorbia tirucalli	Cottonseed oil
Brswellia ovalifololata	

Table 2: PROPERTIES OF KARANJA OIL

Density	0.92gm/cm3
Acid value	5.06 mg KOH/gm
Saponification value	187 KOH/gm
Unsaponifiable matter	2.6 w/w percent
Iodine value	86.5 g
Oil content	27 – 40 %

Table 3: FATTY ACIDS COMPOSITION OF *KARANJA OIL*

SR. No.	Fatty acids	Composition (%)
1	Palmitic (C16:0)	11.6
2	Stearic (C18:0)	7.5
3	Oleic (C18:1)	51.5
4	Linoleic (C18:2)	16
5	Linolenic(C18:3)	2.6
6	Arachidic (C20:0)	1.7
7	Eicosenoic (C20:1)	1.1
8	Behenic(C22:0)	4.3
9	Lignoceric (C24:0)	1

Process of making biofuel from Karanja oil

The seeds contain 30 to 40% oil, which can be converted into biodiesel (fatty acid methyl esters; FAMEs) by transesterification with methanol in the presence of KOH. Transesterification of oils was first conducted as early as 1853, by scientists E. Duffy and J. Patrick. Transesterification, also called alcoholysis, is the displacement of alcohol from an ester by another alcohol in a process similar to hydrolysis, except than a alcohol is used instead of water (Figure 1).

The most important variables that influence transesterification reaction time and conversion are:

- Reaction temperature
- Ratio of alcohol to oil
- Catalyst type and concentration
- Mixing intensity
- Purity of reactants

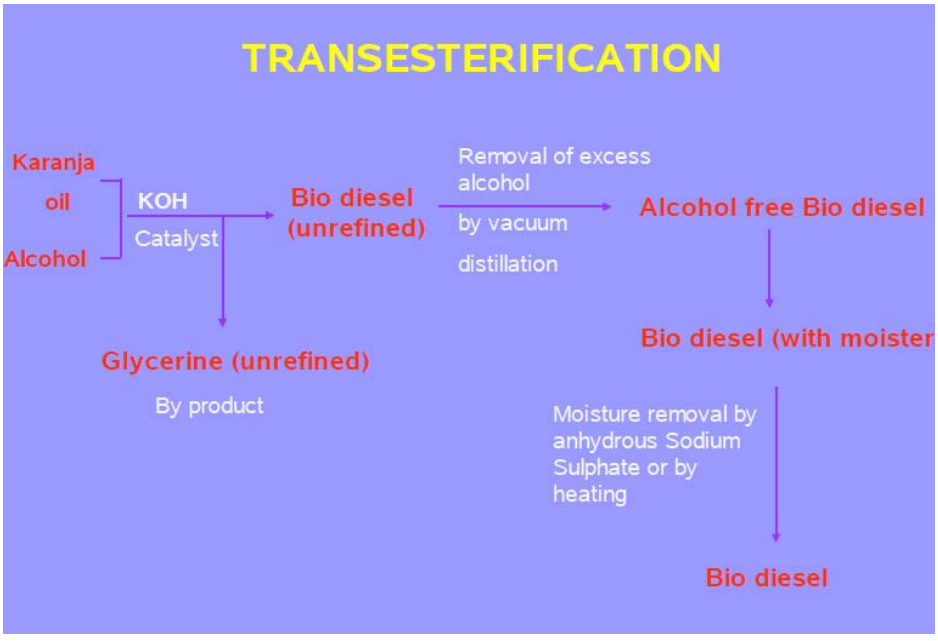

Figure 1: Process of making biofuel (Srivastava and Verma, 2008)

All countries are at present heavily dependent on petroleum fuels for transportation and agricultural machinery. The fact that a few nations together produce the bulk of petroleum has led to high price fluctuation and uncertainties in supply for the consuming nations. This in turn has led them to look for alternative fuels that they themselves can produce. Among the alternatives being considered are methanol, ethanol, biogas and Karanja oil. karanja oil have certain features that make them attractive as substitute for Diesel fuels. Karanja oil has the characteristics compatible with the CI engine systems (Kumar *et al*., 2008). oil is also miscible with diesel fuel in any proportion and can be used as extenders (Mehar *et al*., 2004). India highly depends on import of petroleum crude and nearly two third of its requirement is met through imports. Moreover the gases emitted by petrol, diesel driven vehicles have an adverse effect on the environment and human health (Sharma and Singh, 2008).

ADVANTAGES OF BIOFUEL

- Biodiesel produces approximately 80% less carbon dioxide, almost 100% less sulphur dioxide.
- Combustion of biodiesel alone produces over a 90% reduction in total unburned hydrocarbons, and a 75-90% reduction in aromatic hydrocarbons.
- Used alone or mixed in any ratio with petroleum diesel fuel. The most common blend is a mix of 20% bio-diesel with 80% petroleum diesel
- 100% domestic fuel.
- Neat biodiesel fuel is non-toxic and biodegradable.
- Cetane number is significantly higher than that of conventional diesel fuel.
- Lubricity is improved over that of conventional diesel fuel.

- Bio-diesel is safe to handle and transport.

DISADVANTAGE OF BIODIESEL

- Quality of biodiesel depends on the blend thus quality can be tampered.
- Biodiesel has excellent solvent properties, hence deposits in the filters, result in need for replacement of the filters.
- There may be problems of winter operatibility.
- Spills of biodiesel can decolorize any painted surface if left for long.
- Neat biodiesel demands compatible elastomers (hoses, guskets, etc.).

Medicinal Uses of Karanja

Pongamia has been used as folk medicinal plant, particularly in Ayurvedha and Siddha systems of Indian medicine (Meera *et al.,* 2003). All parts of the plant have been used as a crude drug for the treatment of tumours, piles, skin diseases, itches, abscess, painful rheumatic joints wounds, ulcers, diarrhea etc (Sobha and Thomas, 2001) (Figure 2). Besides, it is well known for its application as animal fodder, green manure, timber and fish poison. It has also been recognized to possess applications in agriculture and environmental management, with insecticidal and nematicidal activity. More recently, the effectiveness of *P. pinnata* as a source of biomedicines has been reported (Brijesh *et al.*, 2006), specifically as antimicrobial and therapeutic agents.

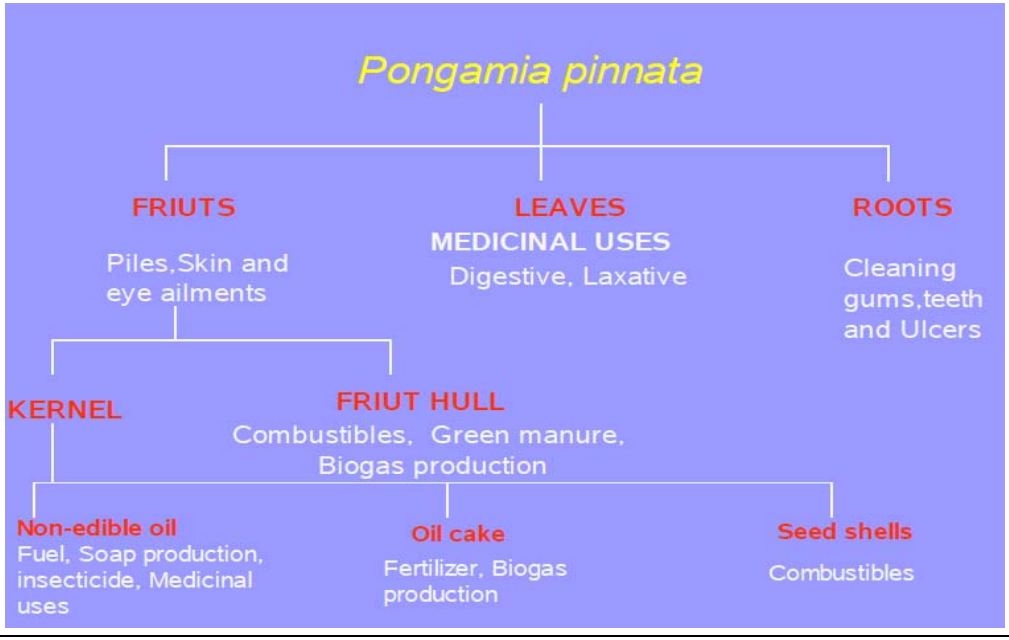

Figure 2: Medicinal uses of Karanja (Srivastava and Verma, 2008)

FUTURE THRUST

Biodiesel is a viable substitute for petroleum-based diesel fuel. Its advantages are improved lubricity, higher cetane number, cleaner emissions, reduced global warming, and enhanced rural

development. Karanja oil has potential as an alternative energy source. However, this oil alone will not solve our dependence on foreign oil within any practical time frame. Use of this and other alternative energy sources could contribute to a more stable supply of energy.

Major production centers on the level of modern petroleum refineries have not been developed. The economics of biodiesel fuels compared to traditional petroleum resources are marginal; public policy needs to be revised to encourage development. Increased Karanja oil production would require a significant commitment of resources. Land for production would need to be contracted, crushing and biodiesel production plants need to be built, distribution and storage facilities constructed, and monitoring of users for detection of problems in large-scale use are all needed to encourage development of the industry.

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Trees and plant biomass : As A Source of Bioenergy and Bioelectricity

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ABSTRACT

Trees and wood have been identified as part of the bioenergy solution. A report investigated the feasibility of producing the estimated 1 billion dry tons of lignocellulosic biomass needed annually to meet the "'30 × '30" goal for a 30% replacement of United States petroleum consumption with biofuels by 2030. In this report, trees grown for bioenergy applications were included under the heading of agricultural resources as part of the broadly defined "perennial energy crops". Purpose-grown trees are expected to account for 377 million dry tons of the 1.37 billion dry ton total biomass resource potential at projected yields of 8 dry tons/acre/yr. Trees play an important role to check air pollution due to the gases, dust, smokes, planting of trees are highly advantageous. The filtering effects of evergreen trees are better than the deciduous trees. A judicious planting of trees enhances the beauty of surroundings. Trees form the living umbrella over streets, parks and gardens. Planting trees in the medium strips of highways reduce glare from oncoming headlights of vehicles. Chest height plants provide partial privacy. Further tree planted effectively will soften the harsh lines of the house or landscape. Trees and shrubs ameliorate air temperatures in urban environments by controlling solar radiation. Tree leaves intercept, reflect, absorb and transmit solar radiation. Trees reduce the summer temperature through evapotranspiration. Trees provide temporary shelter from rain during short showers. Trees also reduce soil moisture evaporation. A typical tree produces about 260 pounds of oxygen each year. Two trees can supply a person's oxygen needs. Trees play a potential role in removing atmospheric contaminants. Trees provide shade from the sun's ultraviolet rays (UV).

Key words: Trees, shrubs , woody plants, bioenergy

INTRODUCTION

Trees are perennial, tall, with marked trunk and grow for several year, bear flowers and fruits. On this planet, trees are growing for the last 50 million years. In different biotic zones, different types of trees dominate which have developed through evolutionary process and ecological succession. With the spread of human civilization and increase in population pressure, forests have been cleared for cereal production. Injudicious felling of trees resulted into ecological imbalance, change in climate, desertification and deterioration of soil conditions.

Trees and wood have been identified as part of the bioenergy solution in the "Billion Ton Report" (Perlack *et al*. 2005). This report investigated the feasibility of producing the estimated 1 billion dry tons of lignocellulosic biomass needed annually to meet the "'30 × '30" goal for a 30% replacement of United States petroleum consumption with biofuels by 2030. In this report, trees

grown for bioenergy applications were included under the heading of agricultural resources as part of the broadly defined "perennial energy crops". Purpose-grown trees are expected to account for 377 million dry tons of the 1.37 billion dry ton total biomass resource potential at projected yields of 8 dry tons/acre/yr (Perlack *et al*. 2005).

Short-rotation, purpose-grown trees have a variety of inherent logistical benefits and economic advantages relative to other lignocellulosic energy crops. Many of these advantages are driven by the fact that trees can typically be harvested year-round and continue growing year after year providing a "living inventory" of available biomass. Due to the flexibility associated with harvest time, trees have reduced storage and inventory holding costs and can minimize shrinkage or degradation losses typically associated with storage of annually-harvested biomass. Since trees can be harvested after several years and at different times, tree biomass mitigates the risk of annual yield fluctuations due to drought, disease and pest pressures, as well as other biotic or abiotic stresses. This allows a better matching of biomass supply with demand. Year-round harvest of trees enables the harvest and transport of wood to be distributed throughout the year, reducing infrastructure needs relative to annually-harvest crops (Sims and Venturi 2004).

TREES AS A SOURCE OF BIOENERGY

Bioenergy is renewable energy made available from materials derived from biological sources. Biomass is any organic material which has stored sunlight in the form of chemical energy. As a fuel it may include wood, wood waste, straw, manure, Jatropha, Jojoba, Palm, *P.pinnata* and many other byproducts from a variety of agricultural processes. In its most narrow sense it is a synonym to biofuel, which is fuel derived from biological sources. In its broader sense it includes biomass, the biological material used as a biofuel, as well as the social, economic, scientific and technical fields associated with using biological sources for energy.

Jatropha

Jatropha is a genus of flowering plants in the spurge family, *Euphorbiaceae*. Most of these are native to the Americas, with 66 species found in the Old World. Mature plants produce separate male and female flowers. In 2007 Goldman Sachs cited *Jatropha curcas* as one of the best candidates for future biodiesel production. It is resistant to drought and pests, and produces seeds containing 27-40% oil, averaging 34.4%. When jatropha seeds are crushed, the resulting jatropha oil can be processed to produce a high-quality biodiesel that can be used in a standard diesel car, while the residue (press cake) can also be processed and used as biomass feedstock to power electricity plants or used as fertilizer (it contains nitrogen, phosphorus and potassium). However, despite their abundance and use as oil and reclamation plants, none of the *Jatropha* species have been properlydomesticated and, as a result, their productivity is variable, and the long-term impact of their large-scale use on soil quality and the environment is unknown.

Estimates of *Jatropha* seed yield vary widely, due to a lack of research data, the genetic diversity of the crop, the range of environments in which it is grown, and *Jatropha*'s perennial life cycle. Seed yields under cultivation can range from 1,500 to 2,000 kilograms per hectare, corresponding to extractable oil yields of 540 to 680 litres per hectare (58 to 73 US gallons per acre). *Time* magazine recently cited the potential for as much as 1,600 gallons of diesel fuel per acre per year.

Jojoba

Jojoba oil is the liquid wax produced in the seed of the jojoba (*Simmondsia chinensis*) plant, a shrub native to southern Arizona, southern California, and northwestern Mexico. The oil makes up approximately 50% of the jojoba seed by weight. Unrefined jojoba oil appears as a clear golden liquid at room temperature with a slightly fatty odor. Refined jojoba oil is colorless and odorless. The melting point of jojoba oil is approximately 10°C and the iodine value is approximately 80. Jojoba oil is relatively shelf-stable when compared with other vegetable oils mainly because it does not contain triglycerides, unlike most other vegetable oils such as grape seed oil and coconut oil. It has an Oxidative Stability Index of approximately 60, which means that it is more shelf-stable than oils of safflower oil, canola oil, almond oil or squalene but less than castor oil and coconut oil.

PALM

Palm oil, like other vegetable oils, can be used to create biodiesel, as either a simply processed palm oil mixed with petrodiesel, or processed through transesterification to create a palm oilmethyl ester blend. Glycerin is a byproduct of transesterification. The actual process used to produce biodiesel around the world varies between countries and the requirements of different markets. Next-generation biofuel production processes are also being tested in relatively small trial quantities.

The IEA predicts biofuels usage in Asian countries will remain modest. But as a major producer of palm oil, the Malaysian government is encouraging the production of biofuel feedstock and the building of palm oil biodiesel plants. Domestically, Malaysia is preparing to change from diesel to biofuels by 2008, including drafting legislation that will make the switch mandatory.

First generation biodiesel production from palm oil is in demand globally. Palm oil is also a primary substitute for rapeseed oil in Europe, which too is experiencing new demand for biodiesel purposes. Palm oil producers are investing heavily in the refineries needed for biodiesel. In Malaysia, companies have been merging, buying others out and forming alliances to obtain the economies of scale needed to handle the high costs caused by increased feedstock prices. New refineries are being built across Asia and Europe.

In Malaysia, an estimated 50,000 tonnes of used frying oils, both vegetable oils and animal fats, are disposed of yearly, without treatment, as wastes. In a 2006 study, researchers found used frying oil (mainly palm olein), after pretreatment with silica gel, is a suitable feedstock for conversion to methyl esters by catalytic reaction using sodium hydroxide. The methyl esters produced have fuel properties comparable to those of petroleum diesel, and can be used in unmodified diesel engines.

Pongamia pinnata

Pierre is a fast-growing leguminous tree with the potential for high oil seed production and the added benefit of the ability to grow on marginal land. These properties support the suitability of this plant for large-scale vegetable oil production required by a sustainable biodiesel industry. The future success of *P. pinnata* as a sustainable source of feedstock for the biofuels industry is dependent on an extensive knowledge of the genetics, physiology and propagation of this legume. More importantly, *P. pinnata* has recently been recognized as a viable source of oil for the

burgeoning biofuel industry. The sustainable production of plant oils for biodiesel production from a tree crop such as *P. pinnata*, which can be cultivated on marginal land, has the potential to not only provide a renewable energy resource but in addition will alleviate the competitive situation that exists with food crops as biofuels and associated arable land and water use.

Simple use of biomass fuel (Combustion of wood for heat).

Solid biomass

One of the advantages of biomass fuel is that it is often a by-product, residue or waste-product of other processes, such as farming, animal husbandry and forestry. In theory this means there is no competition between fuel and food production, although this is not always the case.

Biomass is material derived from recently living organisms, which includes plants, animals and their byproducts. Manure, garden waste and crop residues are all sources of biomass. It is a renewable energy source based on the carbon cycle, unlike other natural resources such as petroleum, coal, and nuclear fuels. Another source includes animal waste, which is a persistent and unavoidable pollutant produced primarily by the animals housed in industrial-sized farms.

There are also agricultural products specifically being grown for biofuel production. These include corn, and soybeans and to some extent willow and switchgrass on a pre-commercial research level, primarily in the United States; rapeseed, wheat, sugar beet, and willow (15,000 ha in Sweden) primarily in Europe; sugarcane in Brazil; palm oil and miscanthus in Southeast Asia; sorghum and cassava in China; and jatropha in India. Hemp has also been proven to work as a biofuel. Biodegradable outputs from industry, agriculture, forestry and households can be used for biofuel production, using e.g. anaerobic digestion to produce biogas, gasification to produce syngas or by direct combustion. Examples of biodegradable wastesinclude straw, timber, manure, rice husks, sewage, and food waste. The use of biomass fuels can therefore contribute to waste management as well as fuel security and help to prevent or slow down climate change, although alone they are not a comprehensive solution to these problems.

Electricity generation from biomass

The biomass used for electricity production ranges by region. Forest by products, such as wood residues, are popular in the United States. Agricultural waste is common in Mauritius (sugar cane residue) and Southeast Asia (rice husks). Animal husbandry residues, such as poultry litter, is popular in the UK.

Electricity from sugarcane bagasse in Brazil

Sugarcane (*Saccharum officinarum*) plantation ready for harvest, Ituverava,São Paulo State. Brazil.

Sugar/Ethanol Plant located inPiracicaba, São Paulo State. This plant produces the electricity it needs frombagasse residuals from sugarcane left over by the milling process, and it sells the surplus electricity to the public grid.

Sucrose accounts for little more than 30% of the chemical energy stored in the mature plant; 35% is in the leaves and stem tips, which are left in the fields during harvest, and 35% are in the fibrous material (bagasse) left over from pressing.

The production process of sugar and ethanol in Brazil takes full advantage of the energy stored in sugarcane. Part of the bagasse is currently burned at the mill to provide heat for distillation and electricity to run the machinery. This allows ethanol plants to be energetically self-sufficient and even sell surplus electricity to utilities; current production is 600 MW for self-use and 100 MW for sale. This secondary activity is expected to boom now that utilities have been induced to pay "fair price "(about US$10/GJ or US$0.036/kWh) for 10 year contracts. This is approximately half of what the World Bank considers the reference price for investing in similar projects (see below). The energy is especially valuable to utilities because it is produced mainly in the dry season when hydroelectric dams are running low. Estimates of potential power generation from bagasse range from 1,000 to 9,000 MW, depending on technology. Higher estimates assume gasification of biomass, replacement of current low-pressure steam boilers and turbines by high-pressure ones, and use of harvest trash currently left behind in the fields. For comparison, Brazil's Angra I nuclear plant generates 657 MW.

Presently, it is economically viable to extract about 288 MJ of electricity from the residues of one tonne of sugarcane, of which about 180 MJ are used in the plant itself. Thus a medium-size distillery processing 1 million tonnes of sugarcane per year could sell about 5 MW of surplus electricity. At current prices, it would earn US$ 18 million from sugar and ethanol sales, and about US$ 1 million from surplus electricity sales. With advanced boiler and turbine technology, the electricity yield could be increased to 648 MJ per tonne of sugarcane, but current electricity

prices do not justify the necessary investment. (According to one report, the World Bank would only finance investments in bagasse power generation if the price were at least US$19/GJ or US$0.068/kWh.)

Bagasse burning is environmentally friendly compared to other fuels like oil and coal. Its ash content is only 2.5% (against 30–50% of coal), and it contains very little sulfur. Since it burns at relatively low temperatures, it produces little nitrous oxides. Moreover, bagasse is being sold for use as a fuel (replacing heavy fuel oil) in various industries, including citrus juice concentrate, vegetable oil, ceramics, and tyre recycling. The state of São Paulo alone used 2 million tonnes, saving about US$ 35 million in fuel oil imports.

Researchers working with cellulosic ethanol are trying to make the extraction of ethanol from sugarcane bagasse and other plants viable on an industrial scale.

Environmental impact

Some forms of forest bioenergy have recently come under fire from a number of environmental organizations, including Greenpeace and the Natural Resources Defense Council, for the harmful impacts they can have on forests and the climate. Greenpeace recently released a report entitled Fuelling a BioMess which outlines their concerns around forest bioenergy. Because any part of the tree can be burned, the harvesting of trees for energy production encourages Whole-Tree Harvesting, which removes more nutrients and soil cover than regular harvesting, and can be harmful to the long-term health of the forest. In some jurisdictions, forest biomass is increasingly consisting of elements essential to functioning forest ecosystems, including standing trees, naturally disturbed forests and remains of traditional logging operations that were previously left in the forest. Environmental groups also cite recent scientific research which has found that it can take many decades for the carbon released by burning biomass to be recaptured by regrowing trees, and even longer in low productivity areas; furthermore, logging operations may disturb forest soils and cause them to release stored carbon. In light of the pressing need to reduce greenhouse gas emissions in the short term in order to mitigate the effects of climate change, a number of environmental groups are opposing the large-scale use of forest biomass in energy production.

Trees and shrubs ameliorate air temperatures in urban environments by controlling solar radiation. Tree leaves intercept, reflect, absorb and transmit solar radiation. Their effectiveness depends on the density of species foliage, leaf shape and branching patterns. Deciduous trees are very instrumental foliage, in heat control in urban settings in temperate regions. During summer they intercept solar radiation and lower temperatures. In the winter the loss of their leaves results in the pleasant warming effects of increased solar radiation.Trees can be considered as matures air conditioners. Trees reduce the summer temperature through evapotranspiration. A single tree may transpire 88 gallons water per day which is compared to five air conditioners with a capacity of 2500 k cal/hr, running 20 hours a day.

The 2005 Canadian government information on Climate Change estimates that you produce three tonnes of CO_2 if you drive a mid-sized car 15,000 km a year and another four tonnes to cover heating, lighting and other appliances, totaling 7 tonnes of CO_2 per year .An acre of mature trees can capture 2.6 tonnes of CO_2 per year that is equal to the CO_2 produced by driving a car 14,000 km or 8,700 miles.

An acre of trees will there has been a 30% increase in atmospheric CO_2 over the past 200 years. The soil is the largest terrestrial source of CO_2. In hotter regions, organic matter decomposes quickly, releasing its CO_2.

Without oxygen life can't be possible. A typical tree produces about 260 pounds of oxygen each year. Two trees can supply a person's oxygen needs. This is a conservative estimate based on the average annual oxygen consumption for a person at rest of 400 pounds a year.

Ingold (1971) reported that the leaves with complex shapes and large circumference area reported to be collected particles more efficiently. Many trees like Neem (*Azadirchta indica*), Silk cotton (*Bombax ceiba*), Indian laburnum (*Cassia fistula* and *C. siamea*), Gulmohar (*Delonix regia*), Pipal (*Ficus religiosa*), Jacaranda (*Jacaranda mimosifolia*), Indian lilac *Lagerstroemia indica*), Temple or Pagoda tree (*Plumeria rubra* and *P. alba*), Java plum (*Syzygium cumini*) and several other roadside and street trees have found more suitable in urban environment (Maheshwari, 1963; Oommanchan,1977; Pokhriyal and Subba Rao, 1986; Chee and Ridwan, 1984). If such trees are to be planted, their local ecological relationship with human environment has to be studied properly. It should be borne in mind that these trees may cause allergic disorders such as hay fever; asthma and toxemia due to airborne pollen grains, which can also contribute to atmospheric pollution significantly.

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Bio-Diesel Production from *Jatropha curcas* Oil Using Advance Heterogeneous Catalyst

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ABSTRACT

Biodiesel is the fatty acid alkyl ester (e.g. FAME, FAEE etc.) and biodiesel production is generally carried out through transesterification reaction. The reaction is facilitated with a suitable catalyst either homogeneous or heterogeneous. Heterogeneous catalyst is being paid more attention in recent times over other catalyst due to its recyclable and non-destructive nature. The selection of appropriate catalyst depends on the amount of free fatty acid in the oil. Heterogeneous catalyst provides high activity, high selectivity, high water tolerance properties and these properties generally depends on the amount and strengths of active acid or basic sites. However the cost of catalyst could be another factor that determines their efficacy. In this article the authors reported the heterogeneous catalyst obtained from the combustion of underground stem of *Musa bilbisiana colla.* Transesterification reaction was carried out with *jatropha curcas* oil and methanol at 1:6 ratios with ash catalyst for about 1 hour at 65 ^{0}C. The chemical compositions of the catalyst have been investigated. XRD pattern analysis shows the amorphous nature of the catalyst. BET surface area, pore size and pore volume have been studied. The biodiesel prepared using this catalyst was characterized for density, viscosity, calorific value, copper strip corrosion and flash point etc. Fatty ester compositions have been analyzed with Gas chromatography and over 95% conversions have been found.

Key words : Ash heterogeneous catalyst, gas chromatography, Jatropha

INTRODUCTION

Biodiesel is known as fatty acid alkyl ester (methyl ester or ethyl ester), biodiesel is a fuel derived from the transesterification of fats and oils. This fuel has similar properties to that of diesel fuel produced from crude oil and can be used directly to run existing diesel engine or as a mixture with petroleum derived diesel. The main advantage to use biodiesel as a fuel is that biodiesel is biodegradable, eco-friendly in nature, NOx, SOx and carbon reduction from the environment (Hanna, 1999).

Transesterification consists of three consecutive reversible reactions viz.; conversion of triglyceride to diglyceride, diglyceride to mono glyceride and monoglyceride to fatty ester and glycerol. The reaction is facilitated with a suitable catalyst (Wang et al., 2009). If the catalyst remains in the same (liquid) phase to that of the reactants during transesterification, it is homogeneous catalytic transesterification. On the other hand, if the catalyst remains in different phase (i.e. solid, immiscible liquid or gaseous) to that of the reactants the process is called

heterogeneous catalytic transesterification (Helwani et al., 2009). The heterogeneous catalytic transesterification is included under Green Technology due to the following attributes: (1) the catalyst can be recycled (reused), (2) there is no or very less amount of waste water produced during the process and (3) separation of biodiesel from glycerol is much easier (Sarma et al., 2008). During homogeneous catalytic transesterification the glycerol produced is of low quality and requires lengthy process and distillation for purification (Kumar and Anju, 2005 , Grandos et al., 2007).

All these processing increases the cost of the end products: biodiesel and glycerin. Moreover, the homogeneous base catalyzed transesterification process encounter problems to handle multiple feed stocks. On the other hand, heterogeneous catalytic transesterification process overcomes these problems because methanol or ethanol does not mix with solid heterogeneous catalyst. After the transesterification reaction it is relatively easy to separate the catalyst from biodiesel and glycerol. Oils (non-edible) with higher fatty acid content lead to the formation of soap, consequent loss of oil and problems of product separation during homogeneous catalytic transesterification (Van Gerpen, 2005). The major drawback of the homogeneous catalyst (NaOH, KOH) is found for its hygroscopic nature, hazardous for the environment as compared to heterogeneous catalyst. Heterogeneous catalyst converts triglycerides into biodiesel slowly but produced biodiesel in a very feasible economic way due to the reusability of catalyst for both the processes, e.g. batch and continuous (Sakai et al., 2009). A large numbers of heterogeneous catalysts available in the literature, but majorly it can be classified into base heterogeneous, acid heterogeneous and enzyme heterogeneous catalyst. (Chouhan and Sarma, 2011).

Very recently Deka and Basumatari (2011) reported the use of ash obtained from the trunk of *Musa bilbisiana colla* by partial combustion. It has been observed that underground stem of *Musa bilbisiana colla* has almost double the concentration of alkali metal by wt. In this article the authors reported the use of ash obtained from *Musa bilbisiana colla* underground stem for biodiesel production. The ash obtained has been used as heterogeneous catalyst during transeterification of *Jatropha curcas* oil. The fatty acid methyl ester obtained was analyzed for density, viscosity, flash point, calorific value and chemical compositions through gas chromatography and has been reported herewith.

MATERIALS

Jatropha Curcas oil was purchased from an oil expeller Industry, Udaipur, Rajasthan in India. This *jatropha curcas* oil has density of 0.918 g/cc at 20 °C. Methanol was purchased from Loba chemicals with a purity of 99%.

EXPERIMENTAL

Catalyst Synthesis: Banana plant underground stems were collected from Sipajhar, Assam, India. These were first combusted traditionally after slicing and drying and the ash so collected were carried to the Institute laboratory. These ashes were further heated at 550 °C in a furnace to concentrate the alkali metal contents. Further, this ash was characterized by atomic adsorption spectrophotometer for alkali and poisonous metal contents. The BET surface area of the ash was evaluated under nitrogen environment and the XRD was studied for their nature of crystalline or amorphous.

XRD studies were carried out on Jagtar, Creation diffractometer. The Cu K α light source was used with an applied voltage and current of about 45 KV and 40 mA. Cu Kα wavelength was maintained at 1.54 and 2θ angles ranged from 20° to 80° at a speed of 2° /min.

The determination of the d- spacing of the catalyst layers identified structure of catalyst. It was measured by the full width half maxima method of the Gaussian fitting using Bragg's and Scherer's equation.

Particle size (D.B) = $0.9\,\lambda / \beta \cos\theta$ (Scherer's equation), $n\lambda = (2\,d \sin\theta)$ (Bragg's equation)

Where, λ is the wavelength of known source = 1.54 (Cu source), β is Gaussian profile height and θ is the scattering angle and could be calculated from the XRD- Gaussian fitting curves.

Biodiesel Production Reactor: The transesterification reaction carried out in an automatic Radley's Reactor purchased from UK in which the reaction time and temperature controlled automatically. This reactor consists glass vessel made of double glass layer, outer layer for circulation of the hot water and heat transfer into the reactor from outer side to inner side. Oil, catalyst and ethanol reactants were taken from top section of the reactor. The sample vessel has 500 ml capacity which is considered for transesterification process, reactor illustrated in Fig.2.

Transesterification Reaction: The crude *Jatropha Curcas* oil (JCO) and methanol were used without further purification. Transesterification reaction was carried out in the automatic Radley's reactor at 65°C temperature with the mixer stirring at 650 RPM speed for 1 hour reaction time as shown in the Fig 2.

Fig. 2: Biodiesel preparation unit

The catalyst used for this process was 5 wt. % of oil. The molar ratio of oil and methanol molar ratio were used about 1: 6 for the transesterification reaction. After the transesterification reaction was over the methanol separated through rotary evaporator at 60 °C temperature under reduced pressure. Then the ethyl ester so obtained were placed in a separatory funnel and left

overnight (12 hours) for the separation of the glycerol and catalyst from the biodiesel under gravity. A refrigerated centrifugal (Model no. 5430R, manufactured by Eppendorf Company, UK) was used to separate the catalyst and glycerol for about 4 minutes at 10,000 RPM at 4 ^{0}C constant temperature. This process was repeated to produce substantial amount of methyl esters of *jatropha curcas oil* and stored in corked poly-ethene vessel for further characterization. Methyl ester and fatty acid compounds identified and quantified using the GC analysis.

Characterization of Biodiesel: The biodiesel fuel characterized for density by digital density meter (model no. DMA 5000 Series, manufactured by Anton Paar Company, Germany), viscosity by (model no. 86-18D Lawler viscometer, manufactured by USA), flash point (model no. ACO-7, made by Tanaka Company, Japan) and calorific value (Toshniwal automatic bomb calorimeter, made in India) and fatty acid and ethyl ester conversion identified and quantified using the GC technique.

RESULTS AND DISCUSSION

Characterization of Catalyst:

Banana plant underground stem has been used traditionally by the Assamese community since the history belongs as the alkali source for Cooking, Baking etc. in a similar fashion to the baking powder. They burn the slice of the underground stem for preparation of ash which is further filtered with water to get the water extract as "Khar", commonly used in kitchen. Basically, underground stem has been selected because it requires less drying effort as compared to the trunk. Moreover, the alkali metal concentration per unit volume of the underground root is higher.

Very recently, Deka and Basumatary (2011) investigated the use of ash obtained from the trunk of *Musa bilbisiana colla* (Bhim Kol) as catalyst for transterification of oleander seed oil using methanol as reactant in 1:20 molar ratio of oil to alcohol, at ordinary temperature 32 ^{0}C in 3 hours of reaction time. They reported 96% biodiesel yield in first reaction cycle, 94 % in second reaction cycle and 91 % in the third in 3, 6 and 9 h , respectively. However, the high alcohol oil molar ratio and very high catalyst amount (20% by wt of oil) cannot be useful for a suitable transesterification process. The oil absorbed by the high catalyst percentage would be tedious to remove. This will eliminate the advantage of using a heterogeneous catalyst. Very high surface area of the catalyst (Table1) is attributed to its good catalytic behavior during transesterification.

High porosity of the catalyst ensures that the maximum site is available for catalytic activity. The total XRD analysis and metal contents analysis showed that 28 % by wt of the catalyst composed of K^{+} which is attributed to its good catalytic behavior. The catalyst represents crystalline behavior with triplet sharp metallic peak during XRD analysis. XRD analysis is depicted in Fig.3.

Table 1: Characterization of heterogeneous catalyst

S.No.	Test Name	*Musa bilbisiana Colla* (heterogeneous catalyst)
1	Density of catalyst (g/cc)	0.434
2	Catalyst structure	Partly Crystalline and mostly amorphous type
3	Alkali metals present	Na^{+} (0.34%) , K^{+} (27.70%)
4	Toxic heavy metals present	Pb (5.19 mg/kg) , Co (1.97 mg/kg) trace amount

5	Anion present	Cl^- (0.60%), CO_3^{2-} (2 mg/kg)
6	BET surface area (m^2/g)	38.710
7	Total pore volume (cc/g)	4.0233 x 10^{-02}
8	Average pore radius (^{0}A)	2.18681 x 10^1

The banana ash (*Bhim Bilbisiana Colla*) heterogeneous catalysts derived from underground stem has a density 0.434 g/cc. Other basic characteristics of the catalyst are presented in Table 1. The presence of both sodium and potassium makes it a good catalyst. Other additional advantage can be obtained from porosity and the moderate surface area of the catalyst.

XRD Analysis:

Fig.3 represented about the structure analysis of *Musa bilbisiana colla* catalyst, this curve represented plotting between counts and 2θ angle, sharp peaks represented the identification of the metallic content and continuous structure identify about the amorphous nature of the catalyst.

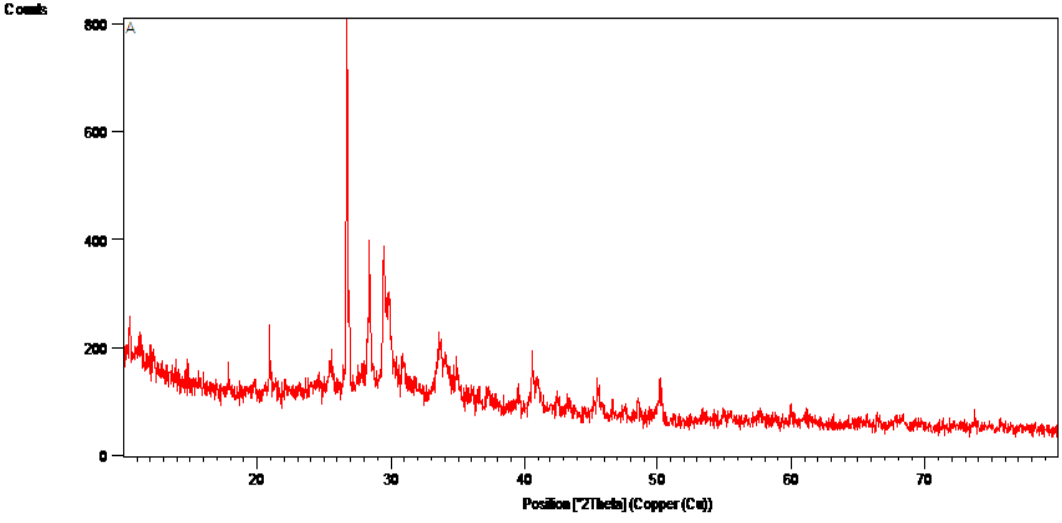

Fig. 3: XRD analysis of the Musa bilbisiana catalyst

The d-spacing was analyzed by the full width half maxima method using Scherer's equation. Catalyst particle size structure analysis like d-spacing between the catalyst layers analyzed by using XRD peaks with drawn a Gaussian profile and using full width half maxima (FWHM) method.

Major peaks obtained at angle of 2(theta) = 20.90 and its FWHM (0.0669) and d-spacing was 4.24 A^0, at 2(theta) = 29.88 and its FWHM (0.1004) and d-spacing was 3.03 and at 2(theta) =30.89 and its d-spacing was 2.89 A^0 was measured.

Chemical Characterization of *Jatropha curcas* Oil and Biodiesel:

Jatropha curcas seed oil is perhaps the most widely accepted seed oil for biodiesel production. Most of the developing countries in South East Asia are cultivating *jatrohpa curcas* as the oilseed bearing plants for energy uses (Silitonga et al., 2011). The fatty acid profile of the pure *jatropha curcas* oil

was evaluated using a GC following the AOCS Official method. The fatty acid profile presented in Table 2 shows that oleic acid (38.069 % by wt) and Linoleic acids(32.309 % by wt) followed by palmitic acid (16.902 % by wt) and stearic acid (8.572 % by wt) are the major contributor to the oil. This clearly demonstrates that over 96 % of the oil can be easily converted to fatty acid esters during transesterification. In our experiment 95 % methyl ester was obtained with the said catalyst and *jatropha curcas* oil.

Table 2: Physio-chemical characterization of *Jatropha curcas* oil and biodiesel

S.No.	Test	Jatropha oil	FAME	Chemical composition name	Jatropha oil (Wt. %)	FAME
1	Density g/cc@15 ^{0}C	0.91	0.89	Palmitic acid (wt.%)	16.902	12.524
2	Kinematic viscosity (cSt)@40 ^{0}C	34	7	Stearic acid (wt.%)	8.572	5.778
3	Flash point (^{0}C)	108	104	Linoleic acid (wt.%)	32.309	24.51
4	Calorific value KJ/kg	40	40.5	Oleic acid (wt.%)	38.069	30.822
5	Acid value	8	0	Others	4.2	21
				Total	96	95

The biodiesel so produced (FAEE) were characterized using GC for % conversion of triglyceride to FAME and found that 95 % oil could be converted to FAME at the selected temperature and other conditions. The fuel properties of the oil and biodiesel were evaluated with respect to density, kinematic viscosity, flash point, calorific value and acid value and found that these values shows well agreement with ASTM Standards. *Jatropha curcas* oil's kinematic viscosity decreased after the transesterification reaction due to the conversion of fatty acids into the fatty acid methyl esters (biodiesel). Flash point and density of biodiesel also decreased. All the results are very similar to the earlier reported results for oleander seed oil by Deka and Basumatary (2011).

The most attractive aspect of heterogeneous catalyst is that it can be separated easily from the biodiesel and reused for several times. Chakraborty et al.(2011) used degraded *Labio Rohita* (fish) catalyst, soybean oil as input feedstock for biodiesel production at operating temperature 70 ^{0}C, 6.9:1 molar ratio of alcohol to oil, 5 wt.% catalyst load, reaction time 5 h and catalyst could be reused up to 6 times and biodiesel yield obtained was reported as 97.73%. CaO derived from waste eggshell was reported as a very effective catalyst for transesterification at 65 ^{0}C, with a oil/alcohol ratio 1:9, catalyst loading 10 wt.% , for a FAME yield 97-98%. The catalyst could be reused for 17 reaction cycle as reported Wei et al., (2009). From these sense it is recommended that waste material based catalyst could replace the conventional alkali catalyst for transesterification in a user friendly green technology.

CONCLUSION

Recently, biodiesel production from non-edible oil with heterogeneous catalyst is gaining renewed attention worldwide. It has been found that *Mosa bilbisiana colla* underground stem is an agricultural waste and can be potentially used as catalyst for biodiesel production. It is non toxic and can be reused for 2-4 times. Moreover, the proposed technology for using 100% waste material based catalyst during biodiesel production attracted the interest of our research team

which may be very much beneficial, farmer friendly technology after the completion of ongoing research.

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Biofuels: An Alternate Source of Energy for Sustainable Development

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ABSTRACT

Clean and renewable biofuels have been touted as the answer to the issue of diminishing fossil fuels. Biofuels are produced from living organisms or from metabolic by-products (organic or food waste products). In order to be considered a biofuel the fuel must contain over 80 percent renewable materials. It is originally derived from the photosynthesis process and can therefore, often be referred to as a solar energy source. There are several types of biofuels categorized under first generation and second generation biofuels. First generation biofuels are those made from sugar, starch, and vegetable oil. This type includes Bioalcohols, Biodiesel,Green diesel,Vegetable oil, Bioethers, Biogas, Syngas and Solid biofuels , whereas the second generation biofuels are fuels produced from sustainable feedstock. Such fuels include cellulosic ethanol, algal fuel, biohydrogen, biomethanol, biohydrogen diesel, mixed alcohols and wood diesel. The major advantages of the use of biofuels include low cost as biofuels have the potential to be significantly less expensive than gasoline and other fossil fuels. Biofuel production will also increase the demand for suitable biofuel crops, providing economic stimulation to the agriculture industry and most significantly it has lower carbon emissions because when biofuels are burned, they produce significantly less carbon output and fewer toxins, making them a safer alternative to preserve atmospheric quality and lower air pollution. Taking into consideration all the above facts it can be well stated that biofuels are the basis for sustainable development.

Key words: Biofuels , bioenergy, biomass , sustainable development

INTRODUCTION

Economic, environmental and energy security concerns resulting from excessive reliance on petroleum are forcing countries the world over to shift to alternatives like biofuels in the form of ethanol and biodiesel (Farrell et al., 2006). Since biofuels can be produced from a diverse set of crops each country is adopting a strategy that exploits the comparative advantages it holds with respect to such crops

Global climate change has stimulated efforts to reduce CO_2 emissions. Use of biomass for energy and industry allows a significant quantity of hydrocarbons to be consumed without increasing the CO_2 content of the atmosphere and thus makes a positive contribution to the Greehouse effect and to the problems of "global climate change" as it occurs in both industrialized and developing countries (Garg and Kumar,2008, 2011) .The Kyoto conference agreement indicates the role clean energy sources will play in future. Biomass is renewable, non pollutant and available worldwide as agricultural residues, short rotation forests and crops. Thermochemical

conversion using low temperature processes are among the suitable technologies to promote a sustainable and environment friendly development. Biomass can play a dual role in greenhouse gas mitigation related to the objectives of the United Nations Framework Convention on Climate Change (UNFCC) i.e. as an energy source to substitute for fossil fuels and as a carbon store. The fact that nearly 90 percent of the world's population will reside in developing countries by 2050 probably implies that local solutions for energy needs will have to be found to cope up with the local energy needs on one hand and environment protection on the other hand.

ADVANTAGES AND DISADVANTAGES OF USING BIOFUELS

There are several advantages of using biofuels: biodiesel burns up to 75% cleaner than petroleum diesel fuel. It reduces unburned hydrocarbons (93% less), carbon monoxide (50% less) and particulate matter (30% less) in exhaust fumes, as well as cancer-causing PAH (80% less) and nitrited PAH compounds (90% less), and Sulphurdioxide emissions are eliminated (biodiesel contains no sulphur). Biodiesel is plant-based and using it adds no extra CO_2 greenhouse gas to the atmosphere. Nitrogen oxide (NOx) emissions may increase or decrease with biodiesel but can be reduced to well below petro-diesel fuel levels. Biodiesel exhaust is not offensive and doesn't cause eye irritation. Biodiesel can be used in any diesel engine without modification. It can be mixed with petro-diesel in any proportion, with no need for a mixing additive. Biodiesel has a higher **octane** number than petroleum diesel because of its oxygen content. The higher the **octane** number the more efficient the fuel the engine starts more easily, runs better and burns cleaner. With slight variations depending on the vehicle, performance and fuel economy with biodiesel is the same as with petro-diesel. It is a much better lubricant than petro-diesel and extends engine life. Even a small amount of biodiesel means cleaner emissions and better engine lubrication: 1% biodiesel added to petro-diesel will increase lubricity by 65%. Other than the above stated advantages, first generation biofuel are salt and drought resistance for growing in wastelands similarly .With several advantages, biofuels also have certain disadvantages like they take a large expanse of area to grow. Land will have to be cleared for more growth. If rainforests and other high biomass lands are cleared on a mass scale for biofuel production (which may happen in lower income countries) then the amount of green house gases emitted would be staggering, up to 420 times more GHG's emitted. Multiple studies have been found to draw the same conclusion. Secondly , biofuel may raise the price of certain foods, which are also used for biofuel such as corn. - as other plants are replaced, soil erosion will grow and a lot of water is used to water the plants, especially in dry climates.

TYPES OF BIOFUELS

Biofuels are broadly categorized as the first generation and the second generation. The first generation biofuels refer to the fuels that have been derived from sources like starch, sugar, animal fats and vegetable oil. The oil is obtained using the conventional techniques of production. Some of the most popular types of first generation biofuels are:

Biodiesel: This is the most common type of biofuel commonly used in the European countries. This type of biofuel is mainly produced using a process called transesterification. This fuel if very similar to the mineral diesel and is chemically known as fatty acid methyl. This oil is produced after mixing the biomass with methanol and sodium hydroxide. The chemical reaction thereof produces biodiesel. Biodiesel is very commonly used for the various diesel engines after

mixing up with mineral diesel. Now in many countries the manufacturers of the diesel engine ensure that the engine works well even with the biodiesel.

Vegetable Oil: These kinds of oil can be either used for cooking purpose or even as fuel. The main fact that determines the usage of this oil is the quality. The oil with good quality is generally used for cooking purpose. Vegetable oil can even be used in most of the old diesel engines, but only in warm atmosphere. In most of the countries, vegetable oil is mainly used for the production of biodiesel.

Biogas: Biogas is mainly produced after the anaerobic digestion of the organic materials. Biogas can also be produced with the biodegradation of waste materials which are fed into anaerobic digesters which yields biogas. The residue or the by product can be easily used as manure or fertilizers for agricultural use. The biogas produced is very rich in methane which can be easily recovered through the use of mechanical biological treatment systems. A less clean form of biogas is the landfill gas which is produced by the use of naturally occurring anaerobic digesters, but the main threat is that these gases can be a severe threat if escapes into the atmosphere.

Bioalcohols: These are alcohols produced by the use of enzymes and micro organisms through the process of fermentation of starches and sugars. Ethanol is the most common type of bioalcohol whereas butanol and propanol are some of the lesser known ones. Biobutanol is sometimes also referred to as a direct replacement of gasoline because it can be directly used in the various gasoline engines. Butanol is produced using the process of ABE fermentation, and some of the experiments have also proved that butanol is a more energy efficient fuel and can be directly used in the various gasoline engines.

Syngas: This is a gas that is produced after the combined process of gasification, combustion and pyrolysis. Biofuel used in this process is converted into carbon monoxide and then into energy by pyrolysis. During the process, very little oxygen is supplied to keep combustion under control. In the last step known as gasification, the organic materials are converted into gases like carbon monoxide and hydrogen. The resulting gas Syngas can be used for various purposes.

In contrast to first generation biofuels, second generation biofuel refers to ethanol produced from cellulose rather than sugar made from corn or sugar cane. By not using food crops as the source of sugar, second generation biofuel production is more sustainable and has a lower impact on food production.

SECOND GENERATION BIOFUELS

Second generation biofuels, also known as advanced biofuels, are fuels that can be manufactured from various types of biomass. Biomass is a wide-ranging term meaning any source of organic carbon that is renewed rapidly as part of the carbon cycle. Second generation biofuel technologies have been developed because first generation biofuels manufacture has important limitations. First generation biofuel processes are useful but limited in most cases: there is a threshold above which they cannot produce enough biofuel without threatening food supplies and biodiversity. Many first generation biofuels are dependent of subsidies and are not cost competitive with existing fossil fuels such as oil, and some of them produce only limited greenhouse gas emissions savings. When taking emissions from production and transport into account, life cycle assessment from first generation biofuels frequently approach those of traditional fossil fuels.

Second generation biofuels can help solve these problems and can supply a larger proportion of our fuel supply sustainably, affordably, and with greater environmental benefits. First generation bioethanol is produced by fermenting plant-derived sugars to ethanol, using a similar process to that used in beer and wine-making (see Ethanol fermentation). This requires the use of 'food' crops, such as sugar cane, corn, wheat, and sugar beet. These crops are required for food, so, if too much biofuel is made from them, food prices could rise and shortages might be experienced in some countries. Corn, wheat, and sugar beet also require high agricultural inputs in the form of fertilizers, which limit the greenhouse gas reductions that can be achieved. Biodiesel produced by transesterification from rapeseed oil, palm oil, or other plant oils is also considered a first generation biofuel.

The goal of second generation biofuel processes is to extend the amount of biofuel that can be produced sustainably by using biomass consisting of the residual non-food parts of current crops, such as stems, leaves and husks that are left behind once the food crop has been extracted, as well as other crops that are not used for food purposes (non food crops), such as switchgrass, grass, jatropha, whole crop maize, miscanthus and cereals that bear little grain, and also industry waste such as woodchips, skins and pulp from fruit pressing, etc. (Calvin 1979)

The problem that second generation biofuel processes are addressing is to extract useful feedstocks from this woody or fibrous biomass, where the useful sugars are locked in by lignin, hemicellulose and cellulose. All plants contain lignin, hemicellulose and cellulose. These are complex carbohydrates (molecules based on sugar). Lignocellulosic ethanol is made by freeing the sugar molecules from cellulose using enzymes, steam heating, or other pre-treatments. These sugars can then be fermented to produce ethanol in the same way as first generation bioethanol production. The by-product of this process is lignin. Lignin can be burned as a carbon neutral fuel to produce heat and power for the processing plant and possibly for surrounding homes and businesses.

Modern bio-energy technologies and bio-fuels are relatively benign from environmental view point and produce very little pollution if burned correctly and completely. The creation of new employment opportunities within the community and particularly in rural areas are one of the major social benefits from the exploitation of biomass for energy, industry and environment(Uppal 2004). Further, specific research work carried out in the areas of biomass production and utilization in less fertile areas will provide satisfactory answers to the double challenge of energy crisis and forced deforestation in the country in general and semi-arid and arid regions of Rajasthan in particular. The possibility of conversion of biomass into strategic liquid fuels and electricity will make it possible to supply part of the increasing demand for primary energy and thus reduce demand for crude petroleum imports which entail heavy expenditure on foreign exchange. Jatropha curcas oil has been used effectively for running diesel engine and its proposed to raise a biodiesel plant facility and cultivate in and around Jaipur districts.

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Effect of Using Hydrogen as Supplementary Fuel on Brake Thermal Efficiency of Diesel Engine

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ABSTRACT

Hydrogen is seen as one of the important energy vectors of the present century. To ascertain the performance of diesel engine using dual fuel (diesel + hydrogen) , a Kirloskar make 9.6 hp four stroke stationary diesel engine was run on dual fuel at three different fuel injection timings i.e. 23^0, 26^0 & 29^0 before top dead center (B.T.D.C.) and at three different fuel injection pressures i.e. 180, 200 & 220 kg/cm^2. It was found that up to 80% of rated brake load, the brake thermal efficiency of engine was maximum at fuel injection timing of 23^0 B.T.D.C and at fuel injection pressure of 180 kg/cm^2. However, at 100% and 110% of rated brake load, the engine gave best thermal efficiency at fuel injection timing of 26^0 B.T.D.C and at fuel injection pressure of 200 kg/cm^2, which was manufacturer's setting. At 60% of rated brake load, the brake thermal efficiency decreased from 31.70% (100% diesel) to 22.69% (30% diesel). At 80% of rated brake load, the brake thermal efficiency decreased from 33.1% (100% diesel) to 29.50% (60% diesel) and at rated brake load, the brake thermal efficiency decreased from 32.7% (100% diesel) to 30.50% (at 80% diesel). Thus, it was found that at all loads, the brake thermal efficiency decreased when the engine was run on dual fuel.

Keywords: Hydrogen fuels, thermal efficiency, diesel engine

INTRODUCTION

Presently, all the agricultural tractors and other heavy duty vehicles are powered by compression ignition (CI) engines using diesel fuel. Agricultural sector is next to transport sector in high speed diesel (HSD) oil consumption in India. Due to its high demand, it has become scarce and costlier. Consequently, in India, oil prices have increased alarmingly and so is the oil import bill. It has, therefore, become imperative that vigorous efforts should be made to conserve and stretch the available reserve of the petroleum fuel. So, it is essential to find out alternative fuels which may fully or partially replace HSD as engine fuel in future.

Hydrogen is seen as one of the important energy vectors of the present century. Hydrogen as a renewable energy source, provides the potential for a sustainable development particularly in the transportation sector. A hydrogen fuelled engine has a substantially cleaner emission than other internal combustion engines. Other benefits arise from the wide flammability limits and the high flame propagation speed, both allowing better efficiency (Verhelst and Sierens, 2001).

A study was conducted on a Kirloskar make 7.1 kW (9.6 BHP) air cooled four stroke constant speed diesel engine (Model DAF 10). To run the engine on dual fuel (i.e.) diesel and hydrogen, a minor modification was made by fitting an adaptor in the intake manifold of engine so that hydrogen gas can be mixed along with the incoming air. In order to know the flow rate of hydrogen, one variable flow rotameter having flow rate of 5 to 50 lpm (litres per minute) calibrated for three different incoming gas pressures of 0.5, 0.75 & 1 kg/cm^2 was used. Another rotameter having flow rate of 50 to 500 lpm calibrated for three different pressures of 0.75, 1 & 1.5 kg/cm^2 was used. Both the rotameters had needle control valves which were used to control the flow rate of hydrogen to the engine. The lay-out of the experimental set-up is given in Plate 1.

After warming up the engine for about 20 to 25 minutes, the tests were conducted at no load, 20% (3.8 kg), 40% (7.7 kg), 60% (11.5 kg), 80% (15.4 kg), 100% (19.2 kg) and 110% (21.1kg) of rated load with diesel fuel and diesel mixed with hydrogen gas in the following order (IS:10000 Part-I to XII, 1980 and Mehta et al 1995

a) 100% diesel run.
b) 10% hydrogen with 90% diesel
c) 20% hydrogen with 80% diesel
d) 30% hydrogen with 70% diesel
e) 40% hydrogen with 60% diesel
f) 50% hydrogen with 50% diesel
g) 60% hydrogen with 40% diesel
h) 70% hydrogen with 30% diesel
i) 80% hydrogen with 20% diesel
j) 90% hydrogen with 10% diesel
k) It was not possible to run at 100% hydrogen gas

For the replacement of diesel with hydrogen, needle control valve of rotameter was used. For example, in an experiment to run the engine with 10% hydrogen and 90% diesel, the flow rate of hydrogen was so adjusted that the engine consumed only 90% of diesel consumption as compared to the diesel consumption when the engine was run on diesel only.

In the above experiments, the performance of the engine which did not allow higher level of diesel replacement with hydrogen gas (either due to knocking or pre-ignition or abnormal engine sound), the experiments were discontinued at that particular level of hydrogen blend.

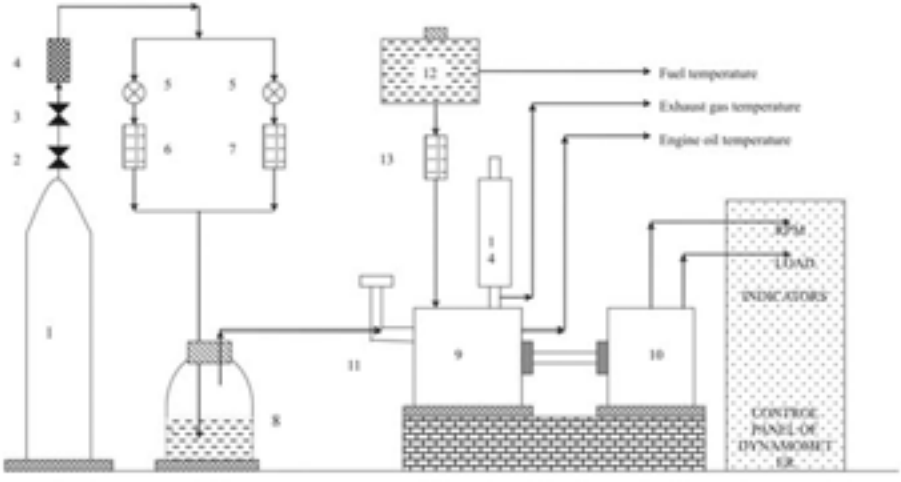
The brake thermal efficiency of the engine was calculated (Anon,2005) as given in Appendix-I.

RESULTS AND DISCUSSION

Brake thermal efficiency is the ratio of output heat energy to the input heat energy. Thus, it indicates the overall efficiency of the engine in converting the fuel energy into heat energy. The effect of dual fuel (diesel + hydrogen) on brake thermal efficiency at various brake loads at fuel injection timings of 23^0, 26^0 & 29^0 B.T.D.C and fuel injection pressures of 180, 200 & 220 kg/cm^2 is shown in Table 1. Brake thermal efficiency at different percentage of diesel at various brake loads at three different fuel injection timings i.e. 23^0, 26^0 & 29^0 B.T.D.C and at three different fuel injection pressures i.e. 180, 200 & 220 kg/cm^2 is shown graphically from Fig. 1 to 9.

When the engine was run on dual fuel, it was observed that up to 80% of full brake load, the engine brake thermal efficiency was maximum at fuel injection timing of 23^0 B.T.D.C. and fuel injection pressure of 180 kg/cm^2. The ignition and engine operation was found to be satisfactory without any ignition aid which is in concurrence with the findings of Ikegami *et al*, (1982). But at higher loads i.e., at 100% & 110% of rated brake load, the engine gave best brake thermal efficiency at fuel injection timing of 26^0 B.T.D.C and fuel injection pressure of 200 kg/cm^2 which was the original manufacturer's setting.

At 20% of rated load, the brake thermal efficiency decreased from 18.1% (at 100% diesel) to 16.44%, 15.33%, 14.81%, 13.90%, 13.80%, 13.80%, 13.80%, 14.18% & 10.26% at 90%, 80%, 70%, 60%, 50%, 40%, 30%, 20% and 10% diesel respectively, at fuel injection timing of 23^0 B.T.D.C. and fuel injection pressure of 180 kg/cm^2.



1. Hydrogen cylinder under pressure, 2 & 3. Double stage double meter regulator
4. Flame preventer, 5. One way gas valve, 6. Rotameter (5-50 lpm)
7. Rotameter (50-500lpm), 8. Flame trap, 9. Engine, 10.Dynamometer
11. Intake manifold, 12. Diesel tank, 13.Diesel flow meter, 14. Silencer

Plate 1: Layout of experimental set-up

At 40% of rated load, the brake thermal efficiency decreased from 27.2% (at 100% diesel) to 25.57%, 24.62%, 24.30%, 23.81%, 23.11%, 22.92%, 18.41%, 18.59% & 18.81% at 90%, 80%, 70%, 60%, 50%, 40%, 30%, 20% and 10% diesel respectively, at fuel injection timing of 23^0 B.T.D.C. and fuel injection pressure of 180 kg/cm^2.

At 60% of rated load, the brake thermal efficiency decreased from 31.7% (at 100% diesel) to 30.29%, 30.10%, 27.48%, 28.72%, 28.30%, 22.22% & 22.69% at 90%, 80%, 70%, 60%, 50%, 40% and 30%, diesel respectively, at fuel injection timing of 23^0 B.T.D.C. and fuel injection pressure of 180 kg/cm^2.

At 80% of rated load, the brake thermal efficiency decreased from 33.1% (at 100% diesel) to 32.40%, 32.48%, 30.74% & 29.50% at 90%, 80%, 70% and 60% diesel respectively, at fuel injection timing of 23^0 B.T.D.C. and fuel injection pressure of 180 kg/cm^2.

At rated load, the brake thermal efficiency decreased from 32.7% (100% diesel) to 31.00% (90% diesel) & 30.50% (80% diesel) at fuel injection timing of 26^0 B.T.D.C.

Table 1: Effect of dual fuel on brake thermal efficiency at various brake loads, fuel injection timings and fuel injection pressures

Brake load (%)	Fuel Injection timing (B.T.D.C)	Brake Thermal Efficiency (%)														
		Percentage of Diesel														
		100			90			80			70			60		
		Fuel injection pressure (kg/cm^2)			Fuel injection pressure (kg/cm^2)			Fuel injection pressure (kg/cm^2)			Fuel injection pressure (kg/cm^2)			Fuel injection pressure (kg/cm^2)		
		180	200	220	180	200	220	180	200	220	180	200	220	180	200	220
20	23^0	18.1	17.9	17.7	16.44	15.65	16.16	15.33	14.83	15.17	14.81	14.21	14.36	13.90	13.36	13.44
	26^0	17.1	17.3	17.1	14.94	15.04	15.33	14.00	14.19	14.58	13.90	13.91	13.90	13.32	13.38	13.51
	29^0	17.2	17.1	17.6	15.24	15.11	15.86	14.29	14.59	15.12	13.91	14.20	14.80	13.70	14.08	14.70
40	23^0	27.2	26.7	26.5	25.57	24.05	24.86	24.62	23.40	24.32	24.30	23.40	23.88	23.81	22.60	23.10
	26^0	25.8	25.8	25.7	23.39	23.19	23.29	22.82	22.62	23.02	22.70	22.60	22.81	22.31	22.19	22.20
	29^0	26.0	25.7	26.1	23.49	23.19	24.10	22.80	23.40	24.00	22.90	23.50	23.79	22.41	22.80	23.51
60	23^0	31.7	31.3	31.2	30.29	29.48	29.80	30.10	27.81	29.41	27.48	28.86	28.72	28.72	27.60	28.40
	26^0	30.5	30.8	30.6	28.61	28.21	28.71	27.92	27.90	28.44	27.61	27.89	27.70	27.39	27.12	27.21
	29^0	30.6	30.3	30.5	27.91	27.72	28.69	27.41	28.30	28.99	27.69	28.59	28.80	27.3	28.07	27.58

Brake load (%)	Fuel Injection timing (B.T.D.C)	Brake Thermal Efficiency (%)														
		Percentage of Diesel														
		100			90			80			70			60		
		Fuel injection pressure (kg/cm^2)			Fuel injection pressure (kg/cm^2)			Fuel injection pressure (kg/cm^2)			Fuel injection pressure (kg/cm^2)			Fuel injection pressure (kg/cm^2)		
		180	200	220	180	200	220	180	200	220	180	200	220	180	200	220
														9		
80	23^0	33.1	32.8	32.7	32.40	31.60	31.39	32.48	31.58	31.80	30.74	30.82	30.56	--	29.50	29.50
	26^0	32.0	32.3	31.9	30.11	30.20	30.01	30.60	30.10	30.38	29.21	29.12	28.32	--	--	--
	29^0	32.3	31.9	32.5	29.80	29.82	31.10	29.79	30.39	31.00	29.30	30.20	--	--	--	--
100	23^0	30.9	30.7	29.8	30.40	30.20	29.29	--	28.70	28.51	--	--	--	--	--	--
	26^0	32.2	32.7	32.1	30.71	31.00	30.50	30.11	--	30.50	--	--	--	--	--	--
	29^0	32.1	31.1	31.5	29.80	29.90	30.50	29.60	--	--	--	--	--	--	--	--
110	23^0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	26^0	30.9	31.5	30.7	29.60	29.50	29.40	--	--	--	--	--	--	--	--	--
	29^0	31.6	28.4	30.9	29.20	28.00	30.10	--	--	--	--	--	--	--	--	--

Table 1 Continued

Effect of dual fuel on brake thermal efficiency at various brake loads, fuel injection timings and fuel injection pressures

Brake load (%)	Fuel Injection timing (B.T.D.C)	Brake Thermal Efficiency (%)														
		Percentage of Diesel														
		50			40			30			20			10		
		Fuel injection pressure (kg/cm^2)			Fuel injection pressure (kg/cm^2)			Fuel injection pressure (kg/cm^2)			Fuel injection pressure (kg/cm^2)			Fuel injection pressure (kg/cm^2)		
		180	200	220	180	200	220	180	200	220	180	200	220	180	200	220
20	23^0	13.80	13.40	13.10	13.80	13.51	12.91	13.80	13.76	13.13	14.18	14.47	13.50	10.26	10.19	9.95
	26^0	13.50	13.11	13.11	13.20	13.20	13.20	13.30	13.30	12.80	13.11	13.40	13.47	9.11	9.29	9.28

	29^0	13.32	13.60	14.10	13.58	13.59	14.10	13.01	13.40	13.91	13.52	13.89	13.66	9.15	9.10	8.86
40	23^0	23.11	22.80	22.01	22.92	22.80	22.20	18.41	18.25	17.52	18.59	18.9	17.80	18.81	18.90	17.80
	26^0	22.50	21.80	22.10	21.81	21.81	21.81	17.50	17.60	17.20	17.32	17.6	17.60	17.69	17.70	17.50
	29^0	22.00	22.58	22.90	21.92	22.01	23.00	17.70	17.70	18.54	17.60	17.7	18.20	17.60	17.60	17.61
60	23^0	28.30	28.00	26.80	22.22	22.03	21.61	--	22.69	21.89	--	--	--	--	--	--
	26^0	26.80	26.80	26.59	21.80	21.39	21.36	--	--	--	--	--	--	--	--	--
	29^0	26.72	26.61	27.00	22.33	21.80	22.10	22.30	20.81	--	--	--	--	--	--	--

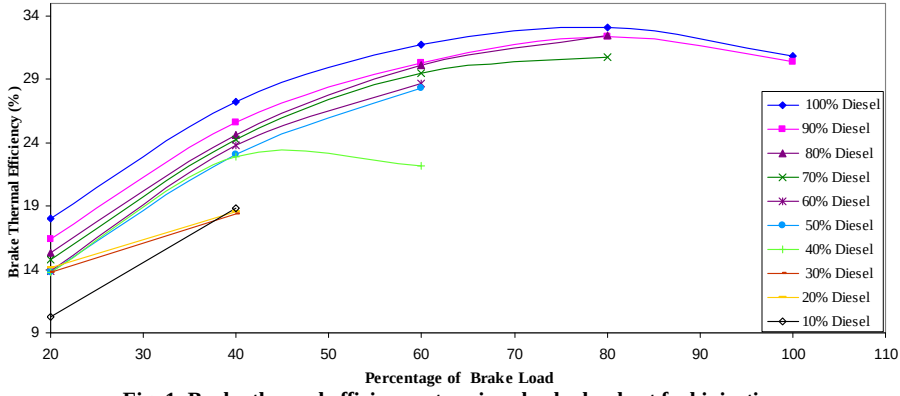


Fig. 1: Brake thermal efficiency at various brake loads at fuel injection timing of 23^0B.T.D.C and fuel injection pressure of 180 kg/cm^2.

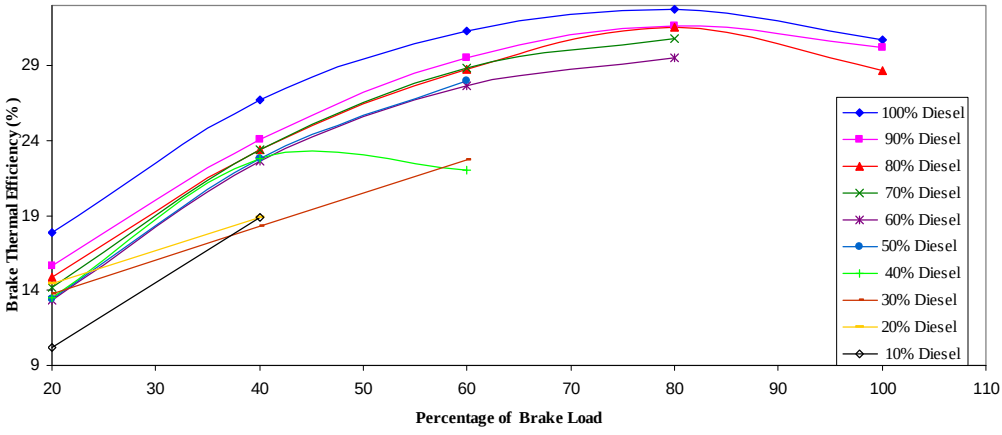


Fig. 2: Brake thermal efficiency at various brake loads at fuel injection timing of 23^0B.T.D.C and fuel injection pressure of 200 kg/cm^2.

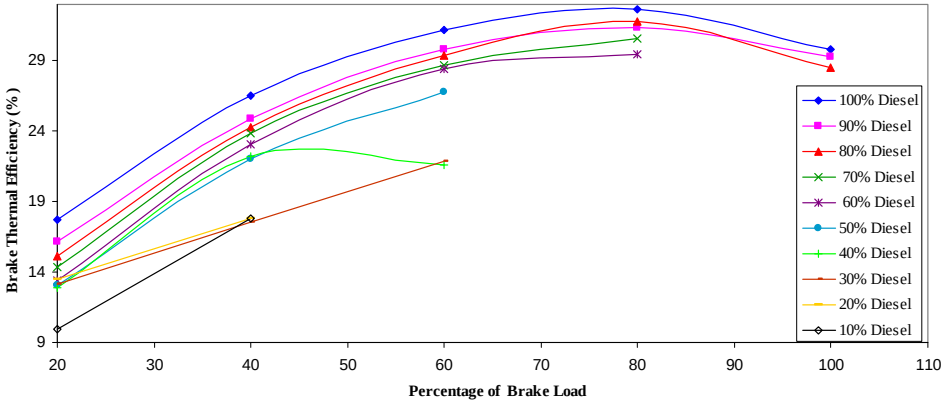


Fig. 3: Brake thermal efficiency at various brake loads at fuel injection timing of 23^0 B.T.D.C and fuel injection pressure of 220 kg/cm^2.

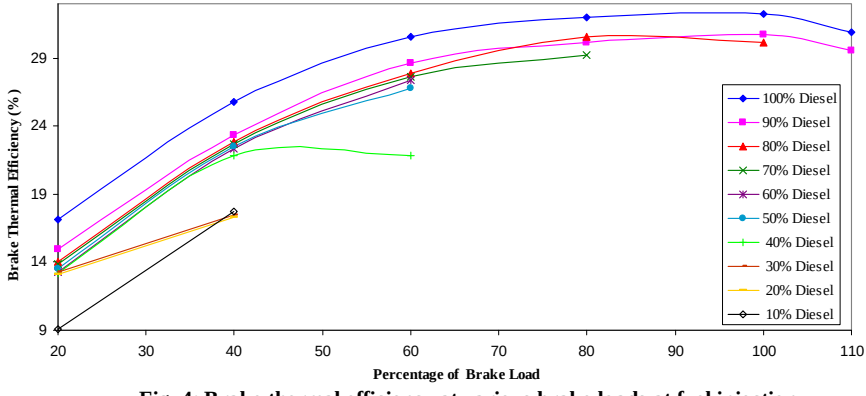


Fig. 4: Brake thermal efficiency at various brake loads at fuel injection timing of 26^0 B.T.D.C and fuel injection pressure of 180 kg/cm^2.

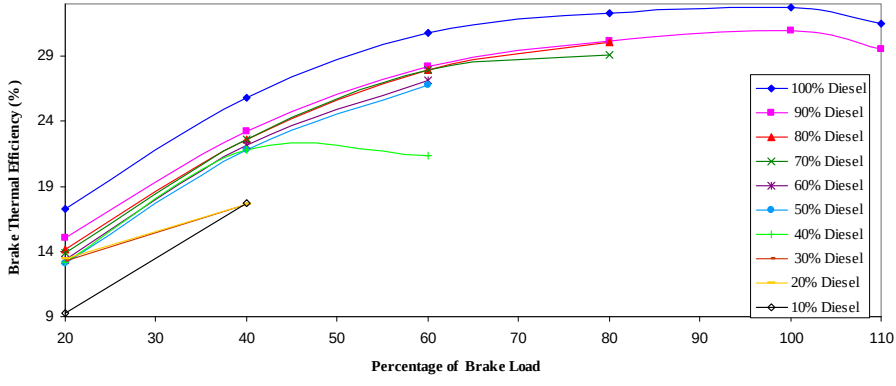


Fig. 5: Brake thermal efficiency at various brake loads at fuel injection timing of 26^0 B.T.D.C and fuel injection pressure of 200 kg/cm^2.

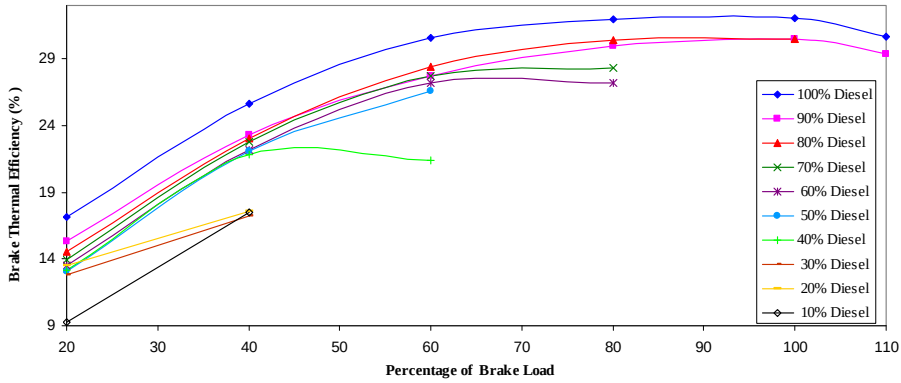


Fig. 6: Brake thermal efficiency at various brake loads at fuel injection timing of 26^0 B.T.D.C and fuel injection pressure of 220 kg/cm^2.

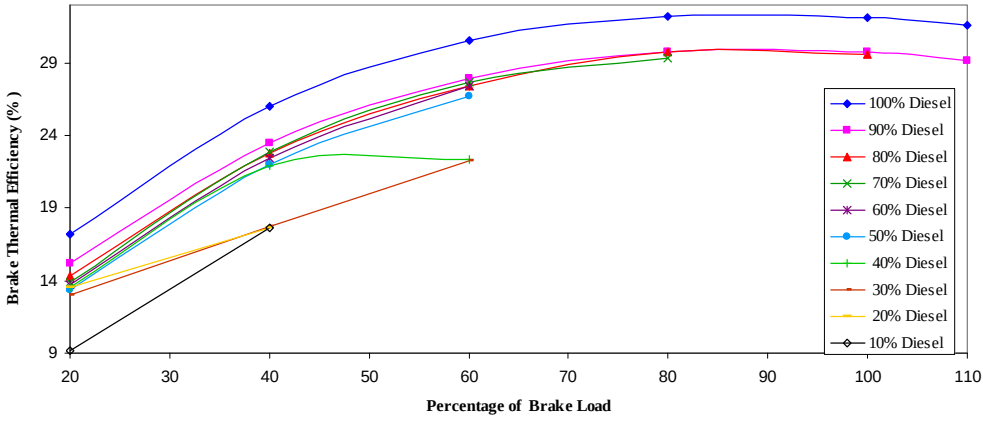


Fig. 7: Brake thermal efficiency at various brake loads at fuel injection timing of 29^0 B.T.D.C and fuel injection pressure of 180 kg/cm^2.

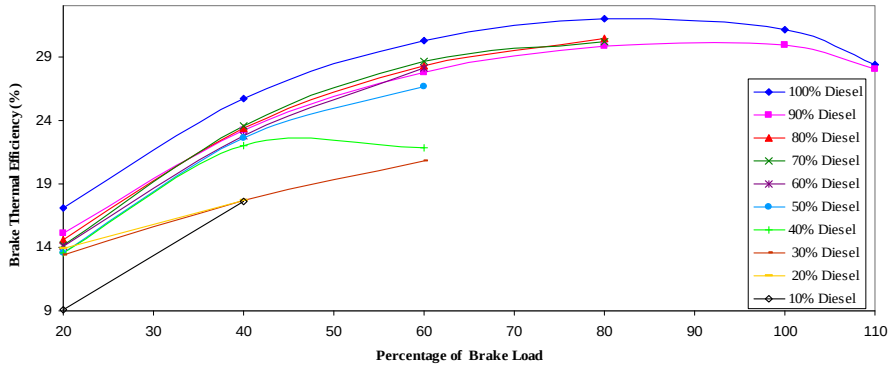


Fig. 8: Brake thermal efficiency at various brake loads at fuel injection timing of 29^0 B.T.D.C and fuel injection pressure of 200 kg/cm^2.

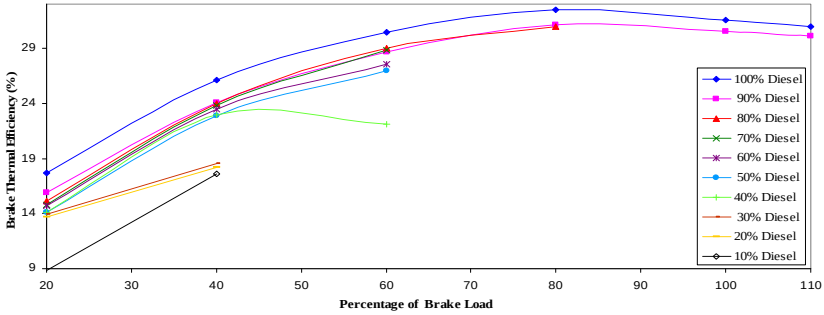


Fig.9: Brake thermal efficiency at various brake loads at fuel injection timing of 29^0 B.T.D.C and fuel injection pressure of 220 kg/cm^2.

Thus, it is very clear that as the percentage of diesel was decreased (corresponding to an increase in the percentage of hydrogen), a decrease in the brake thermal efficiency of the engine was observed at all the loads. This finding is in contradiction with the conclusions drawn by Gopal et al (1982) who reported that the thermal efficiencies obtained were comparable with pure diesel operation. Obviously, in the unmodified engine, same brake thermal efficiency as on 100% diesel could not be expected when run on dual fuel i.e. diesel + hydrogen. The brake thermal efficiency decreased drastically at higher concentration of hydrogen. It might be due to inappropriate ratio of hydrogen and air or incomplete mixing of hydrogen & air or insufficient time for mixing.

CONCLUSION

1. When the engine was run on dual fuel (diesel + hydrogen), it was observed that up to 80% of rated brake load, the engine brake thermal efficiency was maximum at fuel injection timing of 23^0 before top dead center (B.T.D.C.) and fuel injection pressure of 180 kg/cm^2. However, at higher loads i.e., at 100% & 110% of rated brake load, the engine gave maximum brake thermal efficiency at the fuel injection timing of 26^0 B.T.D.C and fuel injection pressure of 200 kg/cm^2 which was the original manufacturer's setting.
2. It was found that as the percentage of diesel was decreased (corresponding to increase in the percentage of hydrogen), there was drop in the brake thermal efficiency of engine at all the loads. The brake thermal efficiency decreased drastically at higher concentration of hydrogen.
3. At 60% of rated brake load, the brake thermal efficiency decreased from 31.7% (at 100% diesel) to 30.29%, 30.10%, 27.48%, 28.72%, 28.30%, 22.22% & 22.69% at 90%, 80%, 70%, 60%, 50%, 40% and 30% diesel respectively, at fuel injection timing of 23^0 B.T.D.C. and fuel injection pressure of 180 kg/cm^2.
4. At 80% of rated brake load, the brake thermal efficiency decreased from 33.1% (at 100% diesel) to 32.40%, 32.48%, 30.74% & 29.50% at 90%, 80%, 70%, and 60% diesel respectively, at fuel injection timing of 23^0 B.T.D.C. and fuel injection pressure of 180 kg/cm^2.
5. At rated load, the brake thermal efficiency decreased from 32.7% (at 100% diesel) to 31.00% (90% diesel) and 30.50% (80% diesel) at fuel injection timing of 26^0 B.T.D.C.

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APPENDIX-I

Calculation of Brake Thermal Efficiency

Let the Diesel Consumption per kWh [SFC (diesel)] = 0.216 kg/kWh

$\therefore$ Heat energy supplied per kWh by diesel = 0.216 kg × calorific value of diesel

= 0.216 kg × 11400 kcal/kg

= 2462.4 kcal.

Let the Hydrogen Consumption per kWh [SFC (hydrogen)] = 0.0124 kg/kWh

$\therefore$ Heat energy supplied per kWh by hydrogen = 0.0124 kg × calorific value of hydrogen

= 0.0124 kg × 33900 kcal/kg

= 420.36 kcal.

Total heat energy supplied by both diesel and hydrogen per kWh

= 2462.4 + 420.36 = 2882.76 kcal.

But the Heat Energy equivalent to one kWh = 860 kcal

We Know

$$1 \text{ kW} = 1000 \text{ W} = 1000 \ {}^{\text{J}}\!/_{\text{sec}}$$

$$\text{But } 1 \text{ cal} = 4.186 \text{ J}$$

$$\therefore 1 \text{ kW} = \frac{1000}{4.186} = 238.89 \ \frac{\text{cal}}{\text{sec}} = 860 \text{ kcal/h}$$

$$\therefore 1 \text{ kWh} = 860 \text{ kcal}$$

$$\therefore \text{Brake Thermal Efficiency} = \frac{\text{Output heat energy}}{\text{Input heat energy}} \times 100$$

$$= \frac{860}{2882.76} \times 100 = 29.83\%$$

Jatropha curcas: A Potential Source for Bio-fuel Production

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ABSTRACT

Jatropha curcas, a multipurpose, drought resistant, perennial plant and considered as one of the major sources of biodiesel. It is easy to establish and grows relatively quickly. Biodiesel, as an alternative fuel has gained significant attention due to the increasing fuel demand of ever increasing population and environmental concern. The wood and fruit of *Jatropha* can be used for numerous purposes including fuel. The seeds of *Jatropha* contain viscous oil, which can be used for manufacture of candles and soap, in cosmetics industry. Jatropha is also used as a diesel/paraffin substitute or extender for meeting the demand for rural energy services and also exploring practical substitutes for fossil fuels to counter greenhouse gas accumulation in the atmosphere. In addition to being a source of oil, *Jatropha* also provides a meal that serves as a highly nutritious and economic protein supplement in animal feed, if the toxins are removed. The plant can be used to prevent soil erosion, to reclaim land, grown as a live fence, especially to exclude farm animals and also planted as a commercial crop. Various parts of the plant are of medicinal value, its bark contains tannin, the flowers attract bees and thus the plant has a honey production potential. Such a multiple utility biofuel crop needs genetic improvement in order to alter its status of wild perennial form to a cultivable crop with higher yield and oil content.

Key words: Biodiesel, *Jatropha curcas*, Medicinal value, Physic nut

INTRODUCTION

Jatropha curcas commonly known as physic nut belonging to family Euphorbiaceae, is a multipurpose plant valued not only for its medicinal properties and resistant to various stresses but also for its use as an oil seed crop. The utilization of liquid fuels such as biodiesel produced from Jatropha oil by trans-esterification process represents one of the most promising options for the use of conventional fossil fuels. The Jatropha oil is converted into jatropha oil methyl ester known as biodiesel, prepared in the presence of homogeneous acid catalyst. The physical properties such as density, flash point, kinematic viscosity, cloud point and pour point of Jatropha oil and Jatropha methyl ester closely matched with the values of conventional diesel and can be used in the existing diesel engine without any modification. The oil is non-edible due to the presence of a toxic substance, 'curcascine'. It is renewable resource, a safe source of energy and a viable alternative to diesel, kerosene, LPG, furnace oil, coal and fuel wood. Currently crop improvement work in this species is very limited. *Jatropha curcas* is a tropical plant that can be grown in low to high rainfall areas either in the farms as a commercial crop or on the boundaries as a hedge to protect fields from grazing animals and to prevent erosion. Before exploiting any

plant for industrial application, it is imperative to have complete information about its biology, chemistry, and all other applications so that the potential of plant could be utilized maximally. Improved agronomic practices of well-managed biomass plantations will also provide a basis for environmental improvement by helping to stabilize certain soils, avoiding desertification, which is already occurring rapidly in tropical countries. Nearly 40% of the land area in India is wasteland. Importance is given on the plantation of *Jatropha* species on waste lands, for the protection of the environment and fulfilling future energy requirements.

BOTANY

The genus Jatropha of Euphorbiaceae family is one of the prospective biodiesel yielding tree crops. It is morphologically a diverse genus comprising 160-175 species of shrubs, rhizomatous shrubs, herbs and small trees. About nine species of Jatropha have been recorded in India. Out of these important ones are *Jatropha curcas, Jatropha gossypifolia, Jatropha glandulifera, Jatropha multifida*, and *Jatropha podagrica*. Out of these nine species *Jatropha curcas* is one of the most important biodiesel yielding crop. *Jatropha curcas* commonly called as ratan jyot, chandrajyot, Jamal gota, Jangli arandi, Kala aranda and physic nut etc, is multipurpose tree of significant economic importance. Linnaeus (1753) was the first to name the physic nut *Jatropha* L. in "Species Plantarum" and this is still valid today. The *J. curcas* is a diploid species with $2n = 22$ chromosomes. The genus name *Jatropha* derives from the Greek word *jatr´os* (doctor) and *troph´e* (food), which implies medicinal uses. The *J. curcas*, by definition, is a small tree or large shrub, with an economic life of up to 35 years and can even extend up to 50 years which can reach a height of three to five meters, but under favorable conditions it can attain a height of 8 or 10m. The shrub has a smooth, gray bark which exudes a whitish color, watery latex when cut. The plant shows articulated growth, with a morphological discontinuity at each increment. Normally, five roots are formed from seedlings, one central and four peripheral. A tap root is not usually formed by vegetatively propagated plants. Leaves five to seven lobed, hypostomatic and stomata are of paracytic (Rubiaceous) type. The size of the leaves ranges from 6-15 cm in length and width. It sheds leaves in the dry season and rejuvenates during the rainy season. Flowering occurs during the wet season and two flowering peaks are often seen, i.e. during summer and autumn. In permanently humid regions, flowering occurs throughout the year. The inflorescence is axillary paniculate polychasial cymes. The plant is monoecious and flowers are unisexual, occasionally hermaphrodite flowers. A flower is formed terminally, individually, with female flowers (tricarpellary, syncarpous with trilocular ovary) usually slightly larger and occurs in the hot seasons. The flowers are pollinated by insects especially honey bees. Each inflorescence yields a bunch of approximately 10 or more ovoid fruits. Jatropha starts producing seeds within 14 months from planting but reaches its maximum productivity level after 4 to 5 years. The seed matures when the capsules changes from green to yellow about 2-3 months after flowering. Three, bivalve cocci is formed after the seeds mature and the fleshy exocarp dries. The seeds are black and the seed weight per 1000 is about 727 g, there are 1375 seeds/kg in the average.

GEOGRAPHY

Jatropha, a drought-resistant shrub or tree, widely distributed in the wild or semi-cultivated areas in Central and South America, Africa, India and South East Asia. It is native of Mexico and tropical South America and reported to have been introduced in Asia and Africa by Portuguese as

an oil yielding plant. Now it is occurring throughout India including Andaman Island in semi wild condition. It adapts well to semi arid marginal site, waste land and dry environment. *Jatropha* grows almost anywhere except waterlogged lands, even on gravelly, sandy and saline soils. It can thrive on the poorest stony soil. It can grow even in the crevices of rocks. The leaves shed during the winter months form mulch around the base of the plant. The organic matter from shed leaves enhances earthworm activity in the soil around the root-zone of the plants, which improves the fertility of the soil. Regarding climate, *Jatropha* is found in the tropics and subtropics and likes heat, although it does well even in lower temperatures and can withstand a light frost. It will grow under a wide range of rainfall regimes from 250 to over 1200 mm per annum. Its water requirement is extremely low and it can stand long periods of drought by shedding most of its leaves to reduce transpiration loss. *Jatropha* is also suitable for preventing soil erosion and shifting of sand dunes. It grows on well-drained soils with good aeration and is well adapted to marginal soils with low nutrient content (Openshaw, 2000). On heavy soils, root formation is reduced. *Jatropha* is a highly adaptable species, but its strength as a crop comes from its ability to grow on very poor and dry sites. A combination of heat and drought stress triggers a complex response involving antagonistic and synergistic interactions as *J. curcas* plants did not show protection against drought-induced oxidative stress, especially at high temperatures (Silva *et al*. 2010). Populations originating from high altitudes had greater chilling-tolerant abilities than populations originating from low altitude. This gives variability in the possibility to breed chilling tolerant genotypes of *J. curcas* for growth and cultivation in higher altitudes and in hill tracts (Zheng *et al.* 2009).

PHYTOCHEMISTRY

Jatropha curcas is a promising species because many products from the plant can be made useful and profitable. The chemical composition of various parts of *Jatropha curcas* plant is shown in the Table 1. These chemicals can be used in various industrial applications. Depending on the variety, the decorticated seeds contain 40–60% of oil (Makkar *et al.*, 1997; Openshaw, 2000), which is used for many purposes such as lighting, as a lubricant, for making soap (Rivera-Lorca and Ku-Vera, 1997) and most importantly as biodiesel. *Jatropha* oil contains approximately 24.60% of crude protein, 47.25% of crude fat, and 5.54% of moisture contents (Akintayo, 2004). Numerous sources are available on the fatty acid composition of physic nut oil originating from different countries. The oil fraction of *Jatropha* contains saturated fatty acids mainly palmitic acid (16:0) with 14.1% and stearic acid (18:0) with 6.7%. Unsaturated fatty acids consisted of oleic acid (18:1) with 47.0%, and linoleic acid (18:2) with 31.6%. The oil with high percentage of monounsaturated oleic and polyunsaturated linoleic acid has a semi-drying property (partially hardens when the oil is exposed to air). This semi-drying oil could be an efficient substitute for diesel fuel. Treatment of plants with growth regulators significantly influenced the production of hydrocarbons. Among the treatments, ethephon and morphactin induced the maximum production of hydrocarbon with 5.0 and 5.4%, respectively (Augustus *et al.*, 2002).

Table1: Chemicals isolated from different parts of the plant.

Various parts	Chemical composition	References
Aerial parts	Organic acids (*o* and *p*-coumaric acid, *p*-OH-benzoic acid, protocatechuic acid, resorsilic acid, saponins and tannins, □-Amyrin, □-sitosterol and taraxerol	Hemalatha and Radhakrishnaiah (1993)
Stem bark	□-Amyrin, □-sitosterol and taraxerol	Mitra *et al.* (1970)
Leaves	Cyclic triterpenes stigmasterol, stigmast-5-en-3□, 7□-diol, stigmast-5-en-3□,7□-diol, cholest-5-en-3□,7□-diol, cholest-5-en-3fl,7□-diol, campesterol, □-sitosterol, 7-keto-□-sitosterol as well as the □-d-glucoside of □-sitosterol. Flavonoids apigenin, vitexin, isovitexin. Leaves also contain the dimer of a triterpene alcohol (C63H117O9) and two flavonoidal glycosides	Khafagy *et al.* (1977), Hufford and Oguntimein (1987) Khafagy *et al.* (1977)
Latex	Curcacycline A, a cyclic octapeptide Curcain (a protease)	Van den Berg *et al.* (1995) Nath and Dutta (1991)
Seeds	Curcin, lectin Phorbolesters Esterases (JEA) and Lipase (JEB)	Stirpe *et al*. (1976) Makkar *et al.* (1997) Staubmann *et al.* (1999)
Seed Kernel and press cake	Phytates, saponins and a trypsine inhibitor	Aregheore *et al.* (1997), Wink *et al*. (1997)
Roots	□-Sitosterol and its □-d-glucoside, marmesin, propacin, the curculathyranes A and B and the curcusones A–D. diterpenoidsjatrophol and jatropholone A and B, the coumarintomentin, the coumarino-lignanjatrophin as well as taraxerol	Naengchomnong *et al.* (1994)

TOXICITY

The seeds of *Jatropha curcas* are a good source of oil, which can be used as a diesel substitute. However, the seeds of *J. curcas* are, in general, toxic to humans and animals. *Curcin*, a toxic protein isolated from the seeds, was found to inhibit protein synthesis in *in vitro* studies. The high concentration of phorbol esters present in *Jatropha* seed has been identified as the main toxic agent responsible for *Jatropha* toxicity (Adolf *et al.*, 1984; Makkar *et al.*, 1997; Makkar *et al.* 1998). Several cases of *J. curcas* nut poisoning in humans after accidental consumption of the seeds have been reported with symptoms of giddiness, vomiting and diarrhoea and in the extreme condition even death has been recorded (Becker and Makkar, 1998). Ionizing radiation treatment could serve as a possible additional processing method for inactivation or removal of certain anti-nutritional factors such as phorbol esters, phytates, saponins and lectins (Siddhuraju *et al.*, 2002). It is not possible to destroy phorbol esters by heat treatment because they are heat stable and can withstand roasting temperature as high as 160 ◦C for 30 min. However, it is possible to reduce its concentration in the meal by chemical treatments. This treatment is promising, but in economic terms it is expensive to produce *Jatropha* meal from it (Aregheore *et al*., 2003). Complete removal of the toxins is therefore necessary before *Jatropha* oil can be used in industrial applications or in human medicine, the oil must be shown to be completely innocuous before it is used commercially.

PROPAGATION METHODOLOGY

Jatropha can be grown in marginal wastelands due to its ability to adapt to adverse agroclimatic conditions. It has an estimated annual production potential of 200,000 metric tonnes in India (Tiwari *et al.* 2007). *Jatropha curcas* can be established from seed, seedlings and cuttings. Jatropha can be bred by both seeds and cuttings. Seed breeding has high survival rate but its seedlings will fruit only after 3–4 years. In addition, tissue culture of Jatropha has been bred successful in the laboratory.

a) **Seeds:** When direct seeding methods are used (planting directly into the ground), seeds are the cheapest method of propagation of Jatropha. Jatropha is rich in seeds with large size. Seed seedlings can easily grow typical taproot with four lateral roots, and fruit after 3–4 years (Lin *et al.*, 2004). Afforestation is generally undertaken in early May with 3–4 seeds in a pit with spacing of 0.8–1.0 m in the ditch and riverside areas, but spacing of 0.4–0.6 m in the eroded slopes (Wang, 2005). However, due to weed competition, insect damage or other soil borne problems, this method of propagation may result in lower germination rates and less plants growing into seedlings and then to mature trees.

b) **Seedlings:** Seedlings are produced from seeds but are grown in small containers (bags or pots) in a more controlled environment such as a nursery shed or greenhouse. Using this method of propagation, non germinated seeds are easily identified and the only plants transferred to the field are developed seedlings which, because of established root and shoot systems stand a better chance of surviving once transferred to the field. A start-up plantation will benefit from using this method in the initial stages of production.

c) **Cuttings:** Cuttings are genetic clones and will therefore be equally as resistant or susceptible to pest, disease, environmental or physiological problems as the mother plant. It is important to select mother trees, ages and diameter of cuttings, proper seedbeds as well as to disinfect them during propagation. Cutting seed beds should be chosen from the flat lands with high water table, good drainage, medium soil fertility and loose sandy loam. Deep plowing, size reduction of soil, fertilizer use, proper moisture and disinfection for soil are needed. Robust plants aged 10 years old or less, without pests but with complete tree shapes, clean stems and healthy rich-seeds are selected as mother trees. Semi-lignified branches from the current-year grown trees or robust branches without pests from the 1 to 2 years old trees are selected as cuttings that have diameters of 1.5–3.0 cm and lengths of 12–15 cm with 2–5 buds. Cross-section of "horseshoe mouth" is cut, and coated with melted wax and soaked in carbendazim solution (50% diluted with 800 times) for 10 min. After natural drying, it is soaked again in ethylene solution (20 mg/L) for 2 h. The cuttings are planted in the spring or autumn as the following procedure:

   i) Make inclined holes with depth of 6–8 cm and spacing 15 cm × 20 cm in the seedbed
   ii) Inserting cuttings along the hole channels to the end and pressing the soil around the cuttings
   iii) Keep the cuttings in the greenhouse at temperature 25–28 ◦C and more than 80% humidity.
   iv) Weeding manually and spraying the bed with 1% urea solution for after 2–3 leaflets appear.
   v) Using 0.2% KH_2PO_4 to fertilize the root zone, 5–7 days before transplantation, and

vi) Controlling watering to harden seedlings, 10 days before transplantation. In the next year, seed yield per plant after planted will be up to 3 kg, an increase in subsequent years [Wang, 2005, Li and Liu, 2006].

However, *Jatropha* trees propagated by cuttings show a lower longevity and possess a lower drought and disease resistance than those propagated by seeds (Purkayastha *et al.* 2010), this is because the trees produced from cuttings produce pseudo-taproots that may penetrate only 1/2 to 2/3rd the depth of the soil.

d) **Tissue Culture and Biotechnology:** New seedlings could be bred through tissue culture of embryos, cotyledons, epicotyls, hypocotyls, petioles, leaves, or even the tender stems with over 20 years old trees (Sardana and Batra, 2000; Lin *et al.*, 2002; Lu *et al.*, 2003; Wei *et al.*, 2004; Chen *et al.*, 2006). This technique will maintain not only the genetic stability of future generations but also rapid propagation. In addition, tissue culture from the seedling stems could induce sprouting and rooting, and rooting frequency reached up to 78.3% [Lin *et al.*, 2002]. It was reported that the endosperm and pollen were also successfully cultured. Jatropha endosperm calluses were induced most effectively by 2.0 mg/L 2,4-dicholrophenoxyacetic acid (2,4-DA), followed by 1-naphthlacetic acid (NAA), IBA, indoleacetic acid (IAA). But the induction by BA and kinetin (KT) was insignificant. Addition of thidiazuron (TDZ) can promote the formation of endosperm calluses (Hou *et al.*, 2006). The mononucleus at middle-late stage is the best period for the callus induction at conditions of low temperature of 4°C, processing time of 4–5 days and MS medium with {2.0 mg/L NAA + 0.4 mg/L KT + 9% sucrose} (Ren *et al.*, 2006). The seed yield per plant could be enhanced by employing biotechnological tools like marker-assisted selection of quality planting material. Use of molecular markers are of great significance in applying genetic technologies to crop improvement such as DNA fingerprinting of plant germplasm, introduction of new strain, marker assisted selection and targeted map based cloning etc. The first advancement came with the introduction of RFLP markers. It helps in assessing the molecular diversity of *Jatropha* germplasm and can be used in breeding program (Kumar, 1999). Recently a new full length cDNA of stearoyl-acyl carrier protein desaturase was obtained by RTPCR and RACE techniques from developing seeds of *Jatropha* and the gene was functionally expressed in *E. coli* (Tong *et al.*, 2006). It is an important enzyme for fatty acid biosynthesis in higher plants and also plays an important role in determining the ratio of saturated fatty acid to unsaturated fatty acids in plants. For understanding the molecular mechanism of salt and drought tolerance, a new full length cDNA encoding aquaporin (JcPIP2) was isolated from seedling of *Jatropha curcas*, the abundance of JcPIP2 was induced by heavy drought stress and it play an important roles in rapid growth of *Jatropha* under dry conditions (Ying *et al.*, 2007).

CULTIVATION, HARVESTING AND PROCESSING OF SEEDS

The number of trees per hectare at planting may range from 1100 to 3300. Growth of the plants is dependent on soil fertility and rainfall. Management of jatropha requires the addition of manure and NPK to the planting hole @ 2kg compost, 20g urea, 120g SSP and 16 g MOP and urea should be applied in two splits (one and two months after transplanting) @ 10 g per plant (Singh *et al.* 1996). Yearly top dressings of fertilizers including the seed cake should be done. *Jatropha curcas* begins bearing seeds within nine months, reaches commercial productivity in three years and lives for up to 50 years. The potential seed yield of jatropha after five years is 6 tons to as high as 12

tons per hectare depending on the site, climate and management of the plants. (Jones and Miller, 1991; Ouwens *et al.*, 2007).

Seeds can usually be harvested one year after planting. It is best to harvest the fruits when these have turned yellow to dark brown. Approximately two to three months after flowering, seeds should be collected when the capsules have split open. Seeds should not be dried in direct sunlight because it will affect its germination. One kilogram of jatropha seeds consists of 600 to1, 600 pieces of seeds. The potential yield of jatropha per hectare is 6 tons to as high as 10 tons depending on the site, climate and management of the plants. Seeds are de-hulled by using wooden plank and then winnowed to separate the hulls from the seeds. Before storing, the seeds must be air dried to 5% - 7% moisture content and stored in air-tight containers. Seeds can be stored up to one year at room temperature. Seeds for replanting can be gathered when fruits are already yellow to dark brown. Dry, black seeds can be used for oil extraction (Makkar *et al.* 1998). The major goal of jatropha cultivation is performed for the sake of extracting jatropha oil. Analysis of *Jatropha curcus* seed shows the following chemical compositions: Moisture: 6.20%, Protein: 18.00%, Fat: 38.00%,Carbohydrates: 17.00%, Fiber: 15.50%, Ash: 5.30%. The oil content is 25-30% in the seed. The oil contains saturated fatty acids and unsaturated fatty acids in the ratio of 1:4. Seeds of Jatropha contain a chemical element *cursin*, which is poisonous and render the oil not appropriate for human consumption. By thermodynamic conversion process, pyrolysis, useful products can be obtained from the jatropha oil cake. The liquid, solid (char), and gaseous products can be obtained. The liquid can be used as fuel in furnace and boiler. It can be upgraded to higher grade fuel by trans-esterification process. Jatropha oil can be used directly in Diesel engines added to Diesel fuel as an extender or transesterified to a bio-diesel fuel. There are some technical problems to using jatropha oil directly in Diesel engines that have yet to be completely overcome. Moreover, the cost of producing jatropha oil as a Diesel substitute is currently higher than the cost of Diesel itself. It will also be used in big Diesel engine based electricity generating sets, pump sets, heavy farm machinery, where the viscosity of oil is not an issue.

Steps involved in Biodiesel production

I. **Extraction** may be done mechanically (by pressing the kernels), chemically and enzymatically. Various methods of oil extraction are as follows:

   a) ***Oil Presses*:** Oil presses have been used for the purpose of oil extraction as simple mechanical devices either powered or manually driven such as Bielenberg ram press. The Bielenberg ram press involves the traditional press method to extract oil and prepares oil cakes as well as soaps. It is a simple device that yields around3 liters of oil per 12 kg of seed input. Since the recognition of jatropha as an alternative energy sources (biofuel), jatropha oil extraction methods have also gained due importance in the market and the optimization of existing methods of extracting the oil have become significant.

   b) ***Oil Expellers*:** The most commonly used oil expellers of jatropha oil extraction are the Sayari oil expeller (also called Sundhara oil expeller) and the Komet Expeller. The Sayari expeller is a diesel-operated oil extraction device that was originally developed in Nepal. It is now being developed for use in Tanzania and Zimbabwe for jatropha oil extraction and oil cake preparation. The prototype included heavy parts made of cast iron. The lighter version has the cast iron replaced with iron sheets. A model driven by electricity is also

available. The Komet expeller is a single-screw oil expeller that is often used for extracting jatropha oil from the seeds and also for the preparation of oil cakes.

c) ***Modern Concepts:*** Methods like ultrasonication have been discovered to be effective in increasing the percentage of jatropha oil that can be extracted using chemical methods like aqueous enzymatic treatment. The optimum yield for such methods has been discovered to be around 74%. Jatropha oil extraction methods are still being researched. The goal of such researches is to discover methods to extract a greater percentage of jatropha oil from the seeds than the current procedures allow.

II. Purification of oil

a) ***Trans-esterification:*** Is the process of chemically reacting a fat or oil with an alcohol in a presence of a catalyst. Alcohol used is usually methanol or ethanol. Catalyst is usually sodium hydroxide or potassium hydroxide. The main product of transesterification is biodiesel and the co-product is glycerin.

b) ***Separation:*** After transesterification, the biodiesel phase is separated from the glycerin phase, both undergo purification .The chemical properties of jatropha oil (Table 2) are given below.

Table 2. Chemical properties of Jatropha oil and Fatty acid composition

Itemi	Value
Palmitic acid (%)	4.2
Stearic acid (%)	6.9
Oleic acid (%)	43.1
Linoleic acid (%)	34.3
Other acids (%)	1.4
Item	Value
Acid Value	38.2
Saponification value	195.0
Iodine Value	101.7
Viscosity (at 31 °C)	Centistokes 40.4
Density (g/cm^3)	0.92

Yield of Jatropha Oil: The optimum oil content in jatropha plants varies between species and genetic variants. Climatic and soil conditions generally affect the yield of the oil as well. However, improper processing techniques such as prolonged exposure of the harvested seeds to direct sunlight can impair the oil yield considerably. The maximum oil content that has been reported in jatropha seeds has been close to 47%. However, the accepted average is 40%, and the fraction that can be extracted is taken to be around 91%.

ECONOMIC IMPORTANCE

Economic significance of Jatropha are presented in Fig. 1.

i) **As an energy source:** The oil from *Jatropha* is regarded as a potential fuel substitute. The types of fuels, which can be obtained directly from the *Jatropha* plant, are: - wood, the whole fruit and parts of the fruit which can be burnt separately or in combination. Processing

increases the energy value of the product, but the overall energy availability decreases unless a use can be found for the by-products. Recently novel approach is developed for extraction of oil from seed kernel of *Jatropha* by using enzyme assisted three-phase partitioning (Shah *et al.*, 2004).

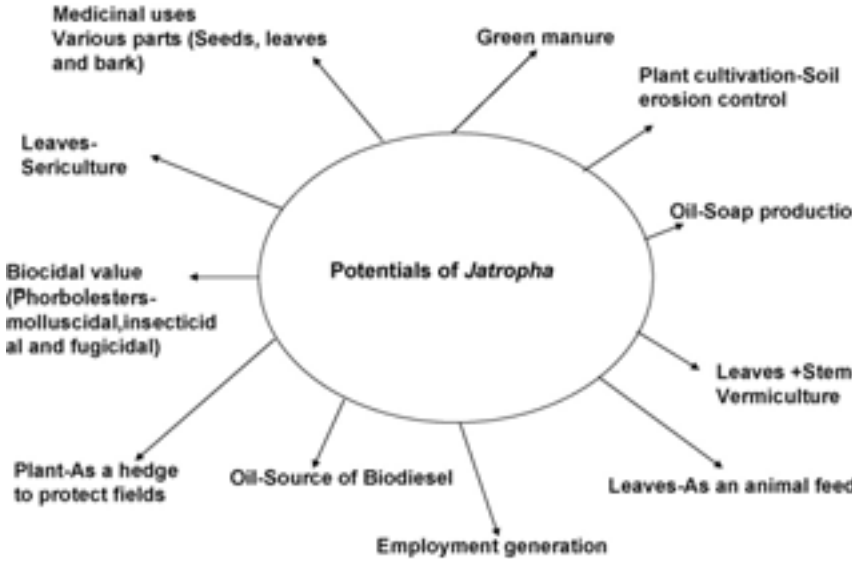

Fig. 1 – Economic significance of *J. curcas*.

ii) **Biodiesel from physic nut:** *Jatropha* oil can be used as fuel in diesel engines directly and by blending it with methanol (Gubitz *et al.*, 1999). The seed oil of *Jatropha* was used as a diesel fuel substitute during the World War II. Engine tests with *Jatropha* oil were done in Thailand, showing satisfactory engine performance (Takeda, 1982). The economic evaluation has shown that the biodiesel production from *Jatropha* is very profitable provided the by-products of the biodiesel production can be sold as valuable products (Foidl and Eder, 1997). Berchmans and Hirata (2008) and Tiwari *et al.* (2007) have been developed a technique to produce biodiesel from *Jatropha* with high free fatty acids contents (15% FFA), in which two-stage transesterification process was selected to improve methyl ester yield. The first stage involved the acid pretreatment process to reduce the FFA level of crude *Jatropha* seed oil to less than 1%and second was the alkali base catalyzed trans-esterification process gave 90% methyl ester yield. In order to reduce the cost of biodiesel fuel production from *Jatropha*, the lipase producing whole cells of *Rhizopus oryzae* immobilized onto biomass support particles was used and found to be a promising biocatalyst for producing biodiesel (Tamalampudi *et al.*, 2007). Moreover important properties of *Jatropha* and other selected seed oil are presented in Table 3.

Table 3. Properties of Diesel, methanol, Jatropha oil and methyl esters of jatropha oil (Vinayak and Kanwarjit, 1991; Basker, 1993)

Properties	Diesel	*Jatropha* oil	Methyl ester of *Jatropha* oil	Methanol
Density (kgm−3)	840	918.6	880	790

Calorfic value (kJ kg−1)	42,490	39,774	38450	19674
Viscosity (cst)	4.59	49.93	5.65	-
Cetane number	45-55	40-45	50	3–5
Flash point (◦C)	50	240	170	-
Carbon residue (%)	0.1	64	0.5	0.0

iii) **As jet fuel:** Aviation fuels may be more widely substituted with biofuels such as jatropha oil than fuels for other forms of transportation. On December30, 2008, Air New Zealand flew the first successful test flight with a Boeing 747 running one of its four Rolls-Royce engines on a 50:50 blend of jatropha oil and jet A-1 fuel. Subsequently, Air New Zealand and Houston based Continental Airlines have run tests in Jan. 2009, further demonstrating the viability of jatropha oil as a jet fuel.

iv) **As hedge:** *Jatropha* is an excellent hedging plant generally grown in most part of India as live fence for protection of agricultural fields against damage by livestock as unpalatable to cattle and goats. Thus in addition to seed yields it serves the purpose of bio fence with respect to cost effectiveness as compared to wire fence.

v) **As green manure and fertilizers:** Seed cake or press cake is a by-product of oil extraction. *Jatropha* seed cake contains curcin, a highly toxic protein similar to ricin in castor, making it unsuitable for animal feed. However, it does have potential as a fertilizer or biogas production (Staubmann *et al*., 1997; Gubitz *et al.*, 1999), if available in large quantities; it can also be used as a fuel for steam turbines to generate electricity. The defatted meal has been found to contain a high amount of protein in the range of 50–62%, and the level of essential amino acids except lysine is higher than the FAO reference protein (Makkar *et al*., 1998). Being rich in nitrogen, the seed cake is an excellent source of plant nutrients. In a green manure trial with rice in Nepal, the application of 10 tonnes of fresh physic nut biomass resulted in increase yield of many crops (Sherchan *et al*., 1989).

vi) **As food:** The physic nut seed is eaten in certain regions of Mexico once it has been boiled and roasted (Delgado and Parado, 1989). *Jatropha* can be toxic when consumed, however, a non-toxic variety of *Jatropha* is reported to exist in some provenances of Mexico and Central America, said not to contain toxic Phorbol esters (Makkar *et al.,* 1998). This variety is used for human consumption after roasting the seeds/nuts, and "the young leaves may be safely eaten, steamed or stewed" (Duke, 1985; Ochse, 1931) Sujatha *et al*. (2005) have been established the protocols for *in vitro* propagation of non-toxic variety of *Jatropha* through axillary bud proliferation and direct adventitious shoot bud regeneration from leaf segments.

vii) **Soap:** The glycerin that is a by-product of biodiesel can be used to make soap, and soap can be produced from *Jatropha* oil itself. In either case the process produces a soft, durable soap and is a simple one, well adapted to household or small-scale industrial activity.

viii) **Pesticide:** The oil and aqueous extract from oil has potential as an insecticide. For instance it has been used in the control of insect pests of cotton including cotton bollworm and on pests of pulses, potato and corn (Kaushik and Kumar, 2004). Methanol extracts of *Jatropha* seed (which contains biodegradable toxins) are being tested in Germany for control of bilharzia-carrying water snails.

ix) **Charcoal:** In simple charcoal making, 70–80% of wood energy is lost with yield of only 30% in an industrial process, where charcoal is still one of the few simple fuel options.

Jatropha wood is a very light wood and is not popular as a fuel wood source because it burns too rapidly. Seed cake results very high-quality charcoal that has the potential to be used in high value markets. The use of press cake as a fertilizer is more valuable to increase crop production than charcoal making from it (Kumar and Sharma 2008). However, the extraction of oil from *Jatropha* seeds is of much higher economic value than converting the wood to charcoal. Converting *Jatropha* seed shells into charcoal would be economically feasible, only if we have a large source of seed shells from *Jatropha* plantations.

x) **Ecorestoration and Controlling Soil Erosion:** *Jatropha curcas* is capable of growing on marginal land, and helps to reclaim problematic lands and prevent soil erosion. So the cultivation of Jatropha leads to the conservation of degraded lands, oil (eco-)restoration and management by preventing soil erosion, protects plants against wind erosion and the roots also form a protection against water erosion (Heller 1996). The plant also serves as protective fence around agricultural fields against live stocks influx and grazing. This is a low cost biofence compared to wire fence and has the advantage of being easily be propagated by cuttings, densely planted or spaced and not fed by cattle.

xi) **Medicinal uses:** All parts of *Jatropha* (seeds, leaves and bark) have been used in traditional medicine and for veterinary purposes for a long time (Duke, 1988). Uses of various parts of *Jatropha* in the treatment of diseases have been presented in Table 4. Substances such as phorbol esters, which are toxic to animals and humans, have been isolated and their molluscicidal, insecticidal and fungicidal properties have been demonstrated in lab-scale experiments and field trials (Nwosu and Okafor, 1995; Solsoloy and Solsoloy, 1997).The seed oil can be applied to treat eczema and skin diseases and to soothe rheumatic pain (Heller, 1996). The latex of Jatropha contains several alkaloids *viz* Jatrophine, Jatropham and curcain with anti-cancer properties (Thomas *et al.* 2008). The roots are reported as an antidote for snake-bites. The 36% linoleic acid (C18:2) content in *Jatropha* kernel oil is of possible interest for skincare. The oil has a strong purgative action and is also widely used for skin diseases and to soothe pain caused by rheumatism. The latex itself has been found to be strong inhibitors to water melon mosaic virus (Tewari and Shukla, 1982). The leaves and latex are used in healing of wounds, refractory ulcers, and septic gums and as a styptic in cuts and bruises. A proteolytic enzyme (curcain) has been reported to have wound healing activity in mice (Nath and Dutta, 1997; Villegas *et al.*, 1997). Investigation of the coagulant activity of the latex of *Jatropha* showed that whole latex significantly reduced the clotting time of human blood. Diluted latex, however, prolonged the clotting time, at high dilutions, the blood did not clot at all (Osoniyi and Onajobi, 2003; Oduola *et al.* 2005).

Table 4. Uses of different parts of *Jatropha curcas* in medicines (Kaushik and Kumar, 2004)

Plant part used	Diseases
Seeds	To treat arthritis, gout and jaundice
Tender twig/stem	Toothache, gum inflammation, gum bleeding, pyorrhea
Plant sap	Dermatomucosal diseases
Plant extract	Allergies, burns, cuts and wounds, inflammation, leprosy, leucoderma, scabies and small pox
Water extract of branches	HIV, tumor
Plant extract	Wound healing

xii) **Potential conservation benefits:** The primary conservation benefits to be derived from production of *Jatropha* relate to improved soil restoration and management. The findings of Kumar *et al.* (2008) have shown that the heavy metal contaminated soil can be restored by using combination of industrial wastes and suitable bioinoculants strain (*Azotobacter*). *Jatropha* in addition to protecting crops from livestock, it reduces wind erosion and pressure on timber resources and increases soil moisture retention. Nevertheless, *Jatropha* does mine soil nutrients. *Jatropha* oil projects are expected to provide income and organic fertilizer to increase crop yields, as well as being an ecologically friendly source of alternative energy to rural farmers.

CONCLUSION

J. curcas is a "miracle tree" and certainly a highly interesting plant with potential uses, particularly as biofuel to help in combating the energy crisis throughout the world and generate income in rural areas of developing countries. The jatropha plant can become globally competitive due to the fact that it belongs to a non-edible category and does not compete with food. Jatropha oil is a clean fuel reducing greenhouse gas emissions, has greater lubricity and reduces engine wear. Pure jatropha biodiesel is non-toxic in nature. The literature reveals several successful application of jatropha which includes functions like soil water conservation, soil reclamation, erosion control, living fences, green manure, and lightening fuel, local use in soap production, insecticide and as raw material for pharmaceutical and cosmetic industries. From the above discussions, it is clear that the jatropha plant has capabilities to provide the products for different applications apart as a diesel substitute which needs to be captured and improved. Jatropha is economically viable not only to the growers but also to the processors and end users. To the rural society, the crop can create regular employment opportunities, as it provides never ending marketing potential. The research on the utilization of the by-products of jatropha namely seed husk, seed kernel, glycerol, etc. in the material manufacturing area needs to be explored. Further large wasteland could be utilized for the cultivation of non-edible oil producing trees for production of biodiesel.

FUTURE STUDIES

The yield and quality of the oil from seeds of the non-toxic genotype of Jatropha are similar to those of the toxic genotype. Studies for a comparative evaluation of the two genotypes for their seed yield and disease susceptibility should be conducted. Selection, breeding and agronomic studies for both genotypes need to be undertaken. Various bioactive moieties and their pharmaceutical and biological effects appear to have been reported using the toxic genotype of Jatropha. It would be interesting to examine the presence of activities in various parts of the non-toxic Jatropha plant. The oil from the toxic genotype could be freed of phorbol esters using the deodorisation or stripping process, an oil pretreatment process, during the process of biodiesel production. The deodorisation/stripping process could be optimised to obtain oil free of phorbol esters. Phorbol ester degradation products could possibly be present in the treated oil so obtained. The toxicity of the stripped oil free of phorbol esters should be investigated using rat and fish as experimental models. The fatty acid composition of Jatropha oil is close to olive oil and the Jatropha oil free of phorbol ester and its degraded products therefore would be a high-value product. Using the non-toxic genotype, normally, the oil would be used as edible oil; the spare oil, if available, could be turned into biodiesel, with the generation of glycerol as a by-product for

edible uses. The seed meal obtained from the non-toxic genotype would find application as livestock feed. On the other hand, for the toxic genotype, the oil would be turned into biodiesel with the production of glycerol and other coproducts for various industrial applications. The detoxified seed meal would be used as fish or livestock feed. The seed cake from the toxic genotype could also be used as a fertilizer or as a substrate for the production of industrial enzymes through fermentative processes. Another plausible scenario would be the extraction of phorbol esters from the toxic oil for use as a high-value biopesticide, and then use of the oil, now containing low levels of phorbol esters, as a feedstock for biodiesel production. A comparative life cycle analysis taking into account the various uses/possibilities listed here would help to assess the environmental impact of producing and using the toxic and non-toxic oils. The comparative life cycle analysis coupled with a socio-economic analysis would lead to the identification of sustainable approaches for exploitation of the Jatropha plant.

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Biogas Plant a Check for Environment Pollution and Global Warming

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ABSTRACT

Biogas produced by anaerobic digestion of organic wastes generated by human population, cattle and poultry is a rich source of clean and environmental friendly renewable energy for kitchen and power generation. Author in this paper have developed a large biogas plant for digesting wastes from a dairy with 500 animals to meet the demand for the kitchen and electricity of the dairy. The biogas plant is fully functional for the past three years to cater demand of the dairy. The whole of biogas plant digester and dome (gas holder) is under ground to keep it warm during winter and the space above the plant can be utilized for any other purpose like storage of fodder etc. The plant generates 250 m^3 of biogas per day sufficient to produce 300 kilo watts of electricity. Three labours are required to bring the dung from the sheds in animal driven car to charge the plant daily and run the generator. The digested slurry waste so produced is a rich source of organic manure free from smell and odour for the field. The plant is most cost effective which can be recovered within four to five years period. The owner of the dairy is most satisfied with the performance and result is that more and more dairy farmers are adopting this technology.

Key Words: Large capacity biogas plants, power generation, economics

INTRODUCTION

Under crop diversification, most of the farmers have adopted dairy farming as an alternative. Even educated youths are very much attracted towards modern dairy farms for white revolution. Although it is not easy to keep livestock healthy for dairy without proper green fodder, nutritional feed and neat and clean water. The atmosphere all around the dairy area should be free from smell as cattle produce lot of semisolid and liquid organic waste which would attract flies and rodents to cause health problem for human and animals. This would require proper sanitary management for organic waste handling from the animal sheds and handle it scientifically. Biogas plant is the only remedy to handle the solid and liquid waste coming out of the dairy sheds. This not only stabilize the waste anaerobically and make waste free from odour but at the same time plenty of biogas is produced for cooking and power generations at the dairy farm for running tubewell and other appliances. The digested organic waste is good quality manure for crops at the farm. The whole process is a step to stop global warming (Singh *et al.*, 2000; Sooch, 2010)

In Punjab alone, thousands of family size biogas plants are satisfactorily functioning for the past two decades for 5-10 cattle heads, but now the concept is slightly changing for keeping large herds of cattle as a whole time job for the keepers. In Punjab, there are around 3000 diary farms

for the production of milk each having capacity from 50-500 cattle. Thus, there is huge quantity of cattle dung is available for the production of biogas. So, large capacity (50-300 m^3) biogas plants based on cattle dung are being installed in Punjab with such dairy farms. (Sooch *et al.*, 2009 a; Sooch *et al.*, 2009c)

METHOD AND MATERIAL

To meet the increasing demand of dairy farmers for efficient and economical biogas plant of large capacity is developed at PAU, having its gas holder fixed one and of hemispherical shape. The hemispherical dome is structurally safer and crack free because whole of the dome is under compressive force and there is no tensile force in any part. The construction of dome is also easy. The new design of large capacity fixed hemispherical dome type (New Inexpensive Modified PAU Model) biogas plant prepared for different capacities of biogas per day are prepared, the dimensions and materials for these capacities biogas plants are calculated. The detail of this biogas plant is shown in Fig.1. The dimensions and approximate cost of these plants for power generation having different capacity are given in Tables 1 and 2 respectively. (Singh and Sooch, 2004; Sooch, 2012; Sooch *et al.*, 2009 b, Sooch, 2012)

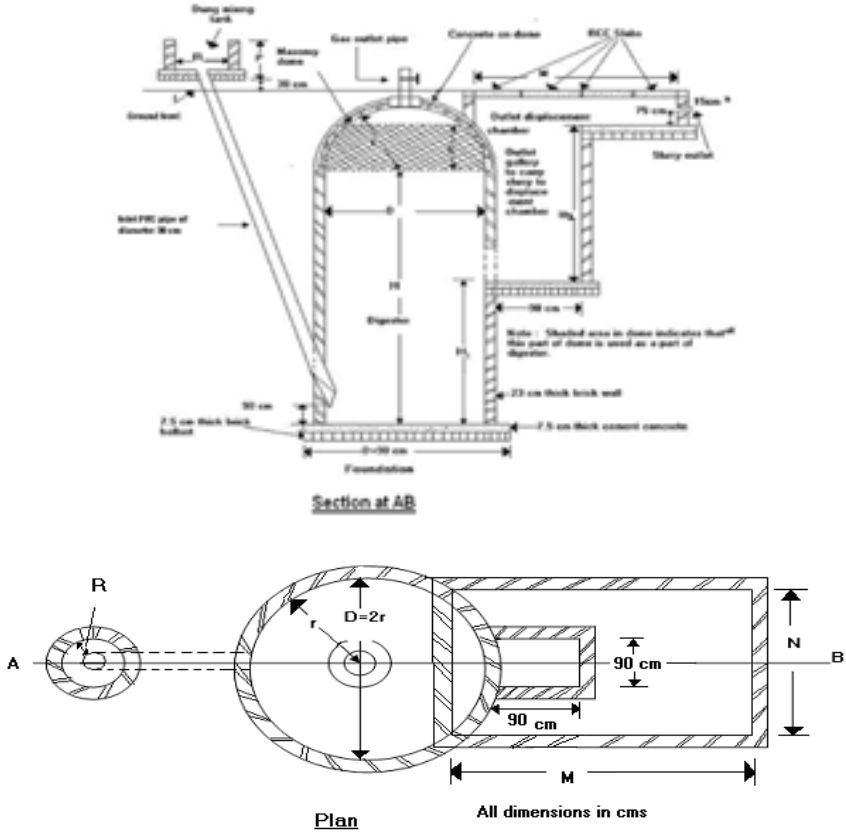

Fig 1 Dimensions of new modified PAU Janta model biogas plant

Table1: Dimensions of New Modified PAU Janta Model Biogas Plants (H.R.T. = 40 days) [Ref. Fig. 1]

Dimensions in (ft)	Symbol	Capacity of Biogas Plant (m^3)				
		50	75	100	125	150
Diameter of Digester	D	15.50	19	20.5	23.5	24
Inner radius of digester	r	7.75	9.5	10.25	11.75	12
Depth of digester	H	14.50	14.50	15.50	14	16.25
Depth of digester up to smaller portion of outlet chamber	H_1	7.25	7.25	7.75	7	8.25
Height of smaller portion of outlet chamber	H_2	12	13.75	15	15.75	17.25
Length of bigger portion of outlet chamber (M)	M	18	22	25	31	31
Width of bigger portion of outlet chamber	N	13	17	19	20	23
Diameter of mixing tank	R	8	8	8	8	8
Height of mixing tank	P	2.5	3	3	3	3

(Table1 continued ------)

Table1: Dimensions of New Modified PAU Janta Model Biogas Plants (H.R.T. = 40 days) [Ref. Fig. 1]

Dimensions in (ft)	Symbol	Capacity of Biogas Plant (m^3)				
		175	200	225	250	300
Diameter of Digester	D	27	28	29.50	30.50	35
Inner radius of digester	r	13.50	14	14.75	15.25	17.50
Depth of digester	H	14	14	14.50	14.50	11
Depth of digester up to smaller portion of outlet chamber	H_1	7	7	7.25	7.25	5.50
Height of smaller portion of outlet chamber	H_2	17.50	18	19	19.50	19
Length of bigger portion of outlet chamber (M)	M	33	34	36	37	40
Width of bigger portion of outlet chamber	N	26	28	30.50	32	35.50
Diameter of mixing tank	R	8	8	8	8	8
Height of mixing tank	P	3	3	3	3	3

Table 2: Project Cost of Large Capacity Fixed Dome Biogas Plants for Power Generation

Capacity of Biogas Plant (m^3)	Recommended capacity of Gen-set (kW)	Cost of Construction of Biogas Plant & Gas Pipe Line System (Rs. in lac)	Cost of dual fuel Gen-set with other accessories (Rs. in lac)	Cost of Bio - digested slurry handling system (Rs in lac)	Total Cost of the Project (Rs in lac)
25	3	2.50	2.50	1.00	7.00
50	6	4.00	3.00	1.00	9.00

Capacity of Biogas Plant (m^3)	Recommended capacity of Gen-set (kW)	Cost of Construction of Biogas Plant & Gas Pipe Line System (Rs. in lac)	Cost of dual fuel Gen-set with other accessories (Rs. in lac)	Cost of Bio - digested slurry handling system (Rs in lac)	Total Cost of the Project (Rs in lac)
75	9	5.00	4.00	1.00	11.00
100	12	6.00	4.50	1.50	13.50
125	15	8.00	5.00	1.50	15.00
150	18	10.00	5.50	1.50	18.50
175	21	11.50	6.00	1.50	20.50
200	24	13.00	6.50	1.50	23.50
225	27	14.50	7.00	2.00	25.50
250	30	16.00	7.50	2.00	27.50
275	33	17.50	8.00	2.00	29.50
300	36	19.00	8.50	2.00	31.50
325	40	21.00	10.00	2.00	35.00

NOTE:

i) Cattle dung available from one cattle = 15 kg.

ii) 1 Kg of cattle dung will produce 0.04m^3 of biogas

iii) Cattle dung required for production of 1m^3 of biogas = 25 kg

iv) 25m^3 of biogas will generate approximately 3kW of Power

The photographs of the Biogas Plant are shown as below:

(i)View of the complete biogas plant along with precast slabs and mixing tank

(ii)View of the complete biogas plant with precast concrete slabs on the displacement chamber

RESULTS AND DISCUSSION

This plant can be constructed with around 60-65% cost as compared to the cost of other conventional floating drum type biogas plant available in India. On the basis of the performance of these biogas plants, the Ministry of New and Renewable Energy (MNRE), Govt. of India (which is the nodal agency for providing financial assistance to install non-conventional energy techniques in the field) accepted this design for installation at users' sites for power generation and starts providing financial assistance to the users of these plants. At present around 100 such biogas plants have been installed in Punjab and all of these plants have been performing very well. Before the installation of big plants, these farmers were using dung cakes or wood as fuel for cooking meals which was very hazardous and a constant source of smoke and atmospheric pollution. The kitchens were black from inside due to smoke and irritant to the eyes. These biogas plants provide neat and clean kitchens and free from eye irritation. This also provides good quality of manure for the fields free from weeds and any smell. Thus the whole process after installation of biogas plant is eco friendly for handling organic wastes from the dairy sheds and a step to prevent global warming (Sooch, 2010).

Economic views of the owner of this plant have been collected and presented as below:

GADVASU SAVES RS 1,000 A DAY BY GENERATING ELECTRICITY THROUGH BIOGAS

Educational institutions and social organisations may be generating a lot of awareness among the masses to save electricity but the Guru Angad Dev Veterinary and Animal Sciences University (GADVASU) has done a remarkable job to promote the cause. About 200 units of electricity (per day) are generated through the recently started biogas plant at the animal varsity and latter has been able to save up to Rs 1,000 daily. This biogas plant runs for about eight hours in a day (Sooch, 2010).

Vice-chancellor Dr VK Taneja is the brain child behind the plant. It saves Rs 1, 71,000 a month in the form of electricity, slurry and carbon dioxide. Talking to the Ludhiana Tribune, Dr VK Taneja said, "The plant was set-up during the month of April to curb environmental degradation and add valuable products back to the environment as the raw dung is being used as a fertilizer. In Kerala, animal owners install digesters to produce electricity through dung, sufficient to run their houses. In Punjab, mostly farmers have animals, they can utilise the cow dung by installing digesters and power can be generated. GADVASU has been saving Rs 30,000 (per month) on electricity, Rs 1, 35,000 on slurry (per month) and Rs 6000 (per month) on carbon-dioxide". (Sooch, 2010)

Besides, the biogas is used as a domestic fuel, for street lighting and for the generation of electricity. The plant reduces burden on forests and fossil fuels, helps in controlling air-pollution, provides a nutrient rich nitrogen/phosphorus) manure for plants and controls water pollution by decomposing sewage, animal dung and human excreta," the VC added. The effluent from the digester can be returned to the fields as a source of nutrient (Sooch, 2010).

CONCLUSION

It is concluded that this biogas plant proved very successful and liked very much by the owner of the dairy cattle. This plant is functional and the owner is making use of biogas for power generation. He is very happy with performance of the biogas plant, with results more and more people are coming forward for the installation of large capacity biogas plants. All these farmers are very happy with the performance of the biogas plants and making full use of biogas for cooking food of the labourers, and running diesel engine for power generation or for their Tubewells. The digested slurry coming out of the biogas plants is either used at their own farms for raising fodder or sells it to the other farmers at reasonable rates. These farmers are saving in lacs by using biogas instead of conventional fuels.

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Improvement in Biogas Production Using Different Techniques

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ABSTRACT

Biogas is a very promising technology for India due to the tropical location and very high population of livestock of over 300 million. Despite many advantages, the biogas technology continues to suffer from certain limitations. Prime amongst these is the large hydraulic retention time (HRT) of 30-50 days that needs to be used in the conventional biogas plants in India based on cattle dung leading to large size of the reactors. The resultant high costs coupled with low gas production in winter season and handling and management of effluent slurry act as deterrents for wider acceptance of the technology in rural areas. Therefore, there is a need to increase biogas production rate, which can reduce the HRT for a given gas production or enhance biogas production for the same HRT. This paper presents a review of various techniques which could be used for enhancing the performance of biogas plants.

Keywords: Biogas, enhancement, fixed film, HRT, biogas recirculation, slurry recycling

INTRODUCTION

In today's energy demanding life style, need for exploring and exploiting new sources of energy, which are renewable as well as eco-friendly, is a must. In rural areas of developing countries a variety of cellulosic biomass (cattle dung, agricultural residues etc.) is available in plenty, which has a very good potential to cater to the energy demand, especially in the domestic sector. Biogas technology offers a very attractive route to utilize certain categories of biomass for meeting some of the energy needs. In fact proper functioning of biogas system can provide multiple benefits to the users and the community resulting in resource conservation and environmental protection. Biogas technology owing to its various advantages has attracted worldwide attention as a source of renewable energy particularly in developing world. It is a very promising technology for India due to the tropical location and very high population of livestock of over 300 million. Use of cattle dung is widespread in rural areas either as cooking fuel in the form of dung cakes or as manure. This resource, when used through biomethanation route, can provide clean cooking fuel and good quality manure. Biogas burners can achieve thermal efficiencies of 60% or above as compared to the 11% that is achieved from cook stoves using cattle dung cakes. Despite many advantages, the biogas technology continues to suffer from certain limitations. Prime amongst these is the large hydraulic retention time (HRT) of 30-50 days that needs to be used in the conventional biogas plants in India based on cattle dung leading to large size of the reactors. The resultant high costs

coupled with low gas production in winter season and handling and management of effluent slurry act as deterrents for wider acceptance of the technology in rural areas. Therefore, there is a need to increase biogas production rate, which can reduce the HRT for a given gas production or enhance biogas production for the same HRT. The present paper here describes various techniques which have been used for improving the performance of cattle dung based biogas plants, *viz.,* fixed film matrices, different slurry concentrations, use of additives in the slurry and recirculation of biogas through experimental studies on pilot size reactors.

TECHNIQUES FOR ENHANCING BIOGAS PRODUCTION

Different methods used to enhance biogas production can be classified into the following categories: -

- Use of additives
- Recycling of slurry, slurry filtrate and biogas recirculation
- Variation in parameters like temperature, hydraulic retention time (HRT) etc.
- Use of fixed film reactors
- Innovations in digester designs

Use of Additives :

Some attempts have been made in the past to increase biogas production by stimulating the microbial activity using various biological and chemical additives under different operating conditions. The suitability of an additive is expected to be strongly dependent on the type of substrate (Chandra and Gupta, 1997). Biological additives include different plants, weeds, crop residues, microbial cultures, etc., which are available naturally in the surroundings. Powdered leaves of some plants and legumes (like Gulmohar, *Leucacena leucocephala, Acacia auriculiformis, Dalbergia sisoo and Eucalyptus tereticonius)* have been found to stimulate biogas production between 18% and 40% (Gunaseelan, 1987; SPOBD, China, 1979; Prasad, 1985; Chowdhary *et al*., 1994). Alkali treated (1% NaOH for 7 days) plant residues (lantana, wheat straw, apple leaf litter and peach leaf litter), when used as a supplement to cattle dung, resulted in almost two-fold increase in biogas production (Dar and Tandon, 1987). Trujillo *et al.* (1993) found that addition of the tomato-plant wastes to the rabbit droppings in proportion higher than 40% improved the methane production. Crop residues like maize stalks, rice straw, cotton stalks, wheat straw and water hyacinth when added in 1:1 ratio with cattle dung enhanced biogas production in the range of 10 to 80% (El Shinnawi *et al.,* 1989; Somayaiji and Khanna, 1994). Cellulolytic strains of bacteria like actinomycetes and mixed consortia have been found to improve biogas production from cattle dung in the range of 8.4 to 44% (Tirumale and Nand, 1994; Attar *et al.,* 1998, Erdal, Zeynep, 2010). Geeta *et al.* (1994) found that sugarcane bagasse pretreated with *Phanerochaete chrysosporium* for 3 weeks under ambient temperature conditions produced higher biogas with cattle dung. Several inorganic additives that improve biogas production from cattle dung have also been reported. Wong and Cheung (1995) found that the biogas plant with a higher content of heavy metals (Cr, Cu, Ni & Zn) had a higher CH_4 yield than the control. The addition of iron salts at various concentrations [$FeSO_4$ (50mM), $FeCl_3$ (70μM)] have been found to enhance biogas production rate (Wodzinski *et al.,* 1983; Patel *et al.*, 1993; Rao and Seenayya, 1993; Clark and Millman, 1995). Nickel ions (2.5ppm and 5ppm) enhanced biogas upto 54% due to the activity of

Ni-dependent metallo-enzymes involved in biogas production (Geeta *et al.,* 1990). Malik *et al.* (1987) obtained an increase of 8-11% in biogas production by the addition of urea and diammonium phosphate. According to Kumar *et al.* (1987) addition of commercial charcoal (Darco G-60) resulted in 17% and 34.7% increase in biogas production in batch and semi continuous fermenters, respectively. Borja *et al.* (1993) studied the effect of natural zeolite on the kinetics of cow manure anaerobic digestion. Zeolite in addition to removing ammoniacal nitrogen, which causes toxicity in an anaerobic digestion, also acts as the support for immobilization of microorganisms. Biogas production kinetic was studied at lab scale using rumen fluid of animal ruminant as inoculums. Rumen fluid inoculums caused biogas production rate and efficiency increase two to three times in comparison to manure substrate without rumen fluid Budiyono *et al.* (2010).

Recycling of Digested Slurry, Slurry Filtrate and Biogas Recirculation:

Recirculation of digested slurry back to the reactor has been shown to improve the biogas production marginally, since the microbes washed away are reintroduced back into the reactor, thereby providing higher microbial population. Recycling of the digested slurry along with filtrate has also been tried out to conserve water and to enhance biogas production (Malik and Dahiya, 1990; Santosh *et al.,* 1999). Kanwar and Guleri (1994) reported that about 60 to 65% more biogas production could be obtained by recycling the digested slurry in $1m^3$ plug flow type pilot plant. An increase of up to 18.8% in biogas production (CH_4, 80%) was observed by Malik and Tauro (1995) when predigested slurry was used along with 10% effluent slurry recycling in a $1m^3$, daily fed, floating drum biogas digester (pilot plant, HRT = 30d). Biogas recirculation has also been found to enhance mixing and thus biogas production (Mohanrao, 1974, Aubart and Farinet, 1983, Van and Faber, 1996). Sludge recirculation in the biogas reactor had also been found to improve the biogas production (Huang, 2011; Rodriguez, 2011).

Variation in Different Parameters :

The performance of biogas plants can be controlled by monitoring the variation in parameters like pH, temperature, loading rate, agitation etc. Any drastic change in these can adversely affect the biogas production. So these parameters should be maintained within a desirable range to operate the biogas plant efficiently. Temperature inside the digester has a major effect on the biogas production process. There are different temperature ranges during which anaerobic fermentation can be carried out: psychrophilic (< 20^0C), mesophilic (30-45^0C) and thermophilic (45-61^0C). However, anaerobes are most active in the mesophilic and thermophilic temperature ranges (Mital, 1996; Umetsu *et al.*, 1992; Maurya *et al.,* 1994; Takizawa *et al.,* 1994; Zennaki *et al.* 1996). The coating of biogas plants with insulating materials helped in keeping the temperature in the digester within the desired range (Molnar and Bartha 1989; Bansal 1988; Tiwari *et al.* 1988).). In order to increase biogas yield, it is preferred to construct biogas plants sun-facing and in a manner as to protect them from cold winds. A simple technique of charcoal coating of ground around the digester had been found to improve biogas production in KVIC biogas plant by 7-15% (Anand and Singh, 1993). Installation of PVC greenhouse type structure over a biogas plant allowed solar heating of the substrate from 18 to about 37^0C (Sodha *et al.*, 1987; Gupta *et al.* 1988; Tiwari and Chandra 1988). pH is an important parameter affecting the growth of microbes during anaerobic fermentation. pH of the digester should be kept within a desired range of 6.8-7.2 by

feeding it at an optimum loading rate. Smaller particles provide large surface area and would result in increased microbial activity and hence increased biogas production (Sharma *et al*., 1988; Gollakota and Meher, 1988; Moorhead and Nordstedt, 1993). It is generally found that during anaerobic digestion, microorganisms utilize carbon 25 to 30 times faster than nitrogen. Thus to meet this requirement, microbes need a 20-30:1 ratio of C to N with the largest percentage of the carbon being readily degradable (Bardia and Gaur, 1997; Malik *et al*., 1987).Stirring of digester contents needs to be done to ensure intimate contact between microorganisms and substrate, which ultimately results in improved digestion process (Baier and Schmidheiny, 1997). Addition of inoculum tends to improve both the biogas yield and methane content in biogas. Even retention period can be reduced by addition of inoculum (Neelkanthan *et al*., 1976; Dangoggo *et al.,* 1996; Kanwar and Guleri, 1995). Biogas production rate is highly dependent on loading rate. Methane yield was found to increase with reduction in loading rate by Vartak *et al*. (1997). HRT is the average time spent by the input slurry inside the digester before it comes out. In tropical countries like India, HRT varies from 30-50 days while in countries with colder climate it may go up to 100 days. It is possible to carry out methanogenic fermentation at low HRT without stressing the fermentation process at mesophilic and thermophilic temperature ranges (Zennaki *et al.* 1996; Singh *et al*., 1995; Garba 1996). Baserga (1984) observed that at a TS concentration of 7%, the duration of digestion could be reduced to 10 days without compromising the stability of the process, but the optimum period was 16 to 20 days.

Fixed Film Reactors :

The low rates of methane production achieved from waste materials in unstirred and continuously stirred tank reactors have led to the development of reactors such as the anaerobic contact reactor, the upflow anaerobic filter (UAF) and downflow stationary fixed film reactor (DSFF) (Peck and Hawkes, 1987). Fixed film reactors have been used since long for the treatment of wastewater where they have helped in reducing the HRT from 30-40 days to a few hours (Kloss, 1991). They help in enhancing the performance of wastewater treatment systems by providing an increased surface area for attached growth of the microbes in the form of a fixed film on an inert medium leading to increased population of microbes in the reactor and their retention in the digester even after the digested slurry flows out (van der Berg and Kennedy, 1983). Lo *et al.* (1983) have shown the effects of solids separation pretreatment on biogas production from dairy manure at 30^{0}C over a range of HRTs from 16 to 6 days. They suggested screening out coarse solids of dairy manure prior to feeding to eliminate the material handling problems. Mostly lab scale studies have been carried out to anaerobically digest the screened dairy manure using fixed film (Lo *et al* 1983; Liao and Lo, 1984; Lo *et al*., 1984a; Lo *et al*., 1984b; Peck and Hawkes, 1987). The use of screened slurry has been suggested in literature as sieving removes most of the suspended coarse particles resulting in a homogenous substrate.

The ideal medium material for fixed film reactors would be the one that provides maximum surface area and occupies minimum volume. High porosity is also important in order to minimize filter clogging and short-circuiting (Anderson *et al*., 1994). Weiland and Peters (1992) obtained reduction in HRT using plastic support for anaerobic digestion of screened cattle excrement at lab scale as compared to conventional system. Vartak *et al*. (1997) found the performance of polyester medium, with its high porosity and surface to volume ratio, to be best both at 37^{0}C and 10^{0}C while treating screened dairy manure at lab scale. Ganesh Kumar *et al.* (1996) achieved an increase

of about 40% in biogas production by the addition of broken burnt bricks as carriers for immobilizing microbes while anaerobically digesting cattle dung in 40 litre reactors. Geeta *et al*. (1986) also tried some inert materials in lab scale reactors and observed enhancement in biogas production. Recently, preliminary work on this concept at pilot scale (400 litre, HRT= 30 d) had been carried out by Rana *et al*. (2002) at IIT, Delhi using stone chips and iron mesh biofilters. For the entire year, the biogas production from the reactor with iron mesh was consistently higher (~17%) than that from the conventional reactor. Similarly Yadvika *et al*. (2005) found that clay as fixed film material was the best among the various materials tried and improved gas production was obtained in this reactor.

INNOVATIONS IN DIGESTER DESIGNS:

Limited efforts have been made to improve the designs of reactors to enhance biogas production. A high performance biogas plant was designed and studied by Aili *et al*. (1991) for treating chicken manure. The system started quickly under mesophilic temperature. Biogas production rate was 3.27-3.87m^3/m^3.d. with a maximum value of 4.041 m^3/m^3.d. In another study carried out by Wanjun (1992) to overcome the weak points of cylindrical biogas digesters such as difficulty in discharging, low biogas production rate etc., a new biogas digester was designed which doubled the biogas yield. Recently, Tumchenok (1996) tested a new bioreactor for anaerobic digestion of animal or poultry waste as substrate. The digester resulted in increased methane percentage in biogas. Kumar (1997) developed a new cost effective biogas plant (Konark Model) with high efficiency by changing its shape to spherical. Here construction cost was reduced by 10-15% (with respect to Deenbandhu) if constructed with brick masonry and by 30-35% if constructed using ferro-cement technology. It was structurally sound due to its spherical shape. Its biogas storage capacity had been increased and short-circuiting had been prevented by providing a baffle wall.

CONCLUSION

A critical analysis of the reported literature had been carried out with focus on practical techniques for enhancing the performance of biogas plants under Indian rural conditions. It reveals that there is a strong possibility to enhance the biogas production under field conditions. Use of certain inorganic as well as organic additives seems to be promising for enhancing biogas production. Among different types of biomass (plant and crop residues) used as additives, some have been found to enhance the biogas production significantly. However, their utility is limited due to their seasonal availability in different regions. Practical aspect of using pure microbial culture as additives should be looked into, in view of certain problems especially related to human health and eco-dynamics. Recirculation of effluent slurry on daily basis and stirring of the digester contents by using simple techniques for enhancing biogas production seems to be quite viable under rural conditions. Keeping various parameters within the desired range also improves biogas production but the practical difficulty lies in maintaining and monitoring these regularly. It is a crucial point which needs due consideration since a slight change in pH or temperature could otherwise result in reduction of biogas production. Similarly formation of volatile fatty acids beyond 2 g/*l* hinders the methane production. Loading rate and solid concentration should be properly balanced and continuously maintained.

As for the fixed film technique, it has certain merits over the above mentioned methods. It may help to reduce HRT considerably resulting in cost reduction of biogas plant, without

compromising on quantity and quality of biogas. Surprisingly, in this promising research area of using fixed film technique for treatment of high solids content substrate like cattle dung slurry, most of the studies have been carried out at laboratory level only, whereas these techniques have been successfully tried in the treatment of wastewater/liquid wastes under field conditions. An extensive study on this aspect is necessary.

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Biogas Plants in Hamirpur District of Himachal Pradesh: Successes and Setbacks

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ABSTRACT

The use of biogas for energy supply provides economic but also ecological and hygienic advantages. Use of biogas systems in agrarian communities can increase agricultural productivity. Producing heat using biogas is more efficient than producing it using combustion, and hence more agricultural and animal waste can be returned to the land by farmers as organic fertilizer. Moreover, the slurry that is returned after methanogenesis is superior in terms of its nutrient content and can be used as a soil conditioner and plant nutrient. The first digestion plant was built at a leper colony in Bombay, India in 1859 AD. The use of farm manure to generate methane was developed, again in Bombay, in the 1930s. It is estimated that over 2 million of small biogas plants have been installed all over India. About 35647 of these biogas plants have been installed since 1982 by the Department of Agriculture, the main agency in Himachal Pradesh. These plants did not emerge without a struggle. This article reviews the experimental introduction of biogas plants in Hamirpur district of Himachal Pradesh since the year 1982. Most of the plants were found to be non-functional and the attempt for large-scale production of biogas did not succeed due to several reasons. The current status of biogas plants in Hamirpur depends upon several factors. The success and failures of the installed biogas plants have been discussed. The solution to the problem is also suggested to make it sustainable in current scenario of the energy scarcity. Shift in energy and environmental policies and limited availability of organic waste is also one of the major setbacks in setting up of the biogas plants.

Key words : Biogas; Himachal Pradesh; digestion

INTRODUCTION

Anaerobic digestion consists of several interdependent, complex sequential and parallel biological reactions in the absence of oxygen, during which the products from one group of microorganisms serve as the substrates for the next, resulting in transformation of organic matter mainly into a mixture of methane and carbon dioxide (Parawira, 2004a; Parawira, 2004b'.Noykova et al. 2002; Pavlostathis and Gomez 1991). A biogas plant is a technical facility in which the biogas production process takes place. The sources for biogas production are principally a wide range of organic material.

The current use of biogas plants for manure and organic waste processing is relatively large in India. The primary domestic uses of biogas are cooking and lighting. Because biogas has different properties from other commonly used gases, such as propane and butane, and is only available at low pressures (4 - 8 cm water), stoves capable of burning biogas efficiently must be specially

designed. To ensure that the flame does not "lift off," the ratio of the total area of burner parts to the area of the injector orifice should be between 225 and 300:1(FAO, 1981). Recent Indian designs have thermal efficiencies of around 60% (Mahin, 1982). In China the Beijing-4 design has a thermal efficiency of 59 - 62%, depending on the pressure (Chan, 1982).

Lighting can be provided by means of a gas mantle, or by generating electricity. Highest lamp efficiencies require gas pressures of 40 cm, which are only possible with fixed dome digesters.

Reported gas consumption for cooking and lighting is 0.34 0.41 m^3 per capita/day and 0.15 m^3 per hour per 100 candle power respectively (NAS, 1977). A typical family of six uses approximately 2.9 m^3/day of biogas.

The Indian development of biogas plants has a long history. It is all but a linear development: both biogas plant concept and functionality of the plants varied over a period of more than 40 years and there were both successes and setbacks. The first sewage plant was built in Bombay in 1859; an idea that was brought to the UK in 1895, when the gas produced was used to light street lamps. The use of farm manure to generate methane was developed, again in Bombay, in the 1930s. It was only developed for use by Indian villagers by KVIC (Khadi and Villages Industries Commission) in the early 1960s. This design, which used a floating steel gas drum, formed the basis of an ongoing Indian Government outreach programme to provide villagers with cooking fuel.

China started a similar programme in the 1960s and claimed that 5 million plants had been built by the early 1980s. The design was based on a septic tank. The original rectangular tank was rapidly replaced by a design based on a dome shape. Similar designs were developed by various groups in India and formed the basis of an effective programme in Nepal, which is now called BSP (Biogas Sector Partnership). The Indian programme inspired a brief enthusiasm for on-farm energy generation via biogas in the UK in the early 1980s, when the oil price spikes caused people to look for alternatives. The drop in the price of oil, and therefore electricity, which followed made the farm-scale biogas plants look uneconomic, so few of the 200 or so plants that were built at that time survived.

The Indian programme became much less centralized, as different groups adapted the fixed dome design so it could be built in India. KVIC adapted by developing glass reinforced plastic floating drums as an alternative to steel drums, but the price was still higher. Several designs of fixed dome plant, based on the Chinese designs were developed such as the Janata and Deenabandu designs. As different NGOs and private companies manufactured these designs, quality became more variable. Programmes were successful, because the respective governments offered subsidies. This allowed the government to have central control of quality.

This article reviews the period of 1982–2011 and aims to provide new insights in different ways. Namely, the article gives a comprehensive historical description of biogas plant development in India and Hamirpur, Himachal Pradesh in particular. Moreover the article shows that the success of a research and development programme as in case of various development programmes in India also depends on national circumstances like political choices, energy infrastructures and historically grown organizational structures, emphasizing that technological development is partly subject to factors that cannot be (easily) influenced.

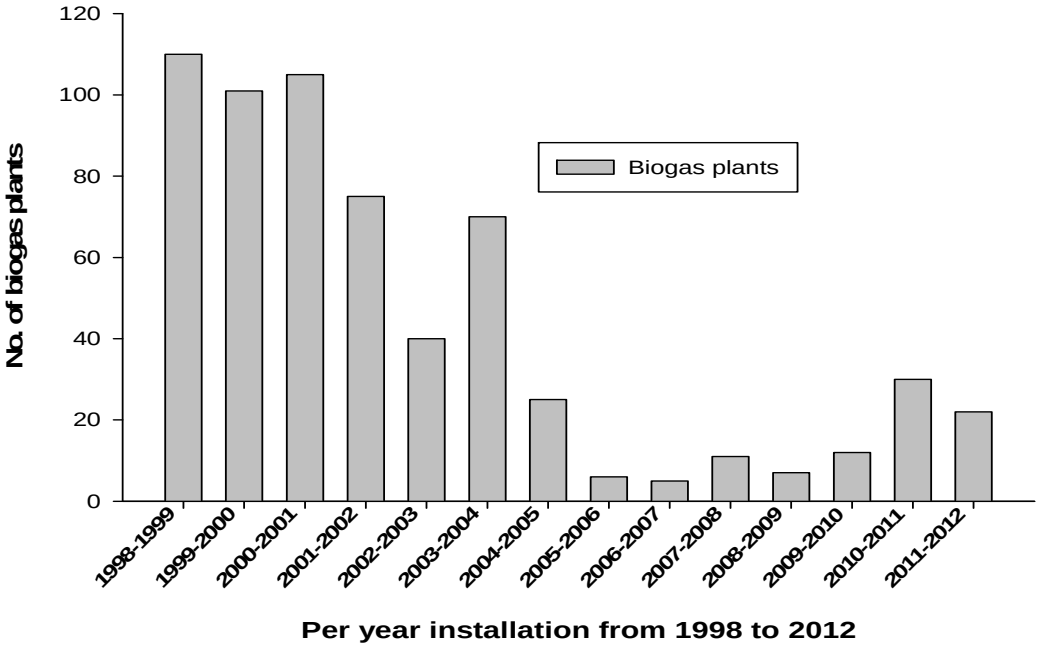

Fig. 1: Trend of Biogas Plants Popularity in Hamirpur District of Himachal Pradesh for Last 15 Yrs

PROBLEMS WITH BIOGAS PLANTS

Many hurdles were observed while dissemination and technology transfer technique by the government agencies (Shiv et al, 2004). The technical feasibility could be proven under ideal conditions for these technologies. However, under practical situations, the institutional challenges for ensuring technology performance were greater than the technologies *per se*. Poor functionality of biogas plant (63%) has adversely affected the pace of plant installation (Shiv et al, 2004). Small-scale farmers frequently lack sufficient domestic animals to obtain enough manure for the biodigester to produce sufficient gas for lighting and cooking.

Design failure was one among many different reasons for the failure of some plants. Few plants were functional as plants are made by local masons/mechanics in the early 1980s. They were not expert in making biogas plants. Two models were popular in Hamirpur district of Himachal as surveyed in the year 2012 namely, Janta Model (Figure 2) and Deenbandhu Model (Figure 3). Janta model was used till 2005-2006, and later on, people started using more improved model Deenbandu. **KVIC (Floating Drum) Model-** This model consists of a pit on which a mild steel or plastic dome rests. It is suitable for most areas except very cold climates. However, maintenance of the dome is sometimes a problem. **Deenbandhu Model** is the most rugged of among different models as it has an underground masonry structure. Experts pointed out that this guards it against cold temperatures and households to use the land above it. However, excavation for the digester in hard bedrock areas is difficult and the investment needed to build it is high. The feedstocks used for methane production has an inherent property of producing the biogas which is decided by the C/N ratio of the raw material as shown in Table 1. When Carbon-Nitrogen ratio exceeds approx. 30, the biogas production starts diminishing.

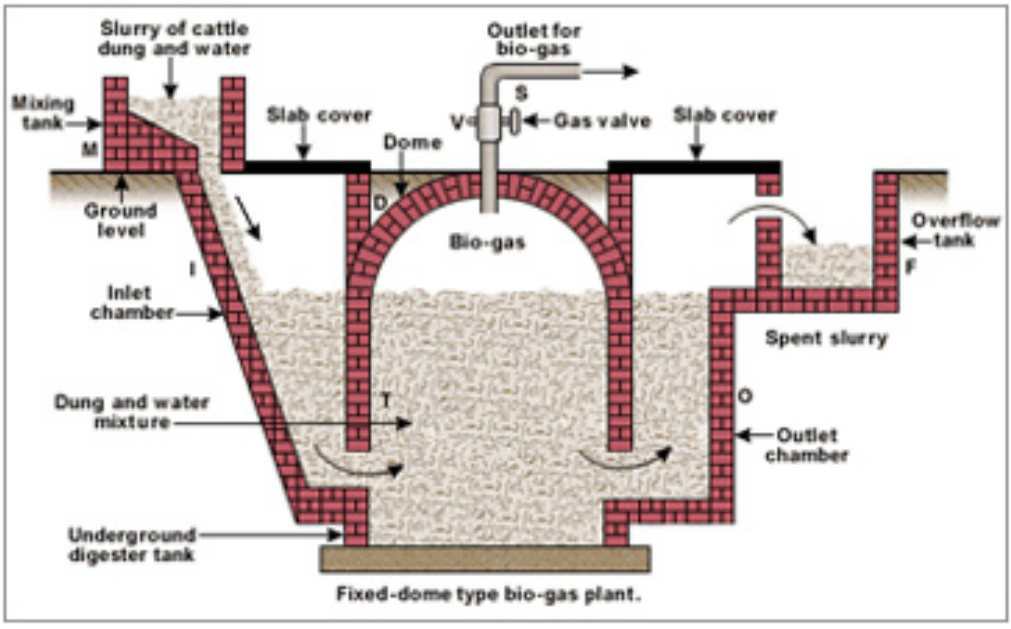

Fig. 2: Janta Model, Source: http://ascentbioenergy.com/bio_gas_types.php

Some plants were found to be in working condition since last 10 to15 years. Figure 4 shows the first biogas plant in Hamirpur District. Some of the plants were also using human waste along with the animal waste. Many small familles are solely dependent on biogas for their cooking needs. Others were using biogas with L.P.G. Currently, trend of nuclear families increased. Therefore, the numbers of animals per house were decreased. It is one of the big causes to the failure of biogas plants. Though many potential raw materials can be used for methane production however the commonly used feedstock in Hamirpur as surveyed was Cow dung as shown in Table 2. Due to unavailability of animal population, the trend has been decreasing and people are shifting towards combining the cow dung with the night soil in rural areas. However, if kitchen waste be promoted as the raw material for the biogas, the problem of inconsistency of feedstock can be solved to some extent.

Table 1: C/N Ratio for different feedstocks

Feed stock	C/N ratio	Biogas yield(m^3 /kg)
Pig Slurry	3-10	0.25 - 0.50
Cow Slurry	6-20	0.20 - 0.30
Chicken Slurry	3-10	0.35 - 0.60

The trend of popularity of the biogas plants has decreased overtime recorded for last fifteen years as shown in figure 1. Foremost reason is the conversions of joint families to nuclear families among many different reasons which lead to another setback for Himachal biogas plant operation i.e resulting in less substrate available for the biogas plants. Therefore, there is usually lack of enough supply of feedstock for efficient and sustainable biogas production.

Respondents in the survey also reported about the social barrier e.g. some potential users are reluctant to try the biogas digesters as they feel the business dirty. Moreover use of human wastes for biogas production and the subsequent digested sludge, for example in schools, as a source of fertilizer faces cultural and health resistance. Even though the anaerobic digestion process naturally reduces the pathogen load, handling biogas feedstock particularly human excreta and using biogas slurry as fertilizer does pose some risk of infection (Brown, 2006).

Use of biofertilizer after biogas production is also not been popularized leading to wastage of an important resource. A major difficulty is utilizing manure sources properly. Liquid manure is preferred for most biogas plants, but households may not be accustomed to storing and handling it. People also find it difficulty to collect, store and deliver fresh manure to the digester.

As observed in other parts of the world the problems also include that animals must be penned for effective collection of animal dung, farmers must own a sufficient number of livestock to generate continuous flows of biogas, and the initial costs for the required infrastructure may be deterrent (Karekezi, 1994).

Other major problems observed were related to government policies and monitoring of the plants after installation. Problems in setting standards and monitory quality depending upon the location and local situation were not dealt with properly by the Government agencies who promoted the technology in villages. Improper gas production due to technical or scientific reasons was not addressed properly by the scientific community.

Moreover the subsidies and ease of availability of LPG in the area have given the option for cooking and this lead to aggravating the problem further since people were reluctant to use the biogas technology.

Table 2: Feed stock used in Hamirpur district

S. No.	Kind Of Feed Stock	Feed Stock Used(Kg)	Daily Consumption (Kg)
	Animal waste	Cow dung	30-60
	Kitchen waste	Mixed waste including cereals, pulses and vegetables	Nil
	Agriculture	Biomass waste not taken by animals	Nil
	Energy crops	Algae, water hyacinth or other Weeds	Nil
	Human waste	Night soil	2-3

MAINTENANCE PROBLEM WITH BIOGAS PLANT

Growth of plant roots penetrating the digester is a common problem in Himachal Pradesh biogas plants which can be maintained through proper monitoring of the plant time to time.

Other problems which need special attentions are

- Repair in Crack in digester wall
- Leakage of gas
- Accumulation of water in the pipe,
- No gas at stove,
- Small flames in burner,
- Pulsating flame,

- Reduced gas production,
- Preventive maintenance of Biogas Plants

The effort of maintenance and control on biogas plants often does not meet the level of literacy skills of rural population. It is also important to realize that lack of information on improved technologies such as biogas technology at all levels, government, energy institutions, and consumers, poses a very serious problem for technology penetration. Poor infrastructures prevent access to even the vast information available in the public domain about biogas technology and its application.

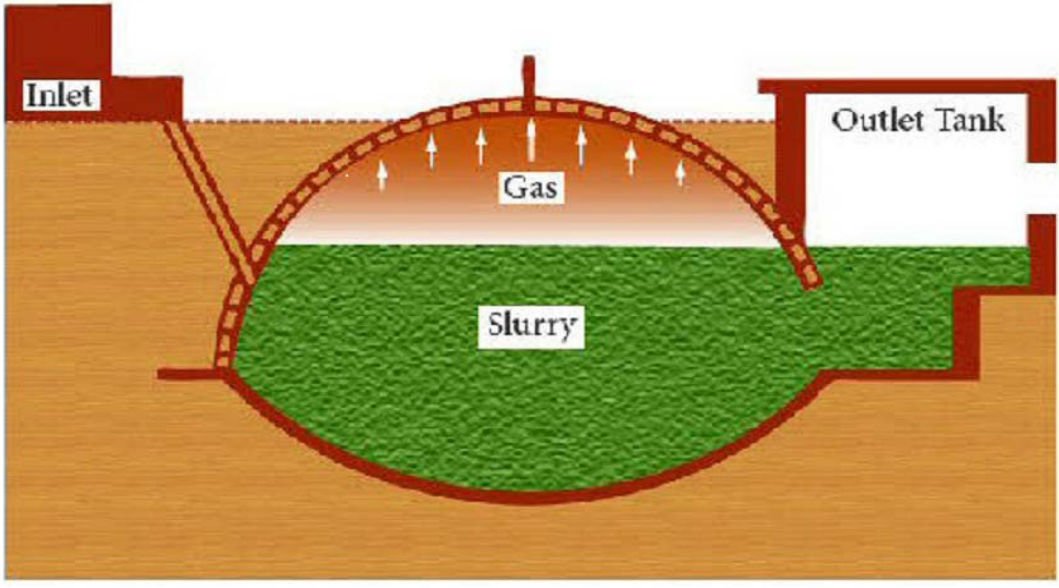

Fig. 3: Deenbandhu Model

Fig. 4: First Biogas Plant in Hamirpur

POSSIBLE MEASURES TO IMPROVE BIOGAS PRODUCTION AND COMMERCIALIZATION

Mixing of Raw Material within a reactor is necessary for effective operation of the biogas unit and maintenance of stable fermentation. The main aims of mixing are: liberation of the biogas produced; prevention of formation of a skin and deposits; prevention of areas with a different temperature within the reactor; provision of uniform distribution of the bacteria population; prevention of formation of cavities and accumulations, reducing the effect reactor area.

The economics of large-scale biogas plants, probably to serve communities, could also be investigated since they may have a much higher benefit-cost ratio compared to family sized plants. However , installation of an oversized plant in small family would mean that the household would not get adequate quantity of dung, due to which the digester would be underfed and the gas production be inadequate. Another key criterion to consider are the **installation costs** of the digester.

In order to overcome some of the socio-cultural barriers, intensive educational and campaign programmes may have to be mounted to raise the awareness consciousness of the benefits of this technology. Generating interest among the various stakeholders and setting up information systems using relatively cheap devices now available can assist greatly. Setting up or strengthening existing information systems is very important for the use of renewable energy technologies such as biogas. These systems should be capable of coordinating energy and energy-related information activities with appropriate means for collection, filtering, storage, retrieval and dissemination.

ECONOMIC FEASIBILITY

The financial feasibility of the facility depends largely on whether outputs in the form of gas and slurry can substitute for costly feeds, the efficiencies with which the fuel is used or possible equipment which could lead to higher efficiencies. If 'externalities' such as employment, import substitution, energy security, environmental protection, and so on are considered then the economics change usually in favour of the biogas technology (Hall et al. 1992).

CONCLUSION

Biogas production has been quite dominant in India at household and community levels (especially in rural areas) than on large scales. In villages especially, thousands of small biogas plants use the cattle waste (especially cow dung) and provide biogas used for home heating and cooking. It is estimated that over 2 million such biogas plants have been installed all over India.

Such use of biogas systems in agrarian communities can increase agricultural productivity as more agricultural and animal waste can be returned to the land by farmers as organic fertilizer. Moreover, the slurry that is returned after methanogenesis is superior in terms of its nutrient content and can be used as a soil conditioner and plant nutrient (fertilizer).

Socio-Cultural barriers must be overcome before launching the biogas programme at large scale in Himachal or any other part of India. Use of night soil and Kitchen waste are important raw materials for methanogenesis which can increase the biogas productivity while maintaining the waste management of the area. Liquid manure must be stored in pits or other installations that

require investment of time and labour. Therefore, promotion of liquid manure digesters requires additional education and training to ensure sustainability.

The installed biogas plants in Himachal Pradesh will be able to save about 0.102 million kg fuel wood per day and provides clean fuel for more than 97,000 peoples. Solar heating design of the biogas plant may improve the temperature maintenance problem (Hills and Stephens, 1980). The wide variation of temperature in hilly areas can be controlled through modifying the design of the digester.

Moreover, the use of biogas reduces the consumption of LPG. Two cylinders were sufficient for a year when biogas was being used. 30 to 35 kg raw material was used per day for 2-hour consumption of the biogas. In other words, nearly 2 to 3 kg waste is required for $1m^3$of gas production. This gas is approximately equal to 0.43 kg of LPG. For a month, in a family of five, approximately 13 kg of LPG can be saved. Unsubsidized cost of the LPG is Rs 50 per kg. Therefore, Rs 650/ month can be saved.

ACKNOWLEDGEMENT

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Solar Energy Application for Electrical Energy Production in Press Mill Industry in Jordan

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ABSTRACT

Theoretical modelling for estimating the electrical load in a local industry (press mill) has been studied, and proper PV cells including all components have been estimated for future erection. The software has taken into account the solar radiation in the area where the industry is located. Advanced PV technology has been chosen to find out the cheapest way of installing the whole system to reduce the electricity bill and to encourage the industry towards cleaner technology. It is found from this study that the PV solar system is one of the best options for reducing the electricity bill of the industry according to the pay back period. This project is for the benefit of the country as it will reduce the indigenous emissions and energy resources.

Key words: Solar energy , electrical energy , press mill

INTRODUCTION

Every day across the globe, the sun shines the earth. The energy in the photons from the sun can be converted to electrical energy. The term for this process is the ´Photovoltaic Effect´(Kurokawa et al, 2006).

Since the first commercially available solar panel in the 1960´s, photovoltaic (PV) technology has continued to be explored and developed throughout the world. The constant development of this technology has resulted in an increasing level of efficiency and PV panels that are more affordable than ever before, though still initially expensive. Today, humans continue to search for new ways to make photovoltaic technology a viable option for everyone throughout the world. Since most of us are not studying the atomic level of this technology, we can help in other ways - by gaining an understanding and spreading that understanding of photovoltaic, as well as by helping others to gain access to solar, or photovoltaic systems (Solar Powering a green future, 2009. http://www.suntech-power.com/ ,Tom Elliot's, Alternative Energy Information Center SolarScript© PV System Design, On-Line Calculator v2.3, 2008 and Planning and installing photovoltaic systems: a guide for installers, architects, and engineers / Deutsche Gesellschaft fur Sonnenenergie (DGS). - 2nd Ed)

Due to the sharp fluctuation in the oil prices, and in order to reduce the emissions produced from fossil fuel combustion, finding new environmental friendly energy sources is the issue. Jordan is blessed with an abundance of solar energy which is evident from the annual daily average solar irradiance (average insulation intensity on a horizontal surface ranges between 5-7

kWh / m^2) which is one of the highest in the world (Build a simple solar powered outdoor light, Jeffery yago, http://www.backwoodshome.com/articles2/yago92.html , METEONORM,2009, www.meteotest.ch, NERC Report , 2004).

This corresponds to a total annual of 1600 -2300 kWh / m^2. and the annual average sunshine duration is more than 300 days /year, this makes the utilization of solar energy as one of the best choices to be used as a source of energy.

So that it is necessary to choose a location that is on or near the place where your loads will be. The most important thing to consider when choosing a location for an array is shading obstacles. Shade covering just one PV cell can reduce the current dramatically. A small amount of shade covering the panel can reduce the panel performance by 80% (Campbell, 2008, Wiles, 2005 and "Procedure for Photovoltaic System Design FSEC standard 203-05", 2005)

In this research work, the feasibility of utilizing the photovoltaic system for industrial electrification is studied, after the calculation of the electrical power demand of the system, the needed photovoltaic system, including the battery sizing; controller and inverters are designed. Finally an economical analysis of the system is performed.

METHODS

Land Calculations for the Industrial Complex

The solar PV system has been designed depending on the following loads at Swailem industry, which is located in Marka city. All the calculations are depending on the loads, so that the designed photovoltaic system and the economical calculations are estimated accordingly (Table .1).

The daily load needed = 51.814kWh

DC load (Losses due to Inverter) = the daily load needed for the station*1.2= 62176.8 kWh

The daily required PV peak current can be determined taking into consideration the PSH which is 5.5 hour/day and losses due to system components and high normal operating PV cell temperature (40-60)°C which are represented by a typical safety factor about 20%, thus;

The inverter input voltage is 24 V, so the total AC *Ampere* hours per day (Ah/day) used by AC Load is,

Total ah/day used by AC loads = (total AC load/inverter input voltage) = 62176.8/ 24 = 2590.7 Ah/day.

Total array of Amperes needed = (total ah/day used by AC load/PSH)*safety factor

= (2590.7 / 5.5) * 1.2

= 565.24A

Then, the required number of PV modules can be determined as follows,

Number of modules per parallel strings= $\frac{\text{Total array of Amperes needed}}{\text{modules peak current}}$ ≈ 72strings

Number of modules per parallel strings= 2 module

Then, the total number of modules needed is,

Total number of modules = Number of modules per parallel strings x Number of parallel strings = 143Modules.

Table 1: Energy Detailed Analysis (kWh)

AC Load	Qty	Watts	Operational hours	Wh
Compressor	1	1500	3	4500
Grinding machine	4	370	2	1480
Work space lighting Fluorescent lamp	6	40	8	1920
Large Mixer machine	3	2000	3	18000
Fluorescent lamp	5	40	8	1600
Pumps	5	1250	3	18750
Filling machine	1	500	3	1500
Fluorescent lamps	16	40	8	5120
Desktop computer	1	300	8	2400
total lighting	assume ,6 demand factor			5184
Total machines	46630			
Total	51814			

RESULTS AND DISCUSSION

For present project, a model for the PV system calculation is created and several simulations were run to test the model. This can be effectively done using the program Simulink in MatLab® (Fig.1). Simulink is an interactive tool for modeling, simulating, and analyzing dynamic systems, including controls, signal processing, communications, and other complex systems. It is an excellent resource for modeling and simulating mathematical systems and subsystems. The addition of Simpower makes electrical circuit modeling achievable. Block diagrams are used to design and model a system with Simulink as in Figure 1.

This study is carried out with the main purpose to establish a library of simple mathematical models for each individual element of a stand – alone PV system, namely solar cells, battery, controller, inverter and load for system performance analysis.

Per definition, a standalone system involves no interaction with a utility grid. A PV generator can contain several arrays. Each array is composed of several modules, while each module is composed of several solar cells. The battery bank stores energy when the power supplied by the PV exceeds load demand and releases it backs when the PV supply is insufficient. the load for a stand – alone PV system can be of many types , both DC (television , lighting) and AC (electric motors , heaters . etc.) . The power conditioning system provides an interfacing between all the elements of the PV system, giving protection and control. The most frequently encountered elements of the power conditioning system are blocking diodes, charge regulators and inverter.

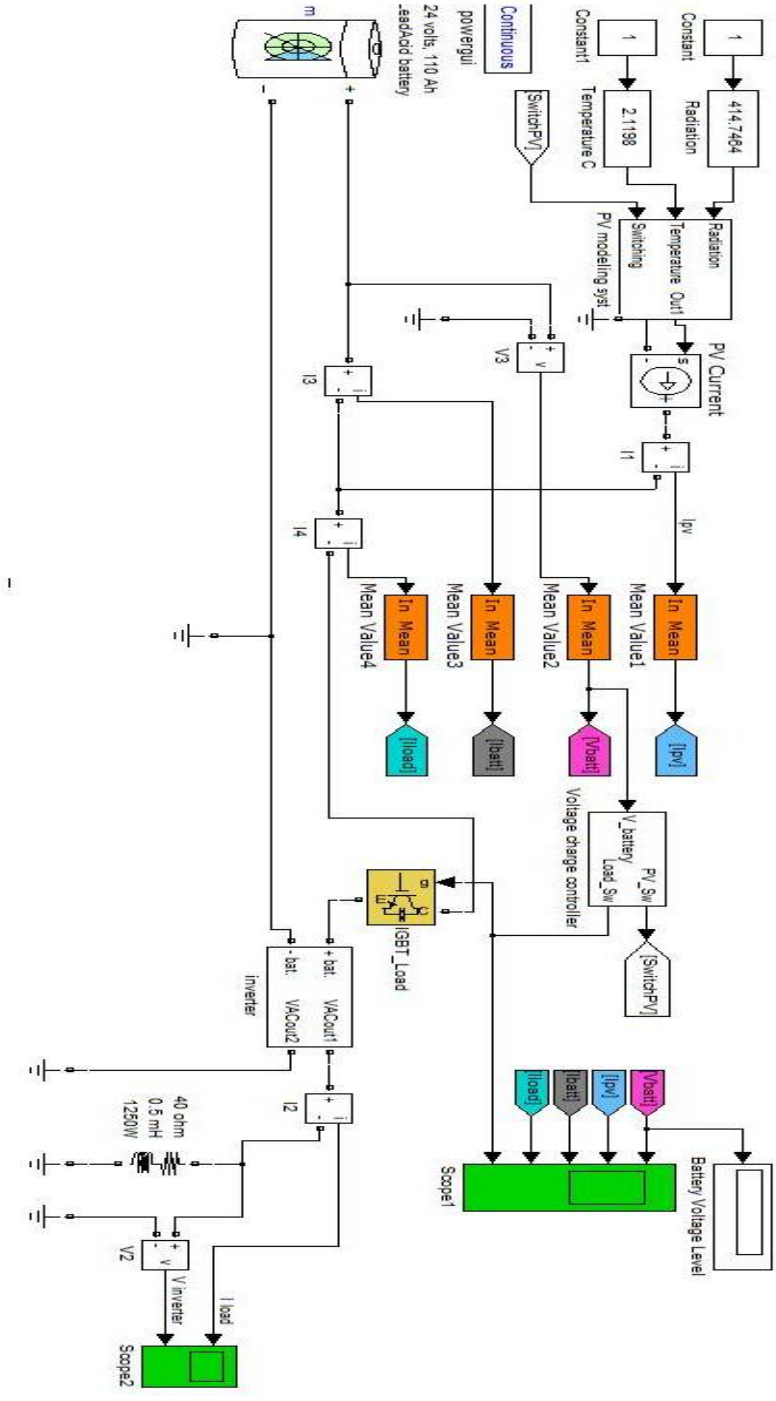

Fig. 1: MATLAB simulation model for stand-alone PV system

Component Models for STAND-ALONE PV System: The main purpose of this section is to describe the models for the elements of a stand – alone PV system: PV generator, battery, controller, inverter. The modeling of the PV system is based on modular blocks, as illustrated in Fig. 2.

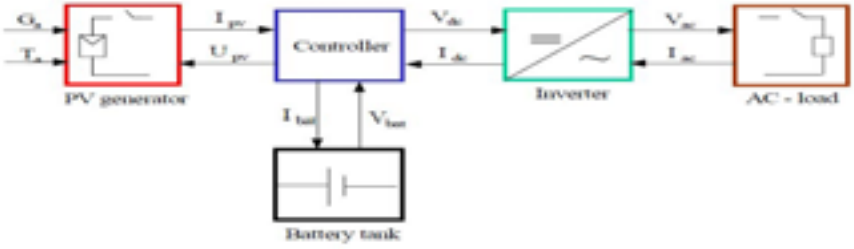

Fig. 2: Block diagram for the stand-alone PV system

Simulation Results: After running the simulation of the whole system at different modes of operation the following results are as shown in the Figures 3-10 below:

Figure 3 to 4 show the performance of the PV module and the P-V and V-I proportionality.

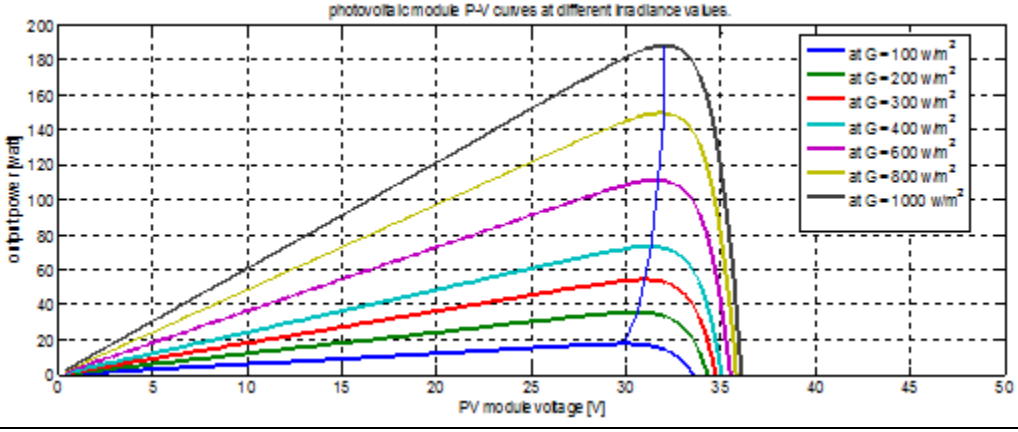

Fig. 3: P-V Characteristic for different irradiance values.

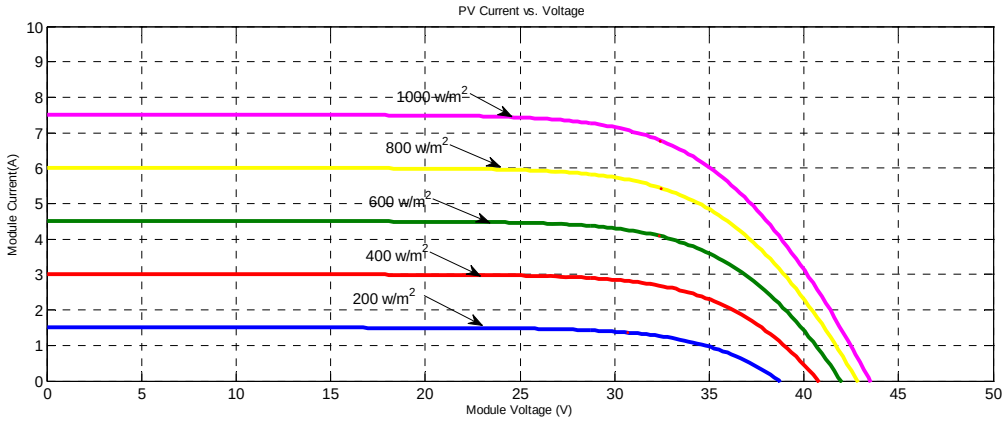

Fig. 4: Current-Voltage I-V Characteristic of PV modules. (Irradiance dependence)

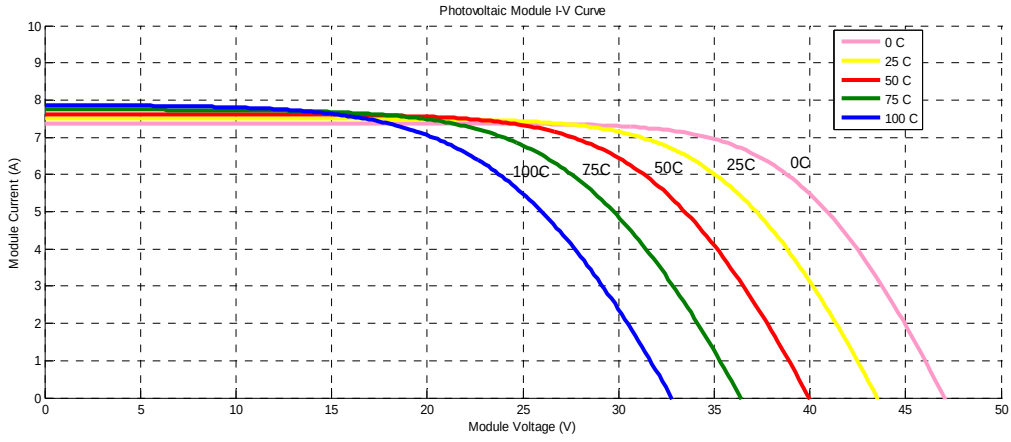

Fig. 5: I-V characteristic (temperature dependence)

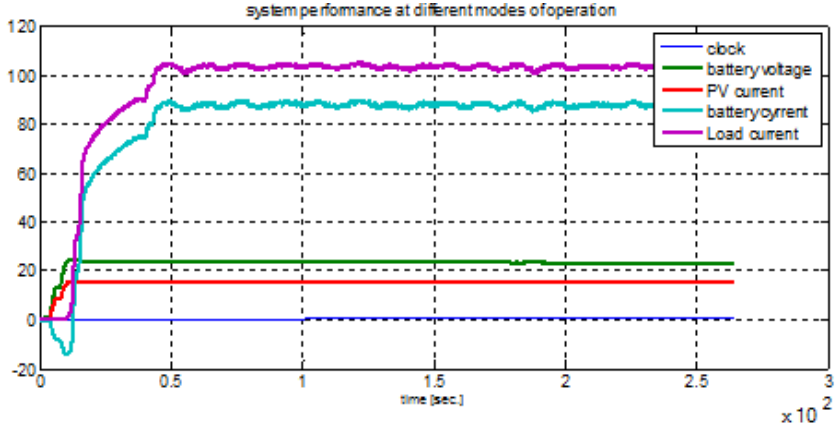

Fig. 6: System performance at different mode

Figure 6 shows that the system performance at T= 0 °C, Radiation = 300 W/m^2 at low radiation most of the load current is delivered by battery bank.

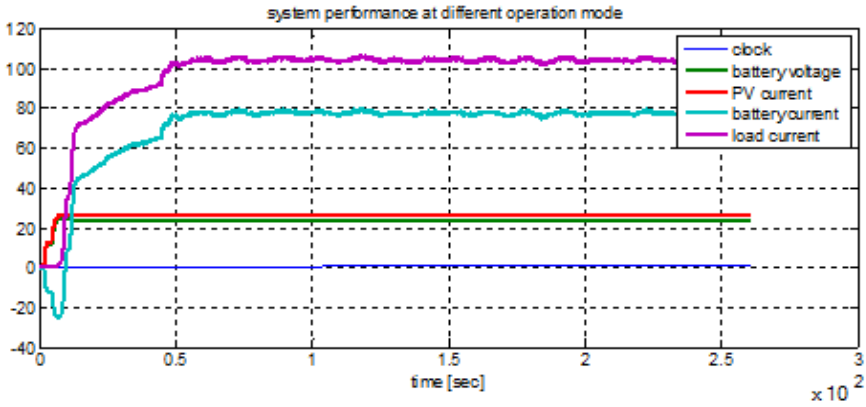

Fig. 7: System performance at T =10 °C, Radiation = 500 W/m^2.

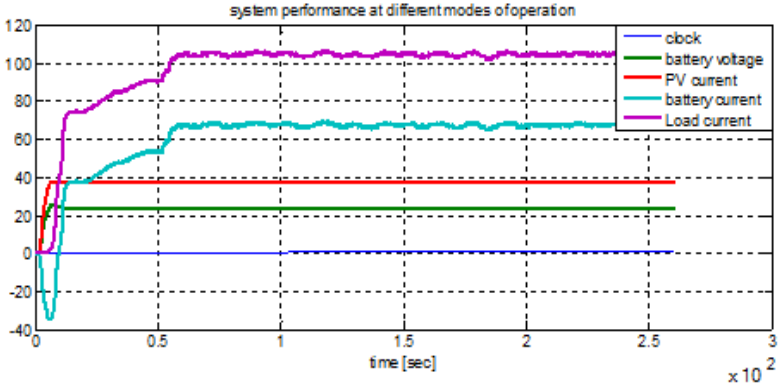

Fig. 8: System performance at T =20 °C , Radiation = 750 W/m^2.

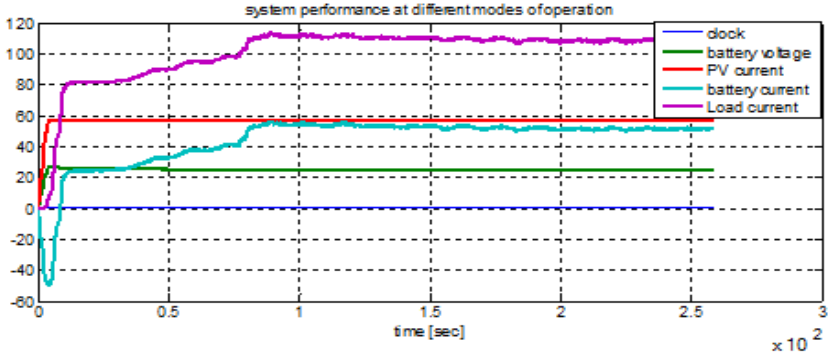

Fig. 9: System performance at different mode.

Figures 7- 9 ,show that at high radiation most of the load current is delivered by photovoltaic arrays.

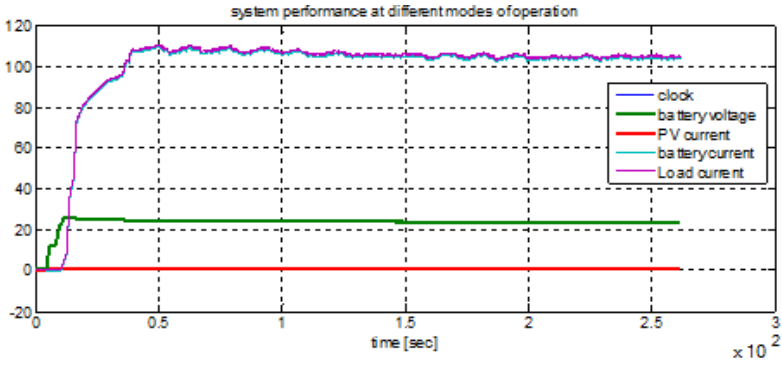

Fig. 10: System performance at different mode

PV modules with low efficiencies mean that larger arrays are required, this means higher cost. In order to cover all electrical loads of press mill industry a PV system of 36 modules, 5 kVA inverter, charge controller with rating ampere of 284 and 20 batteries are needed. The life time is of 30 years except for the batteries, which will be considered to have a life time of 10 years. Also, the annual inflation rate in batteries price is considered to be 5%.

CONCLUSION

Global warming is a deep crisis affecting humanity therefore, the goal is to reduce our dependence of fossil fuels and move energy sectors toward renewable, clean sources of energy. This study is encouraging the industrial sector in Jordan to reduce carbon emissions drastically by implementing clean energy from sun. Furthermore we may be able to reverse the effects of desertification.

The choice of a photovoltaic system is economically rewarding when located in a region that is far from an electricity grid connection from about 200-300 meters or more.

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Solar Power Satellites

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ABSTRACT

In the present day scenario the world is facing energy-crisis and it accounts for the search of alternate renewable sources of energy to quench the demands of the terrestrials .In this paper we have discussed the most vast and unexplored source of energy which is indeed the technology of the future. A solar power satellite, or SPS or Powersat, as originally proposed is a satellite built in high Earth orbit that uses microwave power transmission to beam solar power to a very large antenna on Earth. Advantages of placing the solar collectors in space include the unobstructed view of the Sun, unaffected by the day/night cycle, weather, or season. The paper also discusses the space craft design and the various modes of solar power satellite operation. [1]

Key words : power demand, spacecraft sizing, reception infrastructure, applications

INTRODUCTION

The Solar Power Satellite (or "Space Solar Power," SPS) is a concept to collect solar power in space, and then transport it to the surface of the Earth by microwave (or possibly laser) beam, where it is converted into electrical power for terrestrial use . The recent prominence of possible climate change due to the “greenhouse effect” from burning of fossil fuels has again brought alternative energy sources to public attention. In common with other types of renewable energy such a system could have advantages to the world in terms of energy security via reduction in levels of conflict, military spending, loss of life, and avoiding future conflict over dwindling energy. It is **a renewable energy source**, zero emission after putting the solar cells in orbit, and only generates waste as a product of manufacture and maintenance. (Glaser, 1968)

POWER DEMAND AND PRESENT CONSUMPTION RATE

The demand of coal in present day scenario is maximum amongst the available non-renewable resources as it is evident from figure no 1 and the pie chart is shown in figure 2 . It is believed that approximately 80% of the population is dependent on the electricity produced by coal and the sources of coal are depleting each day followed by the increments in its consumption. Therefore, the need of alternate energy resources is felt and it is high time that we take a proper initiative in this context(Landis,1990).

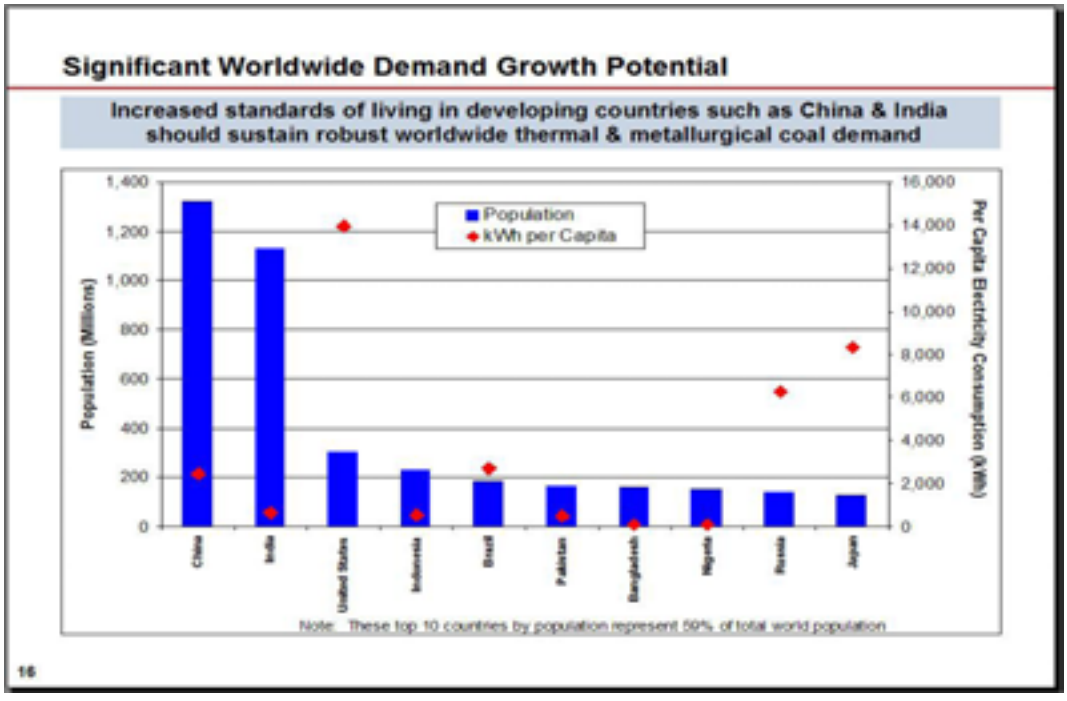

Fig. 1: Bar graph showing per capita power demand in various countries

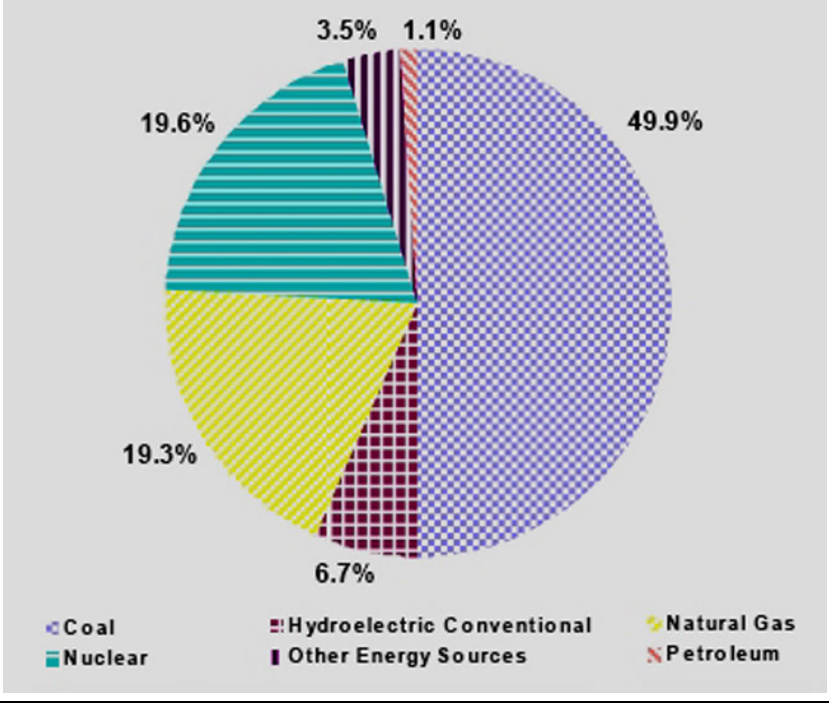

Fig 2: A pie chart showing consumption of various energy sources

SOLAR PHOTONS TO DC CURRENT CONVERSION TECHNOLOGY

Two basic methods of converting photons to electricity have been studied,

- Solar dynamic (SD)
- Photovoltaic (PV).
- Concentrating photovoltaic technology(CPV)

Solar Dynamic (sd) Technology

SD uses a heat engine to drive a piston or a turbine which connects to a generator or dynamo. Terrestrial solar dynamic systems typically use a large reflector to focus sunlight to a high concentration to achieve a high temperature so the heat engine can operate at high thermodynamic efficiencies; an SPS implementation will be similar. A major advantage of space solar is the ease with which huge mirrors can be supported and pointed in the freefall and vacuum conditions of space. They can be constructed from very thin aluminum or other metal sheets with very light frames or from materials available in space (eg, on the Moon's surface) (Landis,1990, 1997).

Photovoltaic (pv) Technology

PV uses semiconductor cells (e.g., silicon or gallium arsenide) to directly convert sunlight photons into voltage via a quantum mechanical mechanism. They are not subject to the thermodynamic limitations of thermal engines such as those used in SD collection systems. Photovoltaic cells are not perfect in practice as material purity and processing issues during production affect performance, but are much less expensive and generally lighter. All are commonly known as “solar cells”, and in an SPS implementation will likely be rather different from the glass-pane protected solar cell panels familiar to many from current terrestrial use. They will, for reasons of weight, probably be built in a membrane form not suitable to terrestrial use where the considerable gravity loading imposes structural requirements on terrestrial implementations (Landis,1990, 1997).

Concentrating Photovoltaic (cpv) Technology

It is also possible to use Concentrating Photovoltaic (CPV) systems, which, like SD, are a form of existing terrestrial Concentrating Solar Energy approaches which convert concentrated light into electricity by PV, again avoiding the thermodynamic constraints which apply universally to heat engines. On Earth, these approaches use solar tracking systems, mirrors, lenses, etc to achieve high radiation concentration ratios and are able to reach efficiencies above 40% Concentrating Photovoltaic Technology. Because their PV area is rather smaller than in conventional PV, the majority of the deployed collecting area in CPV systems is lenses or mirrors, as with most SD systems. They share the advantages of building and pointing large (simple) mirror arrays in space as opposed to more complex PV panels (Landis,1990, 1997).

WIRELESS POWER TRANSMISSION TO THE EARTH

Wireless power transmission was early proposed to transfer energy from collection to the Earth's surface. The power could be transmitted as either microwave or laser radiation at a variety of frequencies depending on system design. Whatever choice is made, the transmitting radiation

would have to be non-ionizing to avoid potential disturbances either ecologically or biologically if it is to reach the Earth's surface. This established an upper bound for the frequency used, as energy per photon, and so the ability to cause ionization, increases with frequency. Ionization of biological materials doesn't begin until ultraviolet or higher frequencies so most radio frequencies will be acceptable for this. To minimize the sizes of the antennas used, the wavelength should be small (and frequency correspondingly high) since antenna efficiency increases as antenna size increases relative to the wavelength used. More precisely, both for the transmitting and receiving antennas, the angular beam width is inversely proportional to the aperture of the antenna, measured in units of the transmission wavelength. The highest frequencies that can be used are limited by atmospheric absorption (chiefly water vapor and CO_2) at higher microwave frequencies.

For these reasons, 2.45 GHz has been proposed as being a reasonable compromise. However, that frequency results in large antenna sizes at the GEO distance. A loitering stratospheric airship has been proposed to receive higher frequencies (or even laser beams), converting them to something like 2.45 GHz for retransmission to the ground. This proposal has not been as carefully evaluated for engineering plausibility as have other aspects of SPS design; it will likely present problems for continuous coverage (Landis,1997) .

SPACECRAFT SIZING

The size of an SPS will be dominated by two factors; the size of the collecting apparatus (eg, panels, mirrors, etc) and the size of the transmitting antenna which in part depends on the distance to the receiving antenna. The distance from Earth to geostationary orbit (22,300 miles, 35,700 km), the chosen wavelength of the microwaves, and the laws of physics, specifically the Rayleigh Criterion or Diffraction limit, used in standard RF (Radio Frequency) antenna design will all be factors.

For best efficiency, the satellite antenna should be circular and for the probable microwave wavelength, about 1 kilometers in diameter or larger; the ground antenna (rectenna) should be elliptical, 10km wide, and a length that makes the rectenna appear circular from GSO (typically, 14 km at some North American latitudes). Smaller antennas would result in increased losses to diffraction/side lobes. For the desired ($23mW/cm^2$) microwave intensity these antennas could transfer between 5 and 10 gigawatts of power.

To be most cost effective, the system should operate at maximum capacity. And, to collect and convert that much power, the satellite would require between 50 and 100 square kilometers of collector area. State of the art (currently, quite expensive, triple junction gallium arsenide) solar cells with a maximum efficiency of 40.7% could reduce the necessary collector area by two thirds, but would not necessarily give overall lower costs for various reasons. For instance, these very recently demonstrated variants may prove to have unacceptably short lifetimes. In either case, the SPS's structure would be essentially kilometers across, making it larger than most man-made structures here on Earth. While almost certainly not beyond current engineering capabilities, building structures of this size in orbit has not yet been attempted (Landis,2000 , Patapoff,1985).

EARTH BASED INFRASTRUCTURE

The Earth-based receiver antenna (or rectenna) is a critical part of the original SPS concept. It would probably consist of many short dipole antennas, connected via diodes. Microwaves broadcast from the SPS will be received in the dipoles with about 85% efficiency. With a conventional microwave antenna, the reception efficiency is still better, but the cost and complexity is also considerably greater, almost certainly prohibitively so. Rectennas would be multiple kilometers across. Crops and farm animals may be raised underneath a rectenna, as the thin wires used for support and for the dipoles will only slightly reduce sunlight, so such a rectenna would not be as expensive in terms of land use as might be supposed (Patapoff, 1985).

OPTIMIZED SPS DESIGN

Due to the geographical structures of the earth, the energy from the solar power satellite can be focused within a range of 87 degree between any two areas and this limitation can be eliminated by increasing the range and this is done by using a relay satellite which can used to reflect the power at any required area over the planet .the following figure depicts the utilization of relay satellite, which increases the efficiency (Landis, 2000).

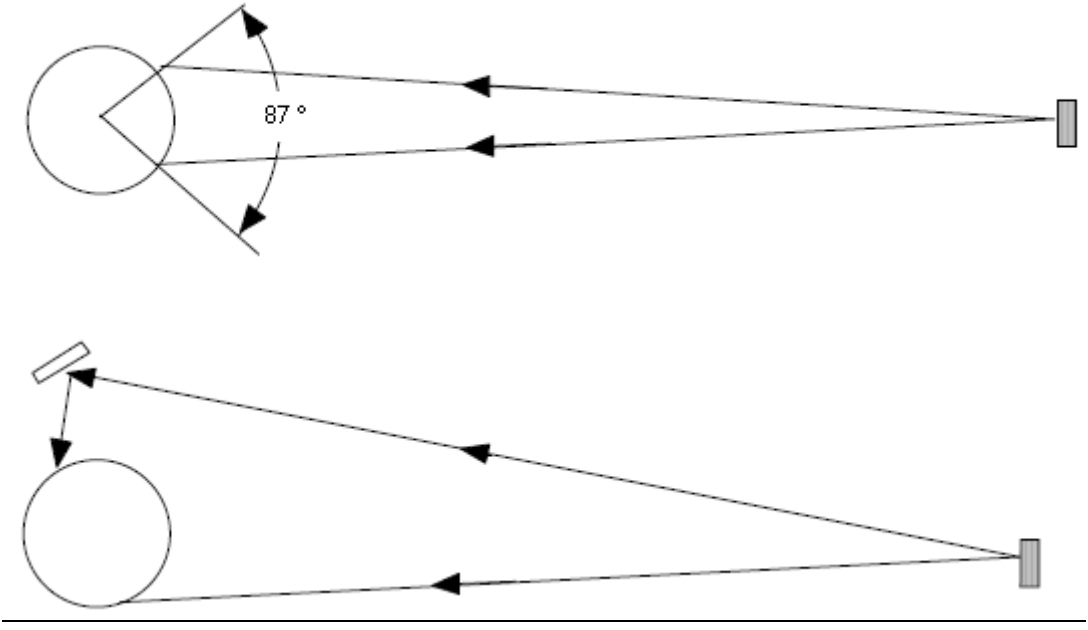

Fig. 3: A single solar power satellite can service two markets on the Earth either directly (top) or by a relay satellite (bottom).

ADVANTAGES

- The SPS concept is attractive because space has several major advantages over the Earth's surface for the collection of solar power. There is no air in space, so the collecting surfaces would receive much more intense sunlight, unaffected by weather.

- In geostationary orbit, an SPS would be illuminated over 99% of the time. The SPS would be in Earth's shadow on only a few days at the spring and fall equinoxes; and even then for a maximum of 75 minutes late at night when power demands are at their lowest.
- SPS based power generation systems do not require the expensive storage facilities (eg, lakes behind dams, oil storage tanks, coal dumps, etc) necessary in many Earth-based power generation systems.
- Additionally, an SPS will have none of the polluting consequences of fossil fuel systems, nor the ecological problems resulting from many renewable or low impact power generation systems (eg, dam retention lakes).
- Economically, an SPS deployment project would create many new jobs and contract opportunities for industry, which may have political implications in the country or region which undertakes the project.
- Developing the industrial capacity needed to construct and maintain one or more SPS systems would significantly reduce the cost of other space endeavors. For example, a manned Mars mission might only cost hundreds of millions, instead of tens of billions, if it can rely on an already existing capability.

CONCLUSION

Humanity faces a new energy crisis. A growing population and rising per-capita energy consumption require a move away from the polluting, finite energy supplies now in use. Moreover, renewable energy sources such as conventional solar and wind power can only meet a portion of projected needs. Space holds the key to an inexhaustible, non-polluting energy supply. That key is space solar power (SSP) -- using space-based systems to collect the sun's energy and turn it into usable power for Earth. Consider the energy situation now confronting the world. Industrialization and urbanization will mean sharply increased energy use. Reliance on fossil fuels could produce unprecedented environmental damage. Moreover, such finite sources may soon be past their peak availability, if they aren't already. The solution to this problem is to utilize terrestrial renewable energy resources to the maximum extent possible, while at the same time developing SSP as a global, 24-hour-a-day energy supply

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Sustainable Development by Sahara Solar Breeder Plan: Energy from the Desert of Algeria

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ABSTRACT

Energy is the most important resource for the development of a country and the utilisation of energy per capita is increasing tremendously. Energy is also central to achieving the interrelated economic, social, and environmental aims of sustainable human development. In fact Energy security, Economic growth and Environmental protection (the three E's) are the national energy policy drivers of any country of the world. In addition, it's no secret that fossil fuel supplies are dwindling and will eventually be depleted within a few decades. At the same time, fossil fuel consumption continues to increase leaving in its wake destructive cumulative effects, which began during the industrial revolution. Such ever-increasing demand could place significant strain on the current energy infrastructure and potentially damage the world environment and people's health. Scientists, governments, and industries are witnessing the long-term consequences of energy consumption and foresee catastrophic outcomes if alternative methods of energy production are not developed and utilized to meet the needs of our global economy. Because photovoltaic (PV) systems convert solar energy into electricity without combustion, they create virtually no pollution and hold the key to future prosperity and a healthy global environment. In recent years, the development and commercialisation of PV systems for different applications is increasing tremendously and is proposed as a competitive energy policy and a step forward to the target of sustainable development and environmental friendly energy source. In this contribution a particular attention is being given to the joint event that bring together the relevant parties, the University of Sciences and Technology of Oran (USTO), Japan International Corporation Agency (JICA), Japan Science and Technology Agency (JSTA), University of Saida and the URER/MS Renewable Energy Centre of Adrar to develop a long-term vision and strategy to boost the ideas for the realization and the development of the Sahara Solar Breeder (SSB) project. SSB = Energy/Climate security with global justice and development of civilisation for whole world, Clever global development strategy for solving the energy and climate problems with existing solar grade Silicon production from Sahara sand technology for a world in a sustainable way. This paper introduced the major global energy challenges and analysed the development and utilisation of alternative methods of energy production to meet the needs of our global economy.

Keywords: Sahara, silica sand, photovoltaic energy, environment

INTRODUCTION

At present, the bulk of our energy comes from fossil fuels (gas, coal, and oil). These are hydrocarbons composed of hydrogen and carbon atoms which when combined with the oxygen

in the air and heat, they react exothermically. Atmospheric and environmental pollution as a result of extensive fossil fuel exploitation in almost all human activities has led to some undesirable phenomena that have not been experienced before in known human history. Fossil fuel consumption continues to increase and emissions have increased dramatically over the past century in that, massive amount of carbon dioxide in the atmosphere has dire implications for the delicate balance of our ecosystem and could eventually lead to runaway climate change. Such phenomena are varied and include global warming and the greenhouse affect (figure 1 and table 1) (International Energy Agency (IEA) 2009), ozone layer depletion, acid rain, hazardous air quality and water pollution, forest destruction and major environmental accidents.

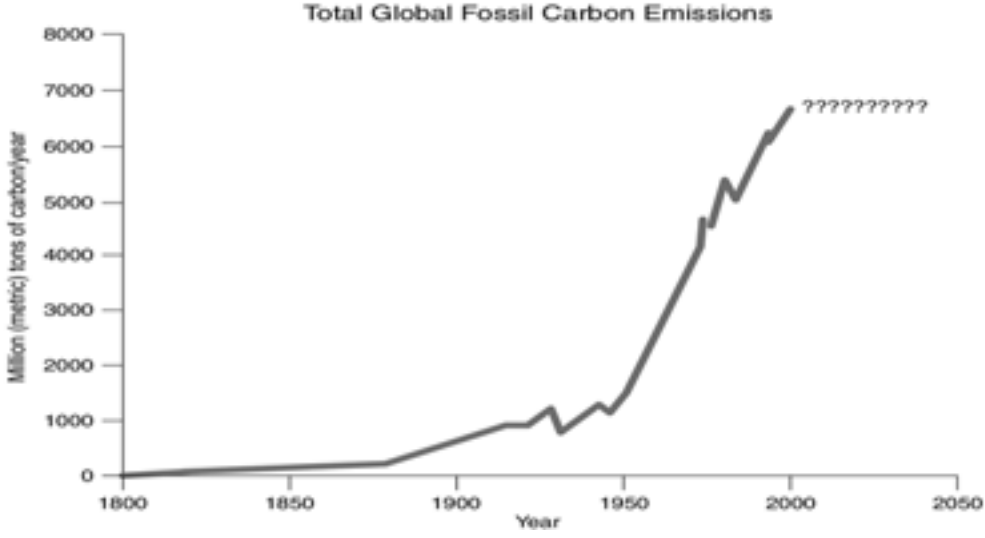

Figure1: Total global fossil carbon emissions

Table 1: Global CO_2 emissions in tonnes/capita (2008)

USA	Australia	Russia	Japan	E.U	World average
19	19	11.1	9.5	8.1	4.3
M.East	China	E.East	L.America	Africa	
6.8	6.8	2.8	2.1	0.9	

World oil production will decline in the next 20-40 years and dependence on energy from fossil fuels is also reaching its limits (figures 2) (H. Ezzeldin, 2007), the development of new power generation technologies will become increasingly important. Simultaneously, interest will likely increase regarding energy-related environmental concerns, to take precautions today for a viable world for coming generations. Hydrocarbons energy sources cannot be expected to fill that increased demand and should not be, for both environmental and practical economic reasons (figure 3) (United Nations, World population Prospect, 1998). Indeed, energy is one of the main factors that must be considered in discussions of sustainable development. The global energy economy will need to decarbonise power generation substantially in order to achieve a sustainable

energy future. This will require large-scale shifts to renewable energy for power generation. Solar radiation is an integral part of different renewable energy (RE) resources, in general, and, in particular, it is the main and continuous input variable from the practically inexhaustible sun. Solar energy is expected to play a very significant role in the future especially in developing countries, but it also has potential in developed countries. The International Energy Agency has identified photovoltaics (PV) as one of the key technologies that are at the heart of the energy technology revolution because they can make the largest contributions to reducing greenhouse gas emissions.

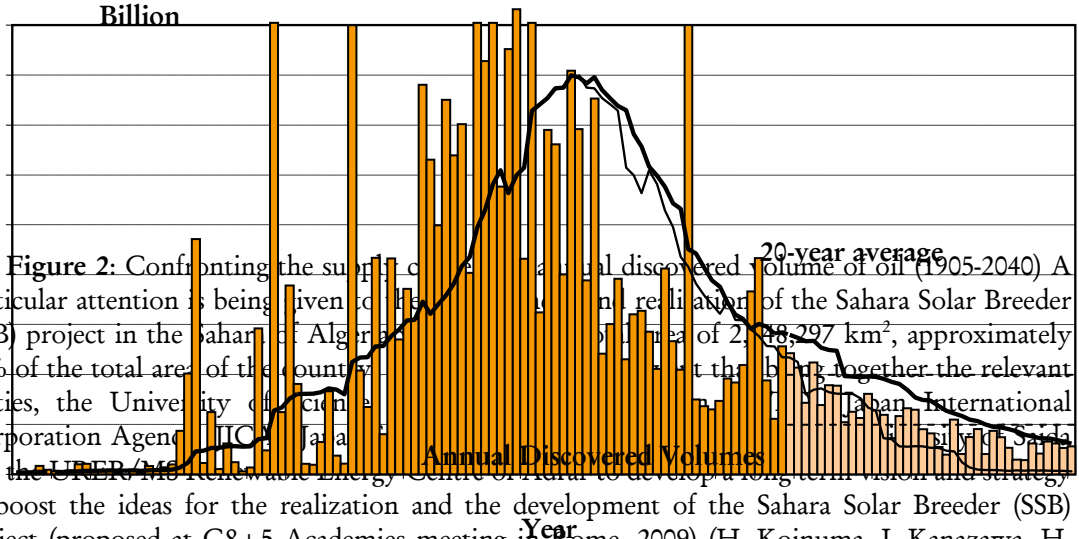

Figure 2: Confronting the supply curve [illegible] annual discovered volume of oil (1905-2040) A particular attention is being given to the [illegible] and realization of the Sahara Solar Breeder (SSB) project in the Sahara of Algeria [illegible] area of 2,[illegible]48,297 km^2, approximately 86% of the total area of the country [illegible] bring together the relevant parties, the University of [illegible] Japan International Corporation Agency (JICA) Japan [illegible] Sahara and the UREP/MS Renewable Energy Centre of Adrar to develop a long term vision and strategy to boost the ideas for the realization and the development of the Sahara Solar Breeder (SSB) project (proposed at G8+5 Academies meeting in Rome, 2009) (H. Koinuma, I. Kanazawa, H. Karaki and K. Kitazawa, 2009).

This project will tackle the key challenges and issues related to the field of Photovoltaics putting forward the material R/D perspective and promoting innovative processes for solar silicon with a focus on the utilisation of Sahara sands by a collaborative research plan between Japan and Algeria. Three Ss should be the national energy policy drivers of Algeria namely: Solar, Sand and Space. A primary project analysis framework is then synthesized and analyzed by clarifying the basic concepts and summarizing the main strategic ideas of SSB plan is directed towards continental and global clean energy supply from the Sahara making PV a significant contributor within a portfolio of energy sources in the coming 10 to 20 years

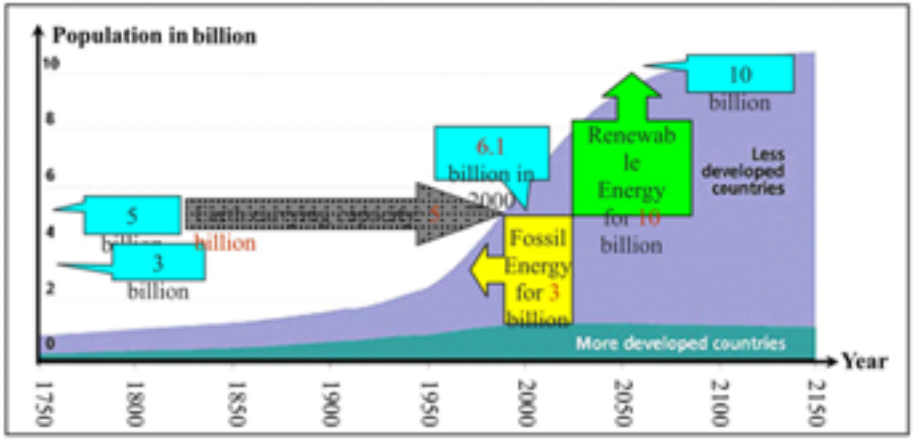

Figure 3: World population growth and carrying capacity of Earth

In order to speed up the electric superhighway, the generated electricity from SSB, made up of a network of Very Large Scale-PV Power Systems in Sahara desert, will have to be transferred to the North Africa, then Europe, Africa, and ultimately the rest of the world, via High critical Temperature Superconducting Cables (HT$_c$SC) that can provide, in compact dimension, firm capacity for base load, intermediate and peaking power, effectively complementing conventional electricity sources. Because HT$_c$SC are compact and can transmit a large amount of electric power (up to 10 times as much power as conventional electric power transmission cable), it can utilize more effectively congested underground space where a lot of piping and other units already exist. This paper introduced the major global energy challenges and analysed the development and utilisation of alternative methods of energy production to meet the needs of our global economy.

RENEWABLE ENERGIES POTENTIALS IN ALGERIA

Due to its geographical location, Algeria holds one of the highest solar reservoirs in the world. Studies of RE sources performed in Algeria during recent years show that it has an important potential for power generation from RE, for the domestic market as well as for export to the European market. Pilot implemented projects justify the possibility to accelerate the use of indigenous energy resources, particularly for electricity supply. The assessment of potential is based on two different types of sources: assessment of the Algerian government and the in-depth studies conducted by the German Aerospace centre (DLR). DLR calculated data mainly from satellite imaging and further processing to derive technical and eventually economic potential. Table 2 summarises the RE potentials for electricity generation (power production in Algeria in 2005 stood at 35 TWh (Wuppertal Institute for climate, Environment and Energy and the CREAD, 2011)). The major advantage of DLR study is that all RE potentials were assessed with an identical set of methodologies.

Table 2: Economic electricity supply side potential of RE in Algeria (TWh/year)

RE in Algeria	Thermal-solar	PV-solar	Wind-power	Hydro-power	Geothermal	Biomass
Economic Potential	168,972	>13.9	35	0.5	4.7	12.1

There is a large difference between potential of thermal and PV solar economic potential. This is somewhat distorting because at the time when the assessments of potentials were made, the cost difference and expected cost differences in the near future were very large. However, this situation has changed significantly during the last three years as PV technology prices decreased sharply; hence, investment costs for power plant investors have decreased. The effect is an increase in the economically utilisable potential on the PV side, which will lead to a decrease of thermal solar potential.

In addition to DLR study, the centre for development of renewable energies (CDER) surveyed several type of RE. Data are gathered in the RE guide report by the ministry of energy and mines (MEM). This latter concludes that the biggest potential of RE in Algeria is solar as seen in table 3 and figure 4 (Renewable Energies Development Centre, 2011).

Table 3: Solar potential in Algeria

Areas	Coastal area	High plateau	Sahara
Surface (%)	4	10	86
Average duration of sunshine (Hours/year)	2650	3000	3500
Received average energy (KWh/m²/year)	1700	1900	2650

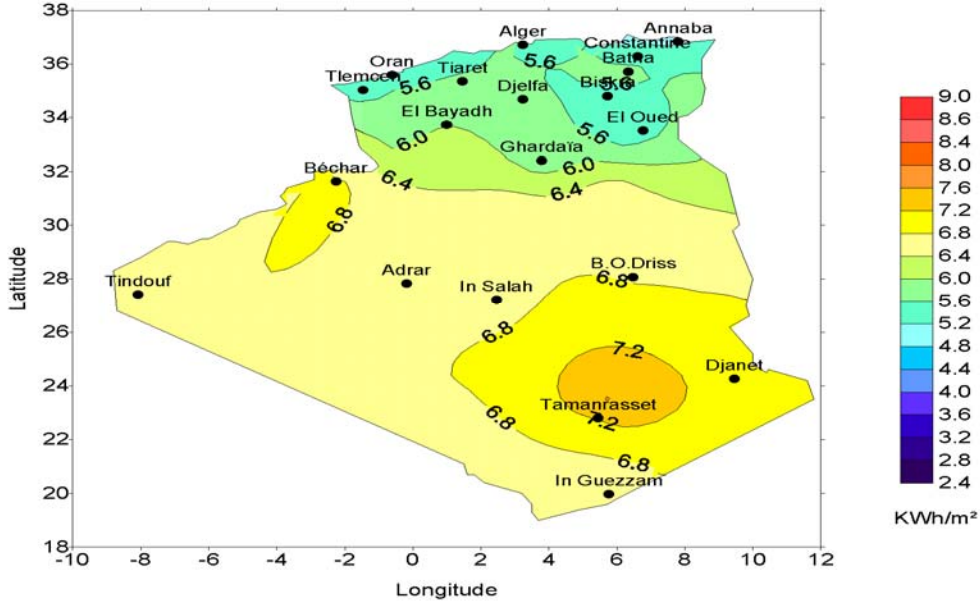

Figure 4: Potential sites for solar electricity supply and example of the overall daily exposure received (in KWh / m² / day) in Algeria

PHOTOVOLTAICS, THE ALTERNATIVES OF FOSSIL FUELS

Admittedly, the future might not see the same degree of dependence on oil and gas as alternative and renewable energy sources should be employed to close the supply-demand gap. Solar energy is becoming more practical and widely applicable as solar PV systems are among the most promising electrical generation technologies to emerge in recent decades in that:

- It is used for the everyday electricity needs
- Constantly replenished and will never run out
- Has distinct advantages that avoid :
  - consuming resources and degrading the environment through polluting emissions,
  - oil spills,
  - toxic by-products.

  And therefore provides :
- Flexible and environmentally acceptable energy conversion technology for a whole range of applications,
- Potential in the stationary and portable power,
- Limit to the damage of world environmental health and global warming.

  Photovoltaic's value : Photovoltaics have a variety of attributes that are:
- Reliable power and power quality
- Plentiful power where you need it
- High value and appropriate applications
- Environmental quality in that :
  - Typically, on an annual "per kilowatt" basis, PV offsets up to 16 kgs of NOx, 9 kgs of SOx, and 6 kgs of other particulates.
  - 1 kW of PV typically, per year, offsets between 600 and 2300 kgs of CO2 and prevents, each month, 75 kg of fossil fuel from being mined, and 473 l of water from being consumed
- PV value is straightforward and truly the power of choice that provide a more stable energy environment and economy
- The IEA projects that 3000 GW of new capacity will be required by 2020, valued at around 3 trillion of Euros; IEA also projects that the fastest-growing sources of energy will be supplied by renewables in particular solar PV.

Photovoltaics in Algeria

The high level of insolation in Algeria, the presence of several Solar projects financed and promoted by national and private industry as well as the experience in solar energy techniques by New Energy of Algeria (NEAL) are all factors that will undoubtedly give Algeria an important role in the implementation of PV energy technology in MENA region, the capacity for providing sufficient energy for the needs of the population, and the possibility of even exporting such projects to other countries in Europe. The population distribution in Algeria also shows that there is a great potential market for renewable energies, among which solar energy should be

highlighted because of its homogeneous presence throughout the entire region (Boudghene Stambouli A., 2007). The amount of solar radiation in Algeria means that it would be feasible to consider solar energy as a potential energy source for different applications in the form of individual PV solar panels or systems (figure 5) (Boudghene Stambouli A, 2011). Solar PV energy is being developed in Algeria mainly for six applications: domestic uses, water pumping, refrigeration, village electrification, lighting, and telecommunication.

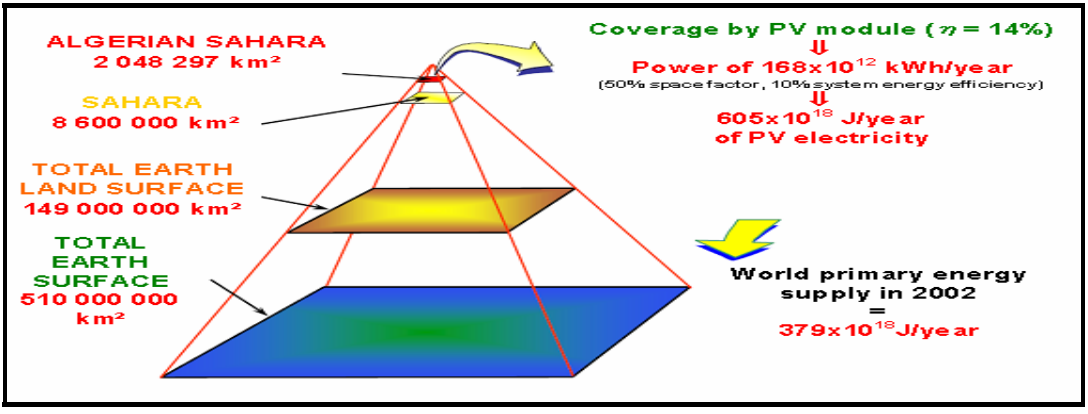

Figure 5: Solar pyramid, the Algerian desert, dead space can be a treasure island of energy used by humanity

SAHARA SOLAR BREEDER, A NEW GLOBAL CLIMATE POLICY

Scientists, governments, and industries are witnessing the long-term consequences of energy consumption and foresee catastrophic outcomes if alternative methods of energy production are not developed and utilised. Photovoltaic is the alternative methods of energy production to meet the needs of our global economy. PV plants can be built over a wide size range from 2 kW to more than 500 MW and are thus adaptable to local requirement. They can also be used for combined heat/cold and power generation (co-and trigeneration) and for desalination. The largest PV plant is in the range of 60 MW.

The SSB plan involves building manufacturing plants around the Sahara desert that would extract silica from the sand and turn it into solar panels to generate renewable energy. The renewable energy from the first facility will then be used to breed more manufacturing plants and, in turn, more solar panels to generate ever increasing amounts of solar power. The ultimate goal is to build enough plants until the breeding strategy can deliver 100 GW of electricity to provide 50% of the world's electrical power generation capacity by 2050 which would be delivered via a global superconducting electrical grid to turn the world's biggest desert into the world's biggest power station taking advantage of two resources that are found in abundance in the Sahara namely silica and sunlight (figure 6) (K. Kurokawa et al, 2009).

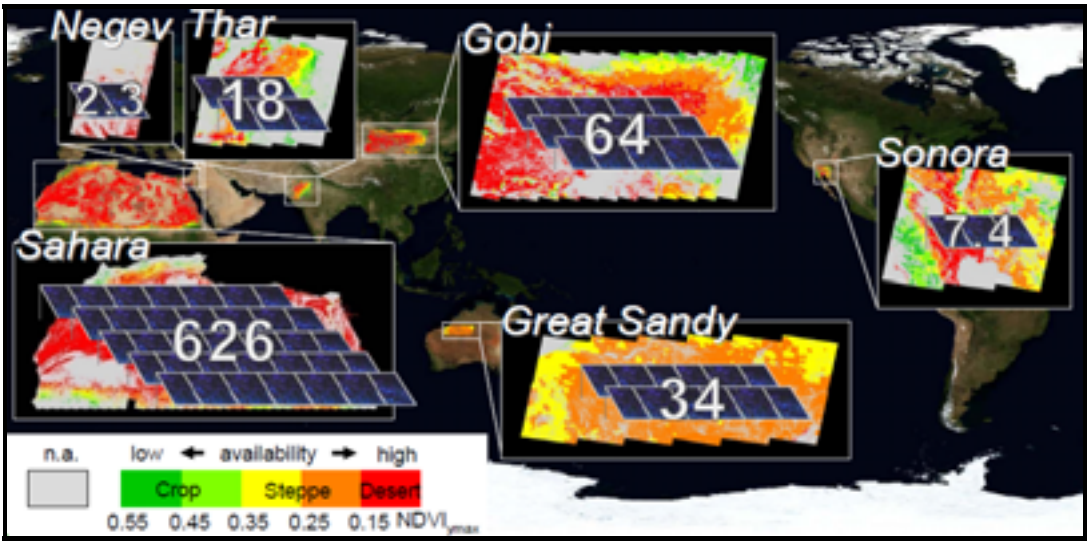

Figure 6: Solar resources of the world six deserts (TW)

In August the 4th 2010, USTO and JICA formed a joint group and signed a series of Memorandum of understanding and bilateral agreements to announce the creation of a Sahara Solar Energy Research Center (SSERC), at the University of Science and Technology of Oran (USTO), to pursue the realisation and the development of PV plant at the chosen experimental site at the University of Saida in the south west of Algeria also known as the gate of the Algerian Sahara.

The development and realisation of the SSB project, in the Sahara of Algeria which covers a total area of 2,048,297 km^2, approximately 86% of the total area of the country, will tackle the key challenges and issues related to the will tackle the key challenges and issues related to the field of PV putting forward the material R/D perspective and promoting innovative processes for solar silicon with a focus on the utilisation of Sahara sands. Three Ss should be the national energy policy drivers of Algeria namely: Solar, Sand and Space.

SSB is a project which proposes a plan of international partnership in basic research and development, industrial production, trade, financing, etc, to construct, gradually over the coming decades, a "Global Clean Energy Superhighway" starting in the Sahara desert in North Africa (beginning from Algeria).

SSB will help migrate from the unsustainable current excessively fossil-fuel-based global energy paradigm to a more sustainable one. It will also help meet global energy challenges, and mitigate climate change and other environmental problems. SSB is more than an energy solution. It is an integrated community, socio-economic, industrial, agricultural, environmental, and science and technology development solution. In particular, through desalination and adequate irrigation technologies, it will help mainstream marginal desert water resources and lands back into national, regional and international development processes. The concept of the SSB is depicted in figure 7 and 8 (K. Kurokawa et al, 2009).

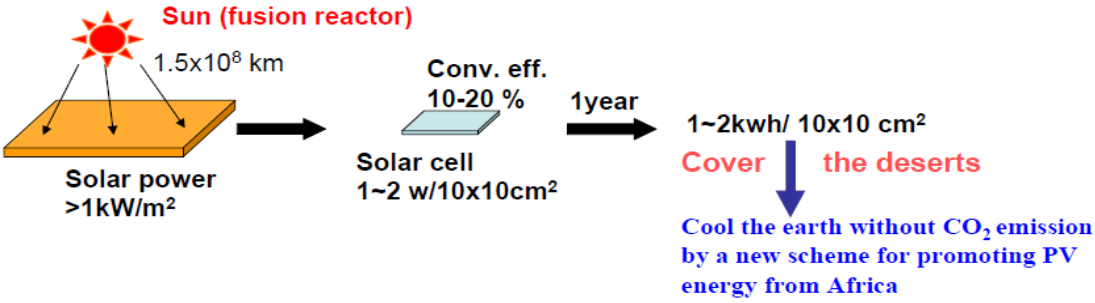

Figure 7: Photovoltaic system using the photoelectric effect of turning light energy into electricity

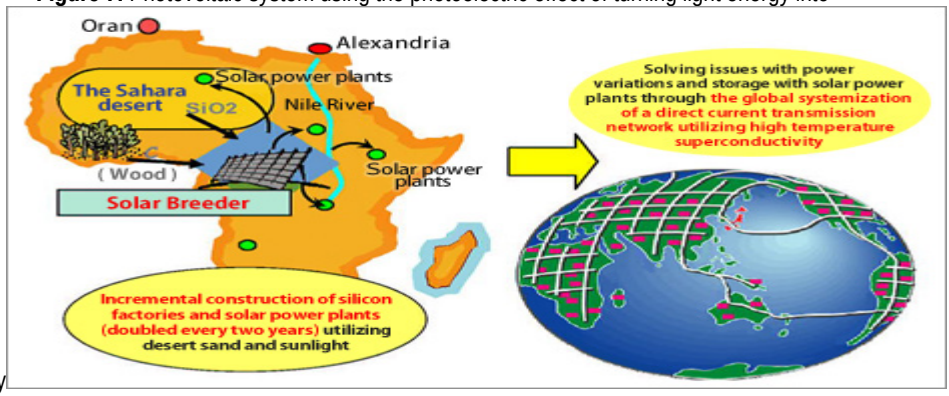

Figure 8: SSB concept and plan

SSB PLAN AND THE SSERC ACTIVITIES

The goals of SSB towards sustainable development are founded on four pillars namely:

- Starting from basic research and development;
- Coupling PV with High critical Temperature Superconducting Cables (HTcSC) for clean energy generation and energy saving transmission;
- Education and training for science and technology of African people
- Solving global crisis by international cooperation and policy

The three basic strategies of the SSERC programmes and indicative targets are based on the following items:

- Innovation processes for solar silicon with a focus on using Sahara sands, the following objectives have been selected:
  - Purification of silica sand by a thermodynamics based process designed in Tokyo and Nihon universities
  - Reduction of silica sand by carbothermal (Hirosaki University) and plasma (NIMS) processes
  - Technology transfer to USTO
- Quantitative data collection for installation of PV and HTcSC systems, the following objectives have been selected:

  - PV system installation at Saida site
  - Data collection for DC power transmission trough desert environment
- Education and training on Energy problems and sustainable development, the following objectives have been selected:
  - Installation of WebEl system at USTO and Saida universities
  - Development of PV materials devices and system
  - PV application such as desalination, green innovation in desert
  - Personal movement between Algeria and Japan

SAHARA SOLAR BREEDER COMPONENTS

The most important objectives of SSB's energy policy and its portfolio include five basic strategies that are:

- Basic, applied, practical research and development, in Japan, North Africa, the Middle East, Africa, and other regions of the world;
- Industrial production of silicon from sand;
- Industrial production of cells, modules, panels, and other PV devices,
- Building, operating, networking and monitoring Very Large Scale Photovoltaic Power Stations (VLS-PVPS);
- Environment monitoring and gradual implementation of SSB

One of the strengths of PV is to be found in its decentralised applications. This is particularly true for supplying isolated consumers in areas of low population density, where the demand consists essentially in satisfying basic energy requirements. Other notable characteristics of PV are:

- Modular design enabling it to be extended according to need;
- The possibility of developing small businesses in areas of low economic development;
- Protection of the environment;
- Limited capital assets, capable of being used flexibly and in a decentralised way, and of being moved about over longer periods of time.

The developing strategy, by the SSB project, has been elaborated to promote the dissemination of renewable energies on sites where they are profitable compared to classical energies and to guide scientific research efforts in order to allow generalisation of renewable energy via mass production. The aims to be achieved consist of the contribution to a conservative policy for hydrocarbons both by increasing the renewable energy share within the international energy balance and by improving the living conditions of isolated communities. The first operation of installation of PV plant in Saida town, considered to be the gate of the Algerian Sahara, would allow on one hand the electricity supply and on the other hand to collect information about:

- Equipment behaviour in Saharan environment;
- Matching the systems with the electricity supply;
- Maintenance of organisation and management;

- Technical -economic system optimisation.

SSB will then ensure an Energy/Climate security with global justice and development of civilisation for whole world, a clever global development strategy for solving the energy and climate problems with existing solar grade Silicon production from Sahara sand technology for a world in a sustainable way. Moreover, SSB is an integrated community, socio-economic, industrial, agricultural, environmental, and science and technology development solution. In particular, through desalination and adequate irrigation technologies, it will help mainstream marginal desert water resources and lands back into national, regional and international development processes as shown in figure 9 (H. Koinuma et al, 2012).

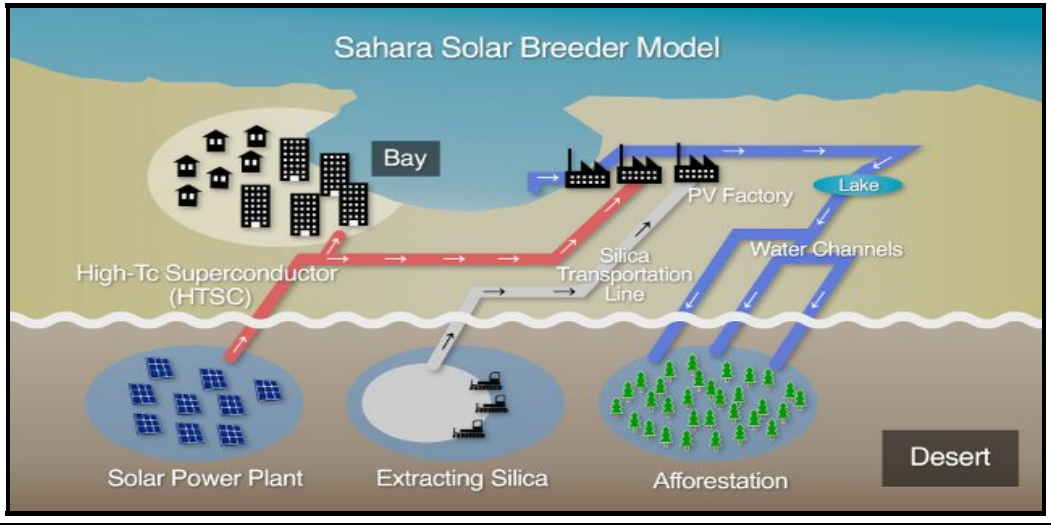

Figure 9: SSB model, key to a sustainable civilization

HIGH CRITICAL TEMPERATURE SUPERCONDUCTING CABLES FOR DC ELECTRIC TRANSMISSION FROM SSB PV POWER PLANT

The demand for power keeps growing at a scale and speed never imagined in the past since the need for more and more electricity is exacerbated. Moreover, demanding economic objectives as well as obligations to reduce greenhouse gases made a strong push for renewable energy sources (RES) with power generation becoming increasingly distributed and a growing number of generation facilities located far away from load centers. This situation has stimulated research on DC electric power transmission systems that are able to transport large amounts of electrical power, in contrast with the more common alternating current systems. For long-distance distribution, DC power systems present lower capital costs and suffer lower electrical losses.

In order to speed up the electric superhighway, the generated electricity from SSB, made up of a network of VLS-PVPS in Sahara desert, will have to be transferred to the North Africa, then Europe, Africa, and ultimately the rest of the world, via HT_cSC that can provide, in compact dimension, firm capacity for base load, intermediate and peaking power, effectively complementing conventional electricity sources. Because HT_cSC are compact and can transmit a large amount of electric power (up to 10 times as much power as conventional electric power

transmission cable), it can utilize more effectively congested underground space where a lot of piping and other units already exist. They are poised to help to reduce grid congestion as well as installation and operating costs. In addition, HT_cSC, using an N_2 cooling system (figure 10) (Takato MASUDA et al, 2005), are characterized by the following advantages:

1. Compactness and high transmission capacity;
2. Low transmission loss and environmental friendliness;
3. No leakage of electro-magnetic field to the outside of the cable;
4. Low Impedance and Operatability; and
5. Effectuate transportation of solar-generated power from the Sahara

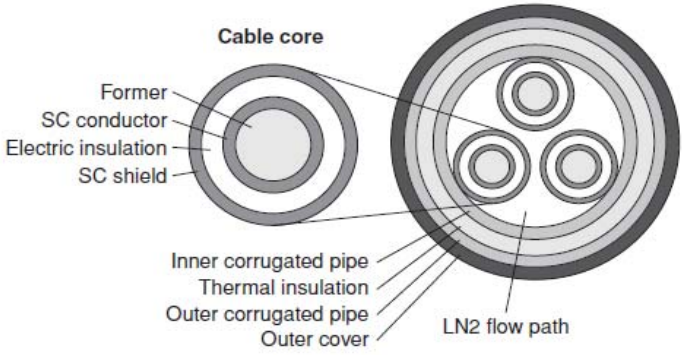

Figure 10: Structure of HT_cSC cable

SSB ROADMAP

The objectives established for the SSB project are focused on raising PV production every 10 years for a global superhighway purpose. Crucial objectives are targeted at substantially increasing and enhancing PV production from an initial value of 2MW to breed into 100 GW in 30 years. Tentative specification and roadmap of SSB plan are outlined in table 4 follows. The electrical power will be obtained from Si based solar PV power plants. By assuming two years energy payback time, solar cell production can be doubled every two years to increase 2 MW PV to 100 GW in 30 years as depicted in table 5.

Table 4: Roadmap of SSB road and global energy superhighway

Year 2009	2010	2020	2030	2040-2050
Planning	Master plan First	Second	Third	Global energy highway Final
SSB construction	First term 2→16 MW PV station Si & cell factory HT_cSC transmission line test station	Second term 32→512 MW	Third term 1 GW→16 GW Extension of SSB to continents	Fourth term 32→512 GW Extension of SSB to the world

Management & finance	International cooperation Sahara clean energy consortium		Continental clean energy consortium	Global clean energy consortium

Table 5: Evolution of PV solar cell production

Starting date 2012	2014	2012 + n	2030	2044
2 MW PV power station made from Si (20 tons)	+1= total 2 → 4 MW	Total= $2^{n/2}$ → 64 MW	→ 1 GW	→ >100 GW
Si plant (10tons/year)	+1	+ $2^{n/2}$ - 1		
p-Si cell Plant	+1	+ $2^{n/2}$ - 1		

CONCLUSION

Clean and secure energy is the key to a sustainable civilization, key to human security, key to a reliable energy supply, key to climate stability and bio-diversity, key for global and inter-generational justice and a key to more civilization and wealth. SSB ensures Energy/Climate security with global justice and development of civilisation for whole world. It has a clever global development strategy for solving the energy and climate problems with existing solar grade Silicon production from Sahara sand technology for a world in a sustainable way.

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Solar Energy: A Clean Energy System

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ABSTRACT

Solar energy is an alternative to non-renewable and polluting fossil fuels in today's world of growing energy needs. Solar energy is the earth's most abundant and freely available resource. It is sustainable, renewable and an inexhaustible resource produced directly by the sun and collected on earth. The sun produces vast amounts of renewable solar energy that can be collected and converted into heat and electricity. Solar power can directly supply much of the world's required energy. It can be used to heat swimming pools, power small appliances, heat water, dry clothes, produce light for both indoors and outdoors, and even to power cars, among other things. With almost one third of the world's population living without electricity, solar energy offers great promise to improve living standards. Being clean energy, it reduces greenhouse gas emissions. There is a continuous improvement in advancements in the technology used to create solar energy so as to make it more cost effective.

Keywords: Sustainable, renewable, Clean energy

INTRODUCTION

Solar energy is an economically and environmentally sustainable source of renewable energy. It is one of the renewable sources of energy which if harnessed in the right earnest, can do wonders for the sustainable development of our world. The amount of solar energy that reaches the Earth each hour is equivalent to the amount of energy used by humans worldwide each year (US Department of Energy). Enough sunlight reaches the earth's surface each minute to satisfy the world's energy demands—for an entire year (Moris *et al*, 2010). Passive energy from the Sun has been used as a form of light and heat since early humankind .Utilization of this energy dates back to the 5th century B.C., when the ancient Greeks used to design their homes to capture maximum sunlight. Later the Romans improved their architecture to prevent the captured sunlight from escaping their houses. In mid 1800s during the industrial revolution it was used to produce steam to drive machinery. Since times immemorial the power from Sun has helped the life on Earth to sustain itself. Only a small part of the radiant energy that the sun emits into space ever reaches our planet, but that is more than enough to supply all our energy needs. Solar energy is abundant and offers a solution to fossil fuel emissions and global climate change related problems. Furthermore, harnessing just one-quarter of the solar energy that falls on the world's paved areas could meet all current global energy needs comfortably (Flavin,1995). This energy from the Sun is the largest exploitable and inexhaustible renewable resource as more energy from sunlight strikes Earth in 1 hour than all of the energy consumed by humans in an entire year (Lewis and Nocera, 2006).

India receives the solar energy equivalent to or more than 5000 trillion kWh/year. Depending on the location, the daily incidence ranges from 4 to7 kWh/m2, with the hours of sunshine ranging from 2300 to 3200 per year (Jaswal 2009, Sharma *et al* 2012). Therefore, every day enough solar energy reaches the Earth to supply our nation's energy needs for a year.

For years, supporters of solar power have proclaimed every new technical breakthrough as a revolution in the field of solar energy development. Yet time and again it has not been accepted with much ease, probably because the technology has proven to be too expensive and inefficient. Since the technology costs too much, the solar panels settled in as a small niche market (Daviss, 2007). The pace of development of solar energy systems has been generally slow globally, because power generation from solar energy besides being expensive, requires special enabling environment for success. In developing countries, solar technologies are already in use to enhance the standard of living whereas in developed countries, most forms of solar energy are currently more expensive than conventional alternatives. At this pre-competitive stage, incentives are needed to encourage their uptake (Ekins-Daukes, 2009). To achieve ecologically stable economic development in the energy sector, an accelerated adoption of solar energy technologies is required. So the need of the day is active solar power conversion that can displace conventional power generation that can eventually contribute towards a truly sustainable energy supply. Most prominent attributes of solar energy are as follows:

- It is a tested, dependable and easily available form of energy
- It is green and clean energy without any harmful environmental impacts
- The raw material i.e. the sunlight is free of cost and virtually limitless
- Its installation is fast and easy
- Does not require complex infrastructure
- Provides a great deal of energy independence to organizations
- Peak hours of energy utilization and consumption in most of the business setups coincide with the maximum availability of sunlight

APPLICATIONS OF SOLAR ENERGY TECHNOLOGIES

Solar energy can be used either to provide heat (passive solar) or to generate electricity (active solar); so the energy generated can be termed solar thermal or solar power, depending on the way it is captured, converted and distributed.

SOLAR THERMAL:

The sun's heat energy can actively be converted to generate water heating, space heating, cooking, disinfecting, etc. Flat collection plates are placed on homes and buildings to face the sun's rays (directed south in the northern hemisphere). The collection plates have a transparent covering with dark metal plates beneath, which absorb heat.

1. Solar Water Heater

Solar panel collector is used by solar water heater to transfer the heat energy of sunlight to the water. Convection (movement of hot water upward) is used by the unit to move the water from collector to tank. Neither pumps nor electricity are used to enforce circulation. For fabrication of

tank insulated material is used so that heat of the hot water cannot be transferred to the surrounding environment and hence water can be kept hot for long time.

Fig.1: Solar Water Heater
Source: http://peda.gov.in/eng/prom_SolarThermalExtension.html

2. Solar Water Disinfection (SODIS)

It is a method of disinfecting water using sunlight and plastic PET (Poly Ethylene Terephthalate) bottles. This method is usually applied at the household level and is a free and effective method for decentralized water treatment. All kinds of water may not be made safe to drink by disinfection. This is because non-biological agents, for example toxic chemicals such as arsenic or petrochemicals may also be present. Chemical toxins usually cannot be removed by disinfection so further means to make water safe to drink may also be required.

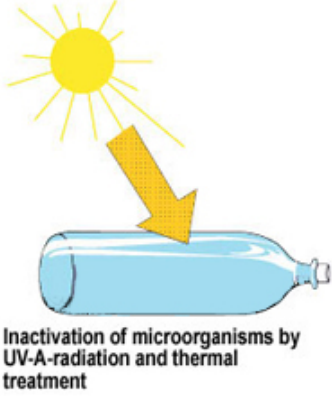

Fig.2: Solar Water Disinfection
Source: http://www.grassrootswiki.org/index.php/Solar_water_disinfection

3. Solar Cooker

A solar cooker is used to convert sunlight to heat energy for cooking purpose. UV light rays get inside the solar cooker and convert them to longer infrared light rays that cannot escape. The energy of infrared radiation make the water, fat and protein molecules in food vibrate vigorously and heat up. It is not the sun's heat or the ambient temperature that cooks the food but it's the sun rays that are converted to heat energy that cook the food and this heat energy is then retained by the pot and the food by the means of a covering or lid.

Fig.3: Solar Cooker
Source: http://solarcooking.wikia.com/wiki/Category:Box_cooker_plans

SOLAR POWER TECHNOLOGY DVICES:

Advanced technologies have made solar energy more competitive with conventional energy fuels for generating electricity.

1. Photovoltaic

Photovoltaic is a method to convert solar radiation into electricity using semiconductors that exhibit the photovoltaic effect. The first solar cell was constructed by Charles Fritts in 1880. There are at least fourteen types of photovoltaic cells such as thin film, mono crystalline silicon, polycrystalline silicon and amorphous cells, as well as multiple types of concentrating solar power. Photovoltaic (PV) technologies are based on the use of solar cells aligned and installed into what is called a PV module. These modules are commonly called Solar Panels. The suns radiation hits the semiconductor material within the PV cell and excites electrons resulting in electric power. These electrons are carried through the PV cell to an electrical circuit. Each PV solar cell is protected by a layer of plastic or glass. A collection of solar panels is called an array. Each array is designed to produce a certain voltage and current. Each is then attached to an inverter that converts the Direct Current (DC) of the array to Alternating Current (AC). This new electricity is connected to the electrical power grid enabling our customers to access energy from their utility company when the solar system isn't supplying all the necessary power to their facility.

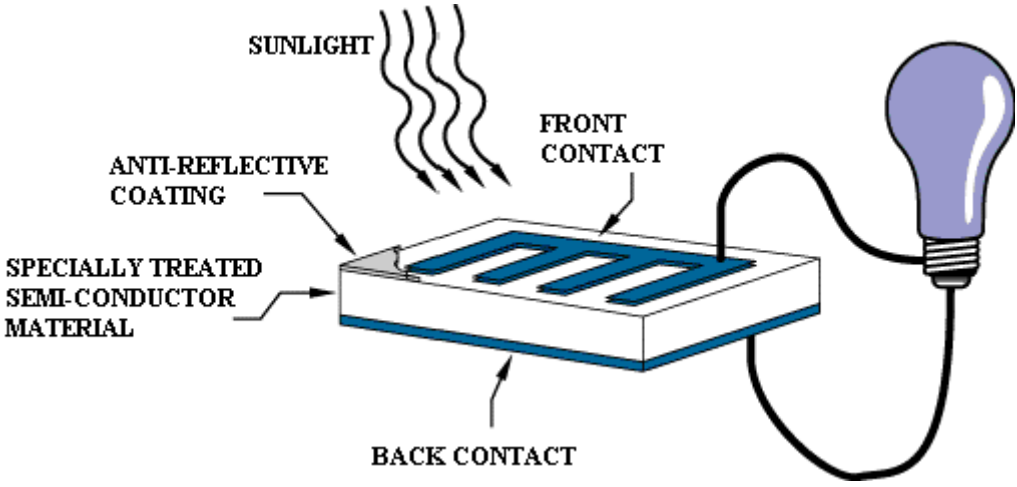

Fig.4 Photovoltaic
Source: http://science.nasa.gov/science-news/science-at-nasa/2002/solarcells/

Concentrated Solar Power (CSP) Systems

Lenses or mirrors and tracking systems are used by concentrating Solar Power systems to focus a large area of sunlight into a small beam. The concentrated heat is then used as a heat source for a conventional power plant. CSP Systems concentrate the sunlight at particular point to convert that energy into another form of energy. Each concentration method is capable of producing high temperatures and correspondingly high thermodynamic efficiencies.

Fig.5: Concentrated Solar Power Systems
Source: http://www.energyboom.com/what-concentrating-solar-power-csp-technology

2. Solar Chimney Power Plant

It has a high chimney around 1000 meter and uses the principle of solar energy, wind energy and greenhouse effect. The chimney is surrounded by a large collector roof made from glass or

resistive plastic supported on a framework. Electricity is generated with the help of a wind turbine located in the center of the chimney using wind velocity which is due to the solar energy.

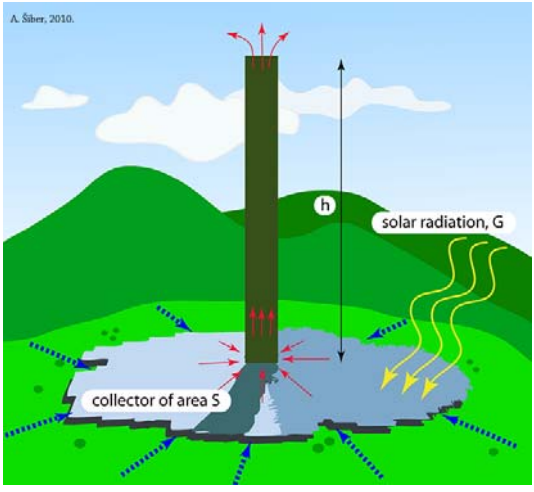

Fig.6: Solar Chimney Power Plant
Source: http://asiber.ifs.hr/olympic_illustrations_en.html

SOLAR ENERGY APPLICATIONS

Solar Energy if harnessed in its right earnest can lead to local as well as global sustainable development, by being applied in most of the sectors such as domestic, power, industrial, agricultural, etc.

DOMESTIC	POWER	INDUSTRIAL/AGRICULTURAL
Cooking Water-heating R and A/C Space-heating	Thermal Hydro-thermal Ocean Thermal Energy Conversion (OTEC) Waves Solar Ponds Hydrogen Tidal	Dryers Process Steam Water Pumping Chilling Green-houses Desalinization Furnaces

Fig. 7: Categories of Applications

Any nation of the world can become energy independent and efficient if it religiously and judiciously focuses on renewable energy especially that of solar energy. In terms of all renewable energy, currently India is ranked fifth in the world and the amount of solar energy produced in India is less than 1% of the total energy produced. India is blessed with abundant solar energy and if harnessed efficiently, the country is capable of producing trillion-kilowatts of electricity. There is need to come together and take initiatives to create technologies for a greater use of these sources to combat climate change by reducing the emission of green house gases. The

Government of India's National Action Plan on Climate Change (NAPCC) released in mid-2008, by the Prime Minister's Council on Climate Change identifies eight critical missions and Nation Solar Mission is one of them(Ghosh 2009).

Due to ever rising demand for energy, more than 100 countries including India have enacted policies and programs for harnessing solar energy. The achievements, however, have been mixed so far. Besides various advantages of solar energy there are many aspects of its production, generation and utilization which need to be evaluated critically. There are areas of concern which must be analyzed thoroughly by researchers and practitioners as these facets of solar power might have certain implications on practice and research (Pandey et al, 2012).Understanding early ground-level efforts for solar energy development is essential, as these insights can prove vital for other regions in India and elsewhere. Kulkarni (2010) in his recent World Bank study examined the critical barriers for solar power development in India and concluded that policy and regulatory aspects were the most significant barriers. Solar energy like other renewable sources of energy needs supportive and consistent government policies to compete against conventional fuels. In addition, majority of developers rate the infrastructure deficit as a critical barrier. Similar conclusions have been arrived at by many other studies (Sargsyan *et al.*,2010; Schmid, 2011). Besides these there can be some technological problems which cannot be overlooked; for instance in developing countries like India where dust is an integral part of the atmosphere, deposition of airborne dust on outdoor PV modules may decrease the transmittance of solar cell glazing and cause a significant degradation of solar conversion efficiency of PV modules (Sharma *et al* ,2012).

CONCLUSION

To make solar power popular, any nation would need to invest in educating the consumers about the benefit of clean energy in the long term for the society. It is also noteworthy that renewable sources such as solar energy generation systems also create regular jobs locally extending the benefits beyond the income earned from those jobs (Akella et al, 2009). However, without a clear understanding, the society always gives preference to energy sources with low initial financial costs even though these sources have large costs related to climate change adaptation and mitigation in the longer-term (Mani and Dhingra, 2012). Therefore, the future viability of solar energy will depend on a combination of factors including lower costs of production; sustained and predictable policy support to aid in the technological challenges; overcoming the innumerable spatial, temporal, and environmental challenges of centralizing solar power generation; and last but certainly not the least; awareness in the society regarding this clean and green energy.

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Sustainable Energy Production and its Utilization in Agro-industrial Processing

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ABSTRACT

Oil, coal and natural gas are collectively called fossil fuels, contributing to 85 % of global energy demand. The constant use of these have led to some serious environmental issues like depletion of resources and green house effect .This situation has created a concern in the world and have started looking for sustainable energy resources like biomass. The main source of biomass is trees, crops and animal waste. It is responsible for providing 14% of global energy and 38% to the developing countries. Technological advancements in biomass energy are derived from two sources are biomass energy production practices and energy conversion technologies. The energy conversions comes from three sources enhanced efficiency of biomass energy conversion technologies such as improved fuel processing technologies and enhanced efficiency of end use technologies.

Briquetting technology is found as a promising field in energy conversion technologies. Biomass briquettes convert non-productive agricultural residues and other, yard wastes into economic and environmentally sound heating and cooking fuel. Briquettes are eco-friendly, economical, pollution free (absence of sulphur and fly ash), high burning efficiency due to low moisture content, easy to transport and uniform combustion in comparison to coal. Though this product cannot compete with coal or ignite in the mining belts but for the states which are away from the coal belt and incur high transportation cost, briquetting industry comes as a hope for sustainable energy resource. Although the proportion of biomass in India's energy demand will decrease from 27% in 2007 to 15.5% but it is considerably higher than the world's average 9.8% in 2007 and 9.5% in 2030. The biomass remains as a major source of energy for the Indian people in the future. The agro industry is based on agricultural and forestry production and its purpose is to preserve and refine raw produce and to extract and concentrate the valuable constituents. Agro processing has recently emerged as the dawn sector of the Indian economy with its enormous prospective for growth and direct assistance to economic aspect especially on employment and income generation. The food industry constitutes the most important sector of the agro industry consisting of mills handling cereal crops, processing of starch sources and root crops, processing of oil bearing seeds and fruits, sugar beet and sugar cane processing, fruits and vegetable processing, dairies, processing of semi-luxury goods and spices, plant fiber extraction and tanneries. Briquettes are seen as a replacement for coal in solvent extraction mills in Punjab, tea factories in Tamil Naidu, Kerala and Karnataka

Key words: Energy production, agro-industrial processing, biomass, briquetting

INTRODUCTION

India is the 7th largest country in the world spanning 328 million hectares producing 450-500 million tones of biomass per year (Anon,2009). India has a large agriculture base but still there has

been very little work done in the field of agro residue usage as fuel. Most of the industrialization has been considering liquid fuel and coal as primary source of thermal energy and for power generation. The pie diagram shows the percentage contribution of different sources towards the primary energy demand (Anon2009).

Total Primary Energy Demand

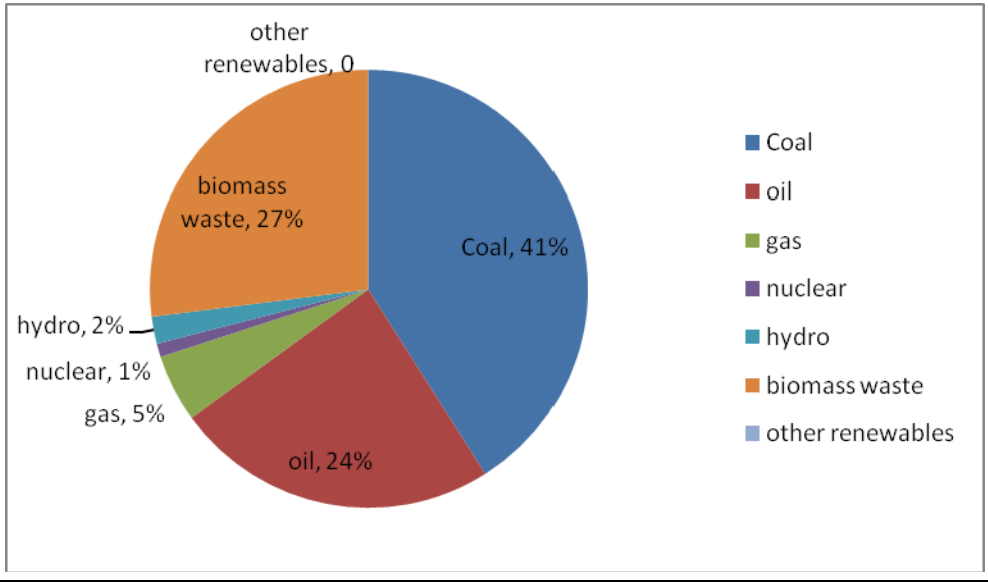

Fig 1.Percent share of different energy resources for year 2007 (Total 595 Mtoe (million tones of equivalent oil)) (Source : Anon 2009)

As per the data in year 2007 major portion of energy demand was satisfied by coal followed by biomass. It holds a major portion of 27 % for satisfying the energy of India in comparison to the world average of 9.8 % in 2007. As per the studies it is expected the biomass source will decrease to 15 % in 2030 but in comparison to world average of 9.5%,(Anon,2009). India's dependence will still be higher, indicating the biomass will remain a major source of energy for Indian people in future. Biomass is a complex class of feed stocks with significant energy potential. To exploit these energy reserves to the best technology intervention becomes inevitable.

The technological advancements for biomass energy conversion comes from three sources (Shukla,1997)

- Enhanced efficiency of biomass energy conversion technologies,
- Improved fuel processing technologies
- Enhanced efficiency of end-use technologies.

According to a study by International institute for applied system analysis (IIASA) and World Energy Council (WEC) (*Nebojsa, et.al* 1998), renewable could contribute as much as 37–39 percent of the global primary energy supply by 2050 with reductions in net carbon emissions below 1990 emissions by as much as 15 percent.

Biomass consumption in India

In India about 32% (Anon, 2009) of total energy consumption is from the biomass like agricultural residues, animal dung, forest waste, firewood, etc .Biomass is highly diverse in nature and its classification on the basis of origin can be done as under:

a) Field and plantation biomass
b) Industrial biomass
c) Forest biomass
d) Urban waste biomass
e) Aquatic biomass

A major portion is put to traditional use like fodder for cattle, domestic fuel for cooking, construction material for rural housing, industrial fuel for boilers etc. Other than the traditional use biomass can be used for heat and electricity, in combined heat and power (CHP) plants, combination with fossil fuel (co-firing) to improve the efficiency by reducing the built up residue and replacing petroleum as a source for transportation fuel.

India's Biomass Demand

The percentage share of biomass demand is expected to decrease in 2030 but the consumption is increasing in all the sectors whether residential/ commercial /industry etc. As per World Economic Outlook(WEO) 2007 Reference Scenario projected (average economic growth rate at 6.3 % from 2005 to 2030) predicted the dependence of 436 million people in rural area and 36 million people in urban area will rely on biomass by 2030.

Table 1:Trend of India's biomass demand

(Mtoe)	1990	2007	2015	2030
Total Final consumption	133	161	170	175
Industry	23	28	28	30
Transport	0	0	2	8
Other sectors	111	113	140	137
Percentage of other sectors	83.5%	82.6%	82.4%	78.3%

(Source: Anon 2009, Reference Scenario. IEA)

The consumption of biomass is expected to increase as it is the cheapest, easily available, efficient technology and helps to keep cleaner environment.

NEW TECHNOLOGIES

Various new technologies have come to light for its utilization as energy source. They are

- Briquetting- Densification of the agricultural waste
- Biomass energy
  - (gasification , pyrolysis, combustion)
  - (anaerobic digestion , fermentation and trans-esterification)

Briquetting

Briquetting converts non-productive agricultural residues and other wastes by densification to produce pellets or briquettes. They are eco friendly, economical , pollution free with low ash content, have competitive burning efficiency and improves the handling characteristics, reduces the transportation cost, storage and makes available for variety of applications. Agricultural residues, woody biomass, sawdust, groundnut shells, cotton stalks, maize stalks, rice husks, tamarind shells, coir pith, coffee husks, mustard stalks, sunflower stalks, bagasse, woodchips, forest residues or a combination of the above can be briquetted (Grover and Mishra, 1996). Selection of raw material depends mainly on the moisture content, ash content, flow characteristics and particle size. The moisture content is preffered in the range of $10 \pm 15\%$, ash (4%) , particle size should be granular (preferably 6 ± 8 mm in size)and homogeneous. The raw materials suitable for briquetting can be broadly divided into three categories based on the size

i) Fine granulated;
ii) Coarse granulated
iii) Stalky.

Briquetting Technologies

Briquetting can be done with or without the binder. Briquetting of raw biomass without binder is more commonly practiced in India. The briquetting machines used for this technology are classified into two types.

- Screw- press technology - The biomass is extruded continuously by a screw through a taper die, which is heated externally to reduce friction. The outer surface of briquettes obtained through this technology is carbonized and has a hole in the centre.
- Piston press technology- The biomass is punched into a die by a reciprocating ram with high pressure. The briquettes obtained through this technology have neither the central hole nor carbonized outer layer.

In both the piston and screw-press technologies the application of high pressure increases the temperature of the biomass, and lignin present in the biomass is fluidized and acts as binder. Piston press technology is more popular in India in comparison to the screw press technology

BRIQUETTING PROCESS

The briquetting process (Fig. 2) primarily involves drying, grinding, sieving, compacting and cooling operations. Any moisture in the raw material is first removed in a dryer, and the dried material is ground in a hammer-mill grinder. The ground material is then passed through a screen for sieving and thereafter stored in a bin placed over the briquetting press to ensure a regular flow of materials into the press. The ram in the press continuously packs the material through a taper die and the briquettes are produced. (Tripathi et.al 1998).

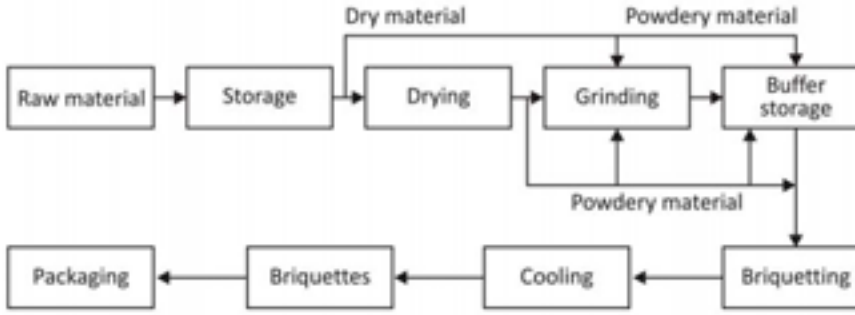

Fig 2. Flow diagram of briquetting process.

BIOMASS ENERGY

Bioenergy technologies provide opportunities for conversion of biomass into liquid or gaseous fuels as well as electricity. The agricultural waste has traditionally been used as solid fuel. The process of converting the organic matter into gaseous/ liquid fuels include both dry (non-biological) and wet (biological) processes.

Dry Process for energy production

- Complete combustion of waste material in excess of air. Commercial application of the process is mainly for drying, steam production or electrical generation.
- Gasification –It is combustion of waste in controlled atmosphere. It involves burning of tightly packed organic matter with limited air supply at temperature above 1100 °C. It gives producer gas with energy 1/6 th petroleum gas.
- Pyrolysis(destructive distillation)–Dry heating of agricultural waste in anaerobic conditions at high temperature (550-1100° C) for several hours producing various proportion of gas , oil and charcoal .
- Hydrocarbonisation (liquification)-Application of high temperature and pressure in a combined way to produce oil/gas.

Wet process : It is based on thermal , chemical and enzymatic conversion methods involving microbiological decomposition of organic matter in the absence of air to yield a gas , mainly methane and carbon dioxide. Different microbes act upon complex organic matter in four stages (Sahay & Singh, 2008).

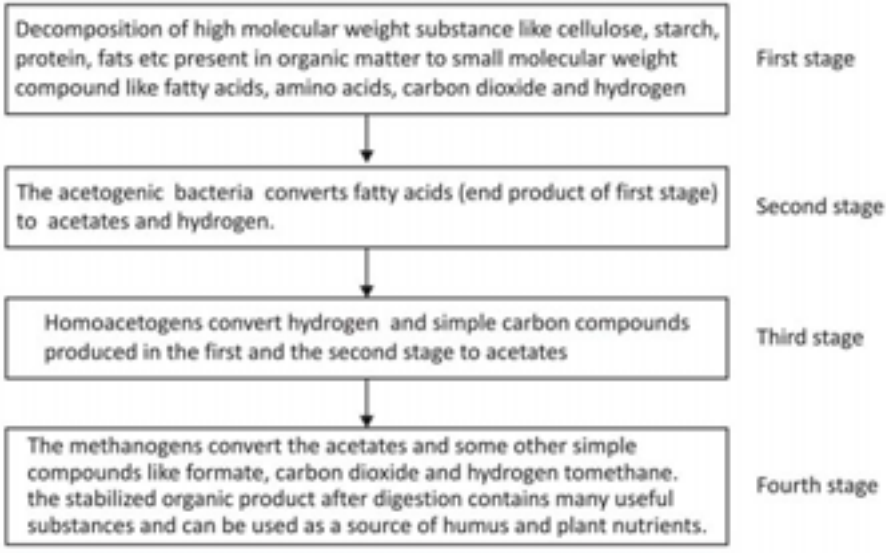

Fig 3. Flow diagram of wet process for energy production

Utilisation of sustainable energy in Agro industrial processing

ASIA

Philippines was among the first nations to initiate the modern biomass programme. China has focused on a process for converting a high quality Chinese sorghum breed into liquid fuel, pyrolysis technology and gasification of agriculture residue and wood. Biomass based electricity generation technologies, with a penetration of 483 MW and 323 MW, respectively in sugar industry in two major sugar cane producing provinces Guandong and Guangxi (Baofen and Xiangjun, 1997) has penetrated. The policy support points to a promising future for modern biomass in China have been introduced. A quarter of total energy in Thailand is contributed by biomass utilization. Bagasse is used in sugar mills as a boiler feedstock (Panyatanya, 1997). A cogeneration potential of 3100 MW biomass based power is identified in chemical, agro-processing and textile industries (Verapong, 1997).Indonesia has immense biomass resource contributing over a third of energy, but the cost of biomass energy is not yet competitive (Martosudirjo,1997),

INDIA

Modern biomass technologies for thermal, motive power and electricity generation applications exists in India. Gasifier technology has penetrated the applications such as village electrification, captive power generation and process heat generation in industries producing biomass waste. Over 1600 gasifier systems, having 16 MW total capacity, have generated 42 million Kilo Watt hour (KWh) of electricity, replacing 8.8 million litres of oil annually (Anon, 1996). The large sized gasifier based power technologies are at R&D and pilot demonstration stage. Two co-generation projects (3 MW surplus power capacity) in sugar mills and one rice paddy straw based power project (10 MW) were commissioned. While the co-generation projects are successfully operated, the 10 MW rice straw based power project completed in 1992 ran into technological problems. A rice husk based co-generation plant of 10.5 MW capacity installed by a private rice processing firm

in Punjab and commissioned in 1991 faced problems (Ravindranath and Hall,1995). Policies for realizing biomass electric power potential through modern technologies under competitive dynamics have a recent origin in India. The focus of modern biomass programme is on the cogeneration, especially in sugar industry. A cogeneration potential of 17,000 MW power is identified, with 6000 MW in sugar industry alone (Rajan,1995). Programme for biomass combustion based power began in late 1994 as a Pilot Programme launched with approval of two 5 MW projects. The programme also initiated a grid connected biomass gasification R&D-cum-Demonstration project of 500 Kilo Watt (KW) capacity. A decentralized electricity generation programme initiated in 1995 provided support for total of 10 to 15 MW of small decentralized projects aimed at energy self sufficiency in electricity deficient rural locales. The programme aims to utilize some of the 350 million tons of agricultural and agro-industrial residues produced annually in India. The cost of electricity generation from these plants are anticipated to be quite competitive at Rs. 1.8 per KWh (Shulka,1997).

Benefits

These technological advancements are responsible for economic, social and security benefits at the national and local levels (Anon, 1994).A major cause for the cost reduction with renewables like solar, hydro, wind and biomass energy are gaining momentum. Renewable sources, particularly biomass, are equitably distributed and less environmentally destructive than the current fossil fuel sources (Goldemberg,et al.1988). Renewables have a considerable potential for displacing conventional energy sources and in some cases are already competitive with them (Jackson, 1992). Projections by Johansson et al. (1993) show that by 2025 given adequate support, renewable could contribute to nearly 30%of direct fuel use and 60% of global electricity. It is a major cause for the rural upliftment of the youth by employment generation. It has the potential to relieve the rural households of drudgery and health problems. Reclamation of land and soil conservation are other indirect benefits of growing biomass for energy on degraded and deforested lands.

Utilization of biomass for electricity generation reduces the Co_2 levels in the atmosphere because Co_2 released in combustion is compensated for that withdrawn from the atmosphere for the carbon synthesis and biomass accumulation (Hall et al. 1991) . Further, bioenergy can lead to net Co_2 emission reduction if substituted for fossil fuels and fossil fuel electricity.

CONCLUSION

Efforts are being made in utilization of biomass for energy production , electricity in various fields. The modern technologies offer possibilities to convert biomass into synthetic gaseous or liquid fuels (like ethanol and methanol) and electricity (Johansson et al. 1993). Lack of biomass energy market has been the primary barrier to the penetration of modern biomass technologies. Modern biomass has potential to penetrate in four segments -

i) Process heat applications in industries generating biomass waste,
ii) Cooking energy in domestic and commercial sectors (through charcoal and briquettes),
iii) Electricity generation
iv) Transportation sector with liquid fuels

Agro processing units are the major biomass producer which can be utilized in energy production for various operations. Various projects were initiated in 90's looking at the future

energy demands and resources. These projects had to stop due to various hindrances in there efficient working. The reasons were many .It varied from inefficient working due to lack of technical capacity, in adequate policy framework , ineffective financing mechanism , absence of effective information dissemination and limited successful commercial demonstrations. Initiative should be taken by the government by giving an adequate policy in term of subsidies, incentives etc to promote and encourage people towards biomass production and energy utilization .

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Experimental Study on Organic Processing of Ginger for Making Ginger Powder

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ABSTRACT

Ginger is an important cash crop of NEH region. A total of around 5 lakh MT of ginger is produced in NEH region of India. Sikkim alone produces around 50 thousand MT of ginger. 95% of the ginger produced is market surplus and it is sold in the whole sale market for average annual price of Rs.10 per Kg, where as the average annual price of ginger in Delhi is around Rs.60 per Kg. Value addition can be done by processing of ginger. Many products can be made from ginger but the easiest and widely consumed is the ginger slices and ginger powder. The present paper deals with the complete technology and economic evaluation of small scale ginger processing unit. The sliced ginger was dried in solar tunnel drier (STD). STD with polycarbonate is very effective and gives good results. A modified arc type solar tunnel drier (35'x 15'x8') can dry up to 400 kg ginger slices . The loading rate was 700g/sq ft and the drying time required from initial moisture content of 85% w.b. to final moisture content of 10% w.b. was around 3-4 days. The recovery was around $1/5^{th}$ of the initial weight. Dried slices can be pulverised using a pulveriser. The storage of slices was found more easy and economical for long term storage even upto 9 months.

Key words : Ginger drying, ginger slices, polycarbonate tunnel drier , NEH ginger

INTRODUCTION

Sikkim the 22nd state of Indian Union is the most peaceful and hilly state in the Indian Union. Sikkim is also the member of North Eastern Council and enjoys special concessions/ benefits for North Eastern States. Located between 27° 00' 46" N - 28° 07' 48" N latitudes and 88° 00 58" E - 88° 55 25" E longitudes in the Himalayas, it is bounded by Nepal in the west, China in the north, Bhutan in the east and West Bengal in the south. *Teesta* and *Rangit* are the two major rivers of the state (Gupta, 2010).The total area of the state is 7096 sq. kilometres (0.22% of the total area of the country) but the habitable areas are up to the altitude of 2100m constituting around 20% of the total area. The areas available for cultivation are not more than 12% of the total area which is around 84000 ha. The North district covers almost 60% of the total area of the State, but has the least population among the four districts. Forty - three percent of the state is covered with forests. The mean annual rainfall varies from 2000mm to 4000mm. The population of Sikkim was 5.65 (0.06% of the population of the Country) in 2001. Sikkim has a very high literacy rate of around 82% at present. The major occupation of the people is agriculture and large cardamom, ginger and tea are the major cash crops. (Gupta, 2010)

Ginger is an important cash crop of Sikkim. The crop Ginger was grown over 8010 hac and the production was around 43,190 MT with a productivity of 5.39 MT/hac in the year 2007-08.

The total production of ginger in India was 3.9lakh MT and the area was 1.04 lakh ha in 2007-08. About 12% ginger of the country is produced in the State. The export of ginger from India in the year 2007-08 was 0.85 lakh MT against the international trade of around 3.85 lakh MT in the year 2006-07.(Gupta 2011a,2011b,2011c ; Gupta et. al. , 2012)

Physiology of the plant

Ginger is an upright tropical plant that grows to about 1 meter tall. The edible parts of the plant are the rhizome and the young tender stem.

Cultivation

Ginger is a perennial plant but is usually grown as an annual for harvesting as a spice. It require warm and humid climate and a heavy rainfall of 150-300cm a year or plenty of irrigation. It thrives well in sandy or clay loam soil with good drainage and humus content. Ginger is best grown in partial shade and can be incorporated as an intercrop in maize etc. Planting of around 50-70 g rhizome is done in the month of April/May during the monsoon rains. Normally the ginger is a 7-8 month crop. Ginger is harvested by digging out the rhizome when the tops have died down. In Sikkim a large size rhizome (150 g) is planted and the digging is done in two stages (m*au* and *baccha*) . Farmer's get good price for "*mau*" in the local market.

Value Addition

There are two important factors to consider when selecting ginger rhizome for processing:

a) **Stage of maturity at harvest**. Ginger rhizome can be harvested from 5 months after planting. At this stage they are immature. The roots are tender with a mild flavour and are suitable for fresh consumption or for processing in to preserved ginger. After 7 months the rhizomes will become less tender and the flavour will be too strong to use them fresh. They are then only used for drying. Mature rhizomes for drying are harvested between 8-9 months of age when they have a high aroma and flavour. If they are harvested later than this the fibre content will be too high.

b) **Native properties of the type grown.** Mainly two varieties are grown in Sikkim *Gurumathane* and *Bhesa*. *Bhesa* is bigger in size and yellowish in colour as compared to *Gurumathane* which is brownish and small in size. *Bhesa* is good for international market but the *Gurumathane* has got more pungency.

Value Chain

Ginger is sold by the farmers to the local traders directly or through a middle man called "*fariwala*"(hawker). The farmer sells the produce of the whole field (without digging/harvesting) to the "*fariwala*" at some lumpsum price. Generally farmer knows the amount of the ginger he had planted at the time of planting and he expects the harvest equal to around 5-6 times that of the planted weight. Either the farmer or the *fariwala* brings the ginger to the trader. The *feriwals* makes an profit of about Rs.5 per kg. The price in local (Sikkim) whole sale market is decided by the trader based on the general price in Delhi (Azadpur Market). The farmer is paid cash by the trader. The ginger is spread on the floor inside the shop. After primary precooling and sorting it is repacked, the same day, in jute bags of 60kg . Bags are sent to Delhi (within 24 hrs) through an handling agent in Silliguri. The agent in Silliguri charges around Rs.30 per bag as handling charges.

The produce is marketed in Delhi by another agent and he charges around 6% of the total transaction as his commission. The total fixed cost of selling by the local trader of Sikkim in Delhi Market comes around Rs.300 per bag (60Kg). It takes around 4-5 days from Sikkim to reach Delhi market by Road.

Value chain of Ginger Practiced

Digging of rhizome by the farmer

Packaging in gunny bagsSelling in the local whole sale marketSorting, cleaning and grading by the local traderRe-packaging in jute bags

Selling in Whole Sale market of SilliguriSelling in Whole Sale market of Delhi

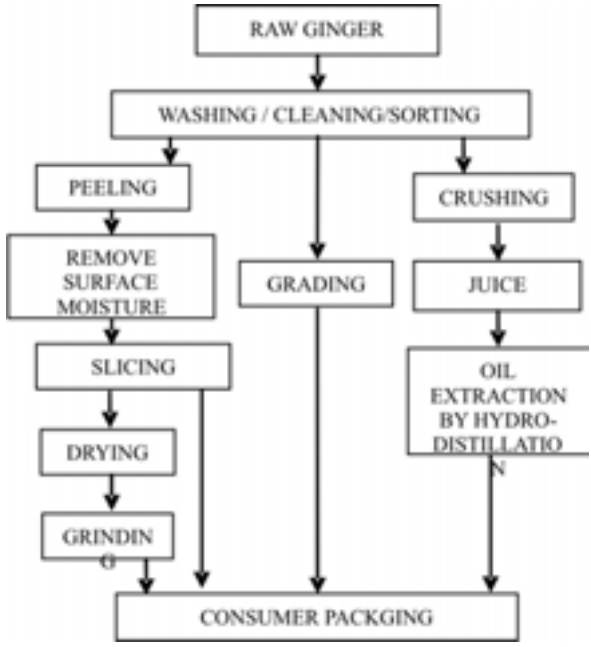
Need for Post Harvest Technology of Ginger and its Value Addition in NEH region

Ginger is an important cash crop of NEH. The crop is planted in the month of April and harvested in December. The NEH is producing around 4 lakh MT of ginger annually and 95% of the ginger produced is market surplus e.g. the ginger is not consumed locally and available for processing. Moreover, the ginger produced in some states e.g. Sikkim is 100% organic. The average annual price of raw ginger in the NEH is Rs.10 per Kg and the average annual price in Delhi is around Rs.60 per Kg (Ref. year 2011). Many value added products like minimally processed packed fresh ginger, ginger paste, dried ginger slices, ginger powder, ginger oil, ginger candy, ginger pickle, ginger wine, crystallised ginger etc. can be made from the ginger. (Gupta , 2012). Some of the most useful commercial products {which can be made from 100 Kg fresh ginger (costing Rs.1000)} are:-

Table: Products which can be made from 100 Kg fresh ginger (costing Rs.1000) (Gupta , 2012)

Item	Weight(Kg)	Unit Price (Rs)	Total price (Rs)
Fresh packed	95	40	3800
Dried Slices	20	300	6000
Powder	19	350	6650
Oil	1-1.5lit	15000	15000-21000

Traditionally ginger is available almost throughout the year. Farmers take “Mau” in the month of July to Sep. and then the fully mature crop (Baccha) is harvested in Dec. as soon as the ginger is harvested , it is sold in the open market at around Rs.200-600 per 40 kg. Instead of selling the entire crop as fresh, farmers can process “some”/some percentage of their produce and sell the ginger after some value addition. Flow diagram is showing the ideal value chain for ginger. The ginger can be either sold as bulk in Silliguri, Delhi or can be exported in consumer packs.



Flow diagram: Ideal value chain for ginger

RESULTS AND DISCUSSION

Post harvest technology for value addition and organic processing of ginger

The work was carried out at AICRP-PHT Center at CAEPHT, Ranipool; one of the colleges of Central Agricultural University-Imphal. The ginger was purchased from the whole sale traders of the (Ranipool) local market. Out of two varieties (*Bhesa* and *Gurumathane*) grown in Sikkim, *Bhesa* variety was used for the present study. The step wise process of making ginger slices and powder is as follows.

Washing: Ginger is a tuberous crop and contains lot of soil. It should be thoroughly washed in water. There should be no soil left in the inner portion of the figures. Ginger washer designed by AICRP-PHT (Gangtok) can also be used for washing the ginger. Sorting is done to remove the infected ginger rhizomes. The damaged portion may be cut with the knife and the remaining part may be used for value addition. For the present study, the ginger was washed manually with bucket. It was found that there were around 1.5% impurities in the form of soil and other organic matter. It required 3 men hours per 100 Kg of raw ginger and the water requirement was 5-6 lit. / Kg of raw ginger.

Peeling: Peeling is done to remove the thick skin and to get good colour of the end product. A manual peeler is used for this propose. However, for immature ginger (i.e. ginger harvested in the month (July to Sep.) the peeling is not required.

Slicing: Excess water from the peeled / washed ginger is drained out. Surface moisture of the cleaned ginger is also removed by pressing it with paper or with the help of an electric blower. The clean ginger can be sliced in a domestic food processer or commercial slicer. A domestic food

processer was used for the present study. Average thickness of the slices were 2mm. The loss (PWL)during slicing was 2.88%. Time of slicing was 1 hr for 20 Kg and the manpower required was 7 man hours per 100Kg

Drying of slices in Solar drier: The drying can be done in the solar tunnel drier or mechanical drier. It takes around 4-5 days in solar drier and 16 hrs in mechanical drier for the complete drying process. Drying is done at 60-70°C. After drying the slices should give a metallic sound. An arc type solar tunnel drier was used for the present study. Half of the tunnel drier was having polycarbonate as its covering and the remaining half was having polythene sheet as its covering. The size of the tunnel drier was around 35'x15'and the central height was 8'. The drier was having 8 racks having three shelves each. The loading rate of slices on the trays was 7.0 Kg/ m^2 or 700 g / sq.ft. Manpower required for spreading the sliced on the trays was 1 man hr for 100kg. The drying bed thickness was 1.5 cm. Hot air blower can be used inside a tunnel drier and that can be used if the solar energy is not available for drying.

Grinding, Packaging and Storage: Based on the study, it is advised to store and market the ginger slices. The storage and handling of slices is very easy as compared to the powder. The slices can be packed in large polythene bags or buckets with lid. The slices can also be ground in a pulveriser or grinder. A total of 10 Kg of the dried slices were grounded to make powder using the Hammer mill with 5 HP motor. Milling was done for 0.5 hours and two persons required for it. Therefore 1 man hour was required for milling of 10kg. After milling a total of 9.5 Kg of powder was obtained. The percentage loss was 5%.The powder can be packed in plastic pouches using a hand sealer or self locking pouches can also be used for packaging the powder. 1 man hour was required for milling of 20kg powder in pouches of 250g each. The best temperature for storage under dry condition is 10-15°C and the storage life is up to nine months

Equipment required for Agro Processing Unit for Ginger: Various equipments required are:-ginger washer, ginger peeler, blower, ginger slicer, solar drier and hot air blower or mechanical tray drier, pulveriser or spice grinder, sealing machine, weighing balance, hand sealer , bucket, trays etc.

A small unit (100 kg per day) require:-

1.	Washing unit(AICRP-PHT,Gangtok)	=	30000.00
2.	Slicer	=	15000.00
3.	CAEPHT-Solar Drier	=	80000.00
4.	CIAE-Mechanical drier	=	60000.00
5.	Hand sealer	=	2000.00
6.	2 Weighing balance	=	10000.00
7.	Grinder	=	15000.00
8.	Mis.		
TOTAL		=	**3-3.5 lakhs**

The same unit can also be used for various other spices like coriander, turmeric etc.

Plate1: Raw ginger

Plate2: Washing of raw ginger

Plate4: Slicing of ginger

Plate6: Sliced ginger

Plate7: Loaded solar tunnel drier

Plate8: Dried ginger slices

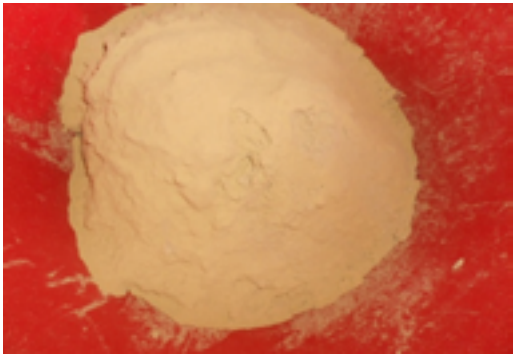


Plate9: Sliced and dried ginger powder

Plate10: Dried ginger sliced powder with label

Economics:

Table: Economic analysis of ginger processing unit for making slices or powder (Srivastav et. al. 2012)

Installed capacity of processing plant	100 Kg / day
Cost of processing plant / equipments	Rs. 4,00,000/-
Power consumption	Rs. 140 / day for 40 units @Rs. 3.50 per unit
Cost of Inputs Raw ginger rhizomes Packaging materials	 Rs.1000 / day Rs.200 / day
Labour cost ((2 person)	Rs. 400/ day
Product recovery Dried ginger slices Ginger powder	 Rs.20kg/day Rs.18kg/day
Cost of production Dried ginger slices Ginger powder	 Rs. 97/kg Rs.108/kg
Estimated sale price Dried ginger slices Ginger powder	 Rs.350/kg Rs.400/kg
Profit Dried ginger slices Ginger powder	 Rs.253/kg Rs.292/kg

The processing plant is expected to be operated for 8 months/year (25day/m. on 8h basis, keeping in view round the year availability of ginger rhizomes in NEH region.) The average annual cost of raw ginger rhizome is estimate to be Rs.10/kg. For remaining 4 months the processing plant can be used for processing of other spices.

Other Ginger products:

Various other value added products that can be made from ginger are Ginger oil & leoresin,Ginger candy,Ginger tit-bit,Crystalized ginger,Ginger dry,Ginger powder,Ginger paste,Ginger in brine,Ginger pickle etc. Out of all these the Ginger oil can really give good returns.

Ginger Oil: Ginger oil can be produced from fresh or dried rhizomes. Ginger oil is obtained using a process of steam distillation. One such unit has been set up near Jorthang in Sikkim. The yield of oil from dried ginger rhizome is between 1.5 to 3.0%. The remaining rhizome powder contains about 50% starch and can be used for animal feed. It is sometimes dried and ground to make an inferior spice or can be used for making curry powder.

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Effect of Pre-treatment and Temperature on the Quality of Convectively Dried Ginger (*Zingiber officinale)*

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ABSTRACT

Ginger (*Zingiber Officinale*) is known for its medicinal value and utilized to treat wide range of ailments like nausea, arthritis and high cholesterol. It is consumed both in fresh (curries, pastes, juices) and dried (mixes, seasoning, pies) form. The dried ginger available in the market lacks the standardization, with a large variation in the quality parameters. Present study was conducted to study the effect of pretreatment and drying temperature on the quality of dried ginger. Dried ginger was prepared from the Kozhikallan variety. Four pre-treatments given were(hot water blanching, citric acid (0.5 %), KMS (0.5 %), lime (2%)) and dried at three different temperatures(50 , 60,70° C) in a tray drier. Quality was evaluated on the basis of color (Δ E), texture, volatile oils, rehydration capacity and sensory score. The temperature had a significant effect on the quality of dried ginger. With the increase in temperature hardness increased whereas rehydration ratio, volatile oils and sensory score decreased. The effect of pretreatment on the volatile oils and hardness was non-significant. Fresh ginger pre treated with citric acid (0.5 %) and dried at 50°C gave the best results with volatile oil (2.2 %) , Δ E (5.93) and maximum sensory score.

Key words: Ginger , temperature, quality , pre-treatment

INTRODUCTION

Ginger (*Zingiber Officinale*) is an important root crop , belonging to the botanical family *Zingiberaceae.* The name Zingibera originates from Sanskrit meaning horn shaped, referring to the protuberances on the rhizome . Its origin and presence in India is known since the medieval period and till date maintain a lead with the total production of 380,100 t followed by China with the production of 331,393t , respectively (Anon 2010). Ginger is characteristically distinguished by color, texture and flavor. Indian ginger is starchy, pungent and has a faint lemon like color due to presence of small quantity of citral.

Ernst and Pittler (2000) reported ginger for its medicinal value and utilized for wide range of benefits like nausea , Grontved and Pittler (2000) recommended for chemotherapy, Nievergelt et.al.(2010) reported for gastrointestinal function. Preliminary studies have revealed ginger affects arthritis pain and have blood thinning and cholesterol lowering properties, but these effects remain unconfirmed. Ginger acts as anti-glycating mechanisms (Saraswat et al. 2010) in the development of diabetic cataract. It helps to clean the congestion in the body and detoxify the

body. Ernst and Pittler (2000) observed it as a catalyst to improve the absorption and effectiveness of other herbs .

Ginger is consumed both as fresh and dried form. Fresh ginger has been used since time immemorial in Indian cooking in pickles, chutneys and juices. Incorporation of dried ginger powder is widely done in flavoring foods such as pies, puddings, cookies, pastries and biscuits. It is a major constituent of curry powders, minced meat and fish seasoning mixtures. It is also extensively used for flavoring beverages, manufacturing ginger oil, oleoresin and essence of ginger to standardize and improve the quality of product.

Pre treatment minimizes the damage to the cellular structure, resulting in better rehydrated product. Vega et. al (2008) studied the effect of pretreatment on red pepper. Various studies have been reported for ginger flakes and piece. Nongsang et al. (2009) studied the effect pretreatment with citric acid 0.5 % , Sukajang et al. (2010) studied the effect of pre treating ginger with sodium ascorbate 0.1 and 0.2 % at 40,50,60°C . Singh et . al (2008) studied effect of calcium oxide 2.5 % for ginger flakes at 40,50,60,70° C. The results revealed in pretreated ginger the damage was minimized to the cellular structure resulting in better rehydrated product displaying comparatively improved color and firmness in comparison to un treated samples. Dried ginger is available in the market but there is large variation in the quality (color, texture etc) as its processing is carried out at small scale unorganized processing sector. The objective of the present study was to standardize the pretreatment and temperature for drying of whole ginger and to study its effect on the quality of the dried ginger.

MATERIALS AND METHODS

Mature healthy and freshly harvested ginger of Kozhikallan variety was procured from the local whole sale market. The diseased bruised and damaged rhizomes were sorted out. The uniform sized ginger was manually cleaned and peeled with a knife. The excess water was drained and wiped with a muslin cloth The peeled rhizome were subjected to four pre-treatments(hot water blanching, citric acid (0.5 %), KMS (0.5 %), lime (2%)) and dried at three different temperatures(50 , 60,70° C) in a tray drier in an electrically heated air dryer .After EMC was achieved the dried samples were sealed in a polyethylene bags to prevent the loss and gain of moisture.

Responses

The pretreated ginger was dried from initial moisture content 719.67 to 13.11 at 50 °C , 714.33 to 11.40 at 60° C and 706.45 to 9.94 at 70°C. the variation in the dried weight was due to different EMC values at different temperature. The quality of dried ginger was evaluated from texture, color, re hydration ratio, volatile oils, and sensory characteristics.

The texture of dried ginger was measured with a TA-XDTi Texture Analyzer (Stable Micro system) using a P75 compression plate. The 250 kg load cell was moved with pre test speed 2 mm/sec, test speed of 1mm/sec, and post test sped 2 mm/sec for a strain of 10 %. Three readings of hardness of dried samples were taken for each sample and averaged.

Hunter Lab Scan XE (Hunter Associates Laboratory, Inc., Reston, VA, USA) was used to determine color values of the dried ginger in terms of the L, a and b as measures of lightness, redness and yellowness, respectively. The measuring head was equipped with 51 mm diameter viewing port and used the system of diffuse illumination with 10° viewing geometry. The

illuminant was D65.The l value measures the psychometric lightness and varies from 100 for perfect white to zero for perfect black .The value of a * and b *gives the color. Four measurements were taken for each sample and averaged. The total color change (ΔE) was calculated as

$$\Delta E = \sqrt{\Delta L2 + \Delta a^2 + \Delta b^2}$$

Where ΔL, Δa and Δb are deviations from L, a and b value of fresh sample.

ΔL = L dried sample – L fresh sample; + ΔL means sample is lighter than fresh, - ΔL means sample is darker than fresh.

Δa = a dried sample- a fresh sample; + Δa means sample is redder than standard, - Δa means sample is greener than standard.

Δb = b dried sample –b fresh sample, + Δb means sample is yellower than standard, - Δb means sample is bluer than standard.

Dried gingers of 5 g were soaked in water at 50 °C. Weight gains were monitored by taking out samples from the soaking water and weight them regularly until the weight was constant (Phoungchandang et al., 2009), volatile oil was determined by official Analytical Methods (2010) using Clevenger apparatus and sensory quality of dried ginger was assessed for color, taste, texture and overall acceptability using a 9 –point hedonic rating scale(Ranganna,1986)

2.8 Statistical analysis

The data recorded from various experiments was analyzed to determine the effect of pre treatment and temperature on the product. The statistical analysis of the data was done by using software CPCS1 in general linear model using RBD. Analysis was done considering the main effects and two factor interactions at 5% level of significance.

RESULTS AND DISCUSSION

Texture: The hardness of the dried ginger (all treatments) ranged from 137 kg -232 kg. The hardness of the dried product increased with the temperature from 50 to 70^{0}C as shown in Fig 1. As the temperature increased the moisture content decreased, increasing the total solids resulting in the higher value of hardness (Gupta et.al 1990). Surjadinata et al (2001). reported similar effect of moisture content that is with the decrease in moisture the hardness increased. Minimum force (137 kg) was required for sample treated with hot water and dried at 50^{0}C . Maximum force (232 kg) was recorded for the products treated with KMS(potassium metabisulphite) and dried at 70^{0}C. At 5% level of significance, the increase in force was significant with the increase in temperature (50 to 70^{0}C) but non significant for all kinds of pre treatments given to ginger (Table 1).

Table 1: Analysis of Variance for quality traits in Ginger in responses effect of temperature treatment

	Parameter	MS	F Ratio	CD (5%)
Effect of drying temperature	Hardness	7158.17	354.43	7.77
	Color	28.87	459.47	0.434
	Volatile Oil	0.75775150E-01	777.29	0.170872E-01
Effect of pre-treatment	Hardness	80.211	3.97	NS
	Color	.423	6.84	0.500

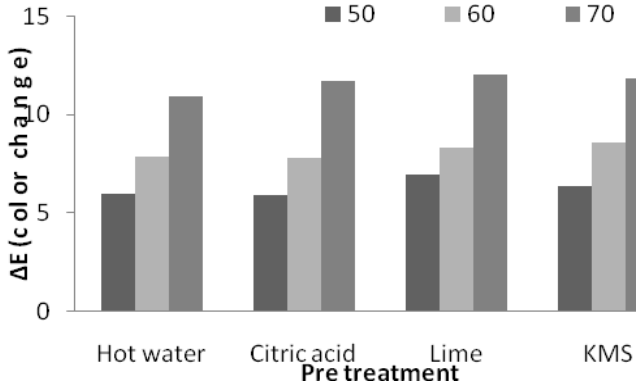
	Volatile Oil	0.45352510E-03	4.65	NS

Table 2 Hunter color values of pretreated fresh and dried ginger at temperature (50, 60 ,70 °C)

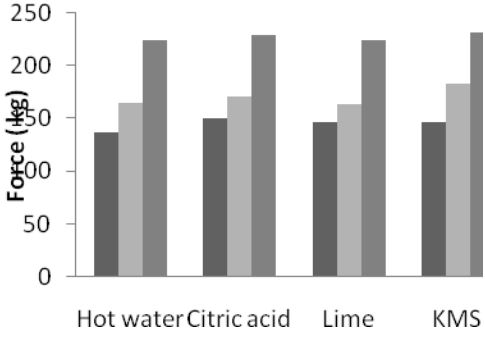
Tempertaure	Color	Fresh	Dried ginger			
			Hot water	Citric acid	Lime	KMS
50°C	L	54.9	48.1	48.3	48.0	48.1
	a	6.3	3.3	3.4	3.4	3.8
	b	16.4	11.5	11.8	11.4	11.3
	□E		9.08	8.79	9.1	8.88
	SD		0.37	0.23	0.16	0.15
60°C	L	54.8	46.1	47.4	47.0	46.0
	a	5.8	2.7	2.8	2.7	2.4
	b	16.3	10.7	10.3	10.5	10.5
	□E		10.97	10.26	10.2	11.2
	SD		0.09	0.59	0.61	0.45
70°C	L	54.1	43.1	43.7	43.5	43.1
	a	5.1	2.3	2.4	2.3	2.0
	b	15.9	8.7	8.5	8.2	9.1
	□E		14.6	14.7	14.3	14.48
	SD		0.08	1.5	0.74	1.1

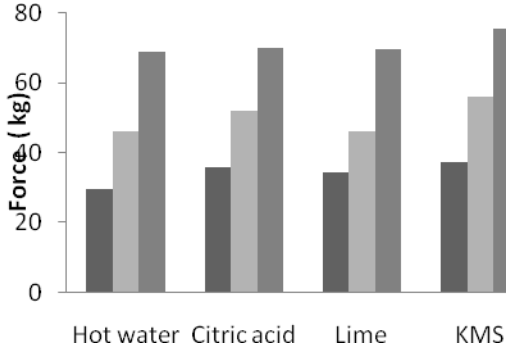
Maximum hardness was recorded at 70°C (KMS) treated rehydrated sample and minimum hardness was recorded at 50°C (hot water blanched)(Fig 1(ii,iii). The hardness was higher for dried sample in comparison to rehydrated as removal of moisture results in strength in comparison to rehydrated sample. At 5% level of significance, temperature (50-70 °C) and pre treatments showed a significant effect (Table 2).

Color : The values of L, a and b for fresh, dried and rehydrated samples are shown in Table 2. There was a small change in color values of each sample after giving the pre treatment. Pre treatment not only removes dirt and microbes from the surface of product but also helps in color fixation. Table 2 shows the values of L, a and b of the rehydrated samples are more than that of dried samples, resulting in slight increase in L, a and b values. It could be due to hydration of voids. Effect of temperature on the value of color change (ΔE) for different pretreated ginger is shown in Fig 1(i). For all the treatments ΔE value increased with the temperature from 50-70°C . Pretreatment and temperature (both) had a significant effect on the value of ΔE. It was minimum(5.93) for the product pre treated with citric acid and dried at 50°C and maximum for the product pre treated with KMS(potassium metabisulphite) and dried at 70°C. At 5% level of significance, the change in color values for fresh and rehydrated ginger was significant for both the pre-treatment and temperature (50-70°C).Azian et al., (2004) reported low temperature drying preserves the active components in material which are decomposed by high temperature.

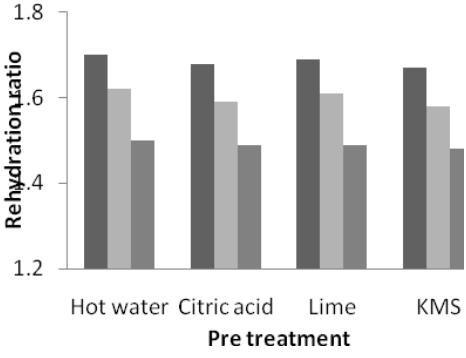


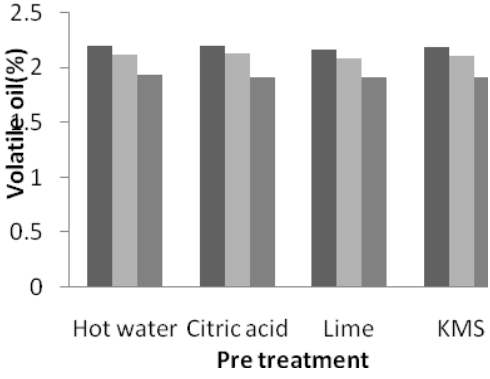
(i)





(ii) (iii)





(iv) (v)

Fig. 1 Effect of temperature and pre treatment on (i) total color change (ΔE) (ii) hardness of dried ginger (iii) hardness of rehydrated ginger (iv) re-hydration ratio of dried product.(*KMS potassium metabisulphite) (v) percentage volatile oil(at 50,60,70°C)

Rehydration ratio : The effect of temperature was significant on rehydration ratio. Rehydration ratio decreased with the increase in temperature. Maximum rehydration ratio of 1.8 was recorded for hot water pretreated ginger and dried at 50°C and minimum of 1.48 when treated with KMS and dried at 70° C (Fig 1(iv).At 5% level significant effect of temperature an d pre treatment were recorded. As the temperature increased from (50-70°C) the rehydration ratio decreased. Similar results were reported by (Singh et al 2008).

Volatile oil: A decrease in volatile content was recorded with the temperature increase(50-70°C).Maximum recovery of 2.2 % was recorded for hot water and citric acid pre treated samples dried at 50°C and KMS pre treated and dried at 70°C.(Fig 1(v).The results are in agreement with Schweiggent (2008) the pungency is affected by the temperature . Drying increases the volatile oil content in comparison to the fresh ginger as the fresh ginger pulp has water rich materials whose moisture content 94.52±0.30% (wb)and this moisture restricts the volatile components to release completely. Ding et al (2011) reported with the drying the moisture reduction and cell damage takes place resulting in greater release of compounds responsible for volatile oil. Due to high temperature the double bonds present in the cyclo compounds, oxidation , degradation reaction and rearrangement took place leading to disappearance of some volatile constituents and formation of novel molecules .The pretreatment had a non-significant effect on volatile oil recovery but the temperature had a significant effect (Table 1) Azian et al.,(2004.). reported ginger undergoes a number of pretreatments to ensure maximum yield of volatile oil.

Sensory evaluation of dried product was carried out on the basis of appearance, odor and hardness. The product treated with citric acid and dried at 50°C scored 8 out of 9. The product treated with citric acid and dried at 50°C had the highest score while KMS treated and dried at 70° C scored the minimum. Increased temperature enhanced the ΔE values thus reducing the sensory evaluation score. The results are in agreement with those reported by Ramanah et.al (2010) at higher temperature the aroma losses were reduced due to short drying time(60°C) but led to sample charring on the other hand as the lower temperature the charring was avoided by aroma was lost due to prolonged drying time(40°C)

CONCLUSION

Ginger (*Zingiber Officinale*) known for its medicinal value and utilized to treat wide range of ailments like nausea, arthritis and high cholesterol. It is consumed both in fresh (curries, pastes, juices) and dried (mixes, seasoning, pies) form. The dried ginger available in the market lacks the standardization, with a large variation in the quality parameters. Present study revealed the effect of pretreatment and drying temperature on the quality of dried ginger. Temperature had a significant effect on color , texture, volatile oil and sensory characteristics. On the other hand pre treatment was significant only for color, re hydration ratio and texture . The best results were recorded with ΔE (5.93), hardness (2.0%) for fresh ginger pre-treated with citric acid (0.5%) and dried at 50°C .

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Solar Drying of White Button Mushrooms (*Agaricus bisporus*)

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ABSTRACT

Mushroom is a fungal fruiting body which is cultivated throughout the world. Freshly harvested mushrooms are highly perishable because of high moisture content metabolism and susceptible to enzymatic browning. If a little technology and money is applied then solar energy can be a possible solution for the dehydration of food. Keeping in view all the aspects, a study was planned to identify the best drying method for drying of mushrooms on the basis of quality. Low cost drying methods viz. domestic solar dryer, medium size solar dryer and open sun drying were evaluated. The white button mushrooms were procured from Mushroom Research Farm, Punjab Agricultural University, India. These mushrooms were washed, trimmed, and cut into slices of thickness about 1 cm and pretreated with 1% potassium metabisulphite prior to drying. The mushrooms dried in medium size dryer gave the maximum values of L i.e. whiteness, rehydration ratio and coefficient of rehydration. The drying time and final moisture content was also comparatively less than the mushrooms dried under shading plates and open sun drying. Based on the results of the study and statistical analysis, it can be concluded that solar dryer particularly medium size dryer with samples treated with 1.0 % potassium metabisulphite gave the best results and the shelf life of the mushrooms could be extended by the farmers' at the farm without using any sophisticated equipments.

Key words: White button mushroom, solar drying, sun drying, quality

INTRODUCTION

Mushroom is defined as a macrofungus with a distinctive fruiting body, which can be hypogeous or epigeous, large enough to be seen with the naked eye and to be picked by hand (Hawksworth, 2001). Production and consumption of edible mushrooms have grown since last decade, particularly due to interest in their nutritional and health benefits. Mushroom is a fungal fruiting body, which produces and disseminates spores. Production of mushroom has already crossed 5 million metric tonnes annually in the world and is expected to reach 7 million metric tones in the next ten years. Large scale white button mushroom production is centered in Europe, North America, and South East Asia. Total mushroom production in India is 50,000 tonnes with 85% of this production being of white button mushrooms (Anonymous, 2012). Although, many species of mushrooms are edible, very few are being cultivated commercially and the most popular are white button mushroom *(Agaricus bisporus),* paddy straw mushroom *(Volvariella spp.),* Oyster mushroom *(Pleurotus spp.)* and Shiitake *(Lentinus edodes).* Many mushrooms have cap and a large

number of mushroom species grow wild and are deadly poisonous (Prakash et al., 1986; Khader, 1999). In India, white button mushroom, paddy straw mushroom and oyster mushroom are cultivated in different parts of the country, depending upon the suitability of region and season as these varieties need different temperature ranges for growing (Khader and Pandya, 1981). White button mushroom is cultivated throughout the world and contributes about 35-45% of total world production of mushroom. The white button mushroom is more acceptable to the consumer and fetches higher prices. It is known for its high yield and quality. Harvesting for processing has to be done at proper stage only when it reaches its peak of perfection with regard to appearance, weight and quality just before the cap opens to expose gills. Mushroom is the most priced commodity among vegetables not because of its nutritive value but because of its characteristic aroma and flavor. Fresh mushrooms contain about 85-95% moisture content, 3% protein, 4% carbohydrate, 0.3-0.4% fat and 1% minerals and vitamins. Mushrooms are a good source of vitamin B2, niacin, folates and many mineral elements (Mattila et al., 2001). They also contain appreciable amount of niacin, pantothenic acid and biotin. In addition, mushroom also contain folic acid and vitamin B12 which are absent in most of the vegetables. Mushroom may be baked, fried, boiled, creamed, roasted, pickled and stuffed. In India, it is mostly consumed fresh and a negligible amount is used for processing. However, where mushrooms can be grown at ambient temperature (i.e. hilly areas) but cannot be transported quickly to consumption places (i.e. big cities in plains) the only way to its utilization is its processing. They can be processed as canned, dried and frozen mushrooms. The vitamins in mushroom are well retained during cooking, canning and dehydration.

Drying of mushrooms is done to remove free water to such a level such that the biochemical and microbial activity are checked due to reduced water activity. Freeze drying yields excellent quality mushrooms but, the cost of removal of water is 10 times higher than the conventional air-drying. White button mushroom were dried in a hot air oven and observed that minimum browning index was recorded at 65°C and rehydration ratio obtained at this temperature was 2.9 (Lidhoo, 2006). EMC values for *Agaricus bisporus* were found out as 9.50, 8.19, 7.00, 5.89 and 4.50 (g/100 g dry matter) at temperatures 30, 40, 50, 60, 70°C, respectively (Shivhare, 2004) . Solar energy is diffuse in nature and provides low-grade heat which is good for the drying at low temperature. The high capital cost of solar dryers can be compensated if the dryer is used for drying other products also. The studies were conducted on dehydration of mushroom by sun drying, thin layer drying, fluidized bed drying and solar bed drying (Suguna, 1995). Trials with natural convection solar cabinet dryer showed a drying time of 7 h, when the ambient temperature varied between 29-32°C. If a little technology and money is applied then solar energy can be a possible solution for the dehydration of food. Solar drying system must be properly designed in order to meet particular drying requirement of specific crop. Keeping in view all the aspects, a study was planned to identify the best drying method for drying of mushrooms on the basis of quality. Low cost drying methods viz. domestic solar dryer, medium size solar dryer and open sun drying were evaluated.

MATERIALS AND METHODS

Sample Preparation

The white button mushrooms (*Agaricus bisporus*) were procured from Mushroom Research Farm, Punjab Agricultural University, India. These mushrooms were washed, trimmed, and cut into slices of thickness about 1 cm and were pretreated using 1.0 % potassium metabisulphite for 15 min as well as control (samples without pretreatment) were dried using domestic solar dryer, medium size dryer and open sun drying to select the best drying method. The samples were prepared depending upon the type of drying and type of dryer. The samples for solar dryers i.e. domestic solar dryer and medium size dryer were taken depending upon the size and the capacity of trays. The samples were fed into the dryers and kept out for solar drying. The samples taken for sun drying on black polythene sheet and transparent polythene sheet were 0.5 kg.

Construction and Working of Driers

The domestic solar dryer was of natural circulation, integral type (Fig. 1). There were three trays with shading covers to cover the produce from direct sun light. The shading plates got heat from sun and transfer this heat to the produce and provides shade and it allows air to pass through it. It has been designed in such a way that air enters from the bottom and passes through all the trays. The material used for its construction was mainly window glass (4 mm thick), mild steel sheet and angle iron. The top layer of the dryer was designed in such a way that the rain water does not enter the dryer. The medium size dryer was of natural circulation, integral, open solar drying type (Fig. 2). Main difference being that there was no covering of the produce from direct sunlight. It had five perforated trays arranged at five different levels. The trays were designed in such a way so that after loading the material, there was no heat loss in the form of air leakage and could easily put in or draw out from the dryer. The sun drying of mushrooms was done on different polythene sheets viz. black polythene sheet (0.12 mm thick), transparent polythene sheet (0.07 mm thick).

Fig. 1: Domestic solar dryer

Fig. 2: Medium size solar dryer

OBSERVATIONS

The decrease in weight of sample, internal temperatures of solar dryers, ambient air temperatures, dry and wet bulb temperatures, and incident solar intensity readings were also recorded at a regular interval of one hour till the weights become constant.

Drying Time: Total drying time for different methods was recorded.

Drying Behavior of Mushrooms in Different Dryers

The observations taken during the drying of mushrooms were used to plot the drying curves. The drying curves for moisture content (% db) versus drying time (h) and drying rate (% db/h) versus drying time (h) for all drying techniques were plotted.

Moisture Content: Moisture of fresh sample and samples dried with different methods were found out using the standard method (AOAC, 2000). Three samples of known weight were kept in the oven and average moisture content was found out. All moisture contents in the text are expressed on wet basis.

Temperature and Relative Humidity: Mercury thermometers were used to measure the inside temperature of the dryers and the ambient air temperature. To find the relative humidity of the air, the dry and wet bulb thermometers were used.

Solar Radiation Intensity: Surya mapi (Make: Central Electronic Cell, range 0-1 kW) was used to measure the intensity of solar radiation incident on the surface of the dryer.

Colour: Colour of fresh and dried mushrooms was observed using the colorimeter (Make: Hunter Lab, Virginia, USA Model: Miniscan XE Plus). Before taking actual reading of the sample, the colorimeter was calibrated using black and white tiles supplied with the instrument. The sample was densely packed in a Petri dish and covered with a thin transparent glass plate. The colorimeter was then placed on the plate in such a way that all the light falls on and is reflected back from the sample only. The average value of two consecutive readings of the sample was displayed as L, a, b. The L, a, b values were recorded and from these the overall change in colour

(ΔE) of different samples with respect to that of fresh were calculated to estimate variation in sample colour. Following relationship was used (Waliszewski, 1999).

$$\Delta E = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}$$

Rehydration Characteristics: The rehydration characteristics (Ranganna, 1986) were studied in terms of:

a) Rehydration ratio (RR): Ratio of weight of rehydrated sample to that of dehydrated sample.

b) Coefficient of rehydration (COR):

$$COR = \frac{W_2\, x(100 - M_I)}{(W_1 - M_F)x100}$$

Where, W_2 is the drained weight of dehydrated sample; W_1 the weight of dried sample taken for rehydration; M_I the moisture content of sample before drying; M_F the amount of moisture present in dried sample taken for rehydration.

Statistical Analysis: The data observed from various experiments was analyzed in terms of effect of different methods on the quality of dried mushrooms. The statistical analysis of the data was done by employing univariate analysis of variance (UNIANOVA) in general linear model using SPSS- 7.5.

RESULTS AND DISCUSSION

Initial moisture content of fresh mushroom samples was 900 % (d.b) and initial colorimeter readings were: L = 57.41; a = 3.68; b = 15.54. Trends for inside air temperature (°C), ambient temperature (°C) and relative humidity (%) for medium size solar dryer are shown in Fig.3. Trend of incident solar intensity (kW/m²) of medium size dryer is shown in Fig. 4.

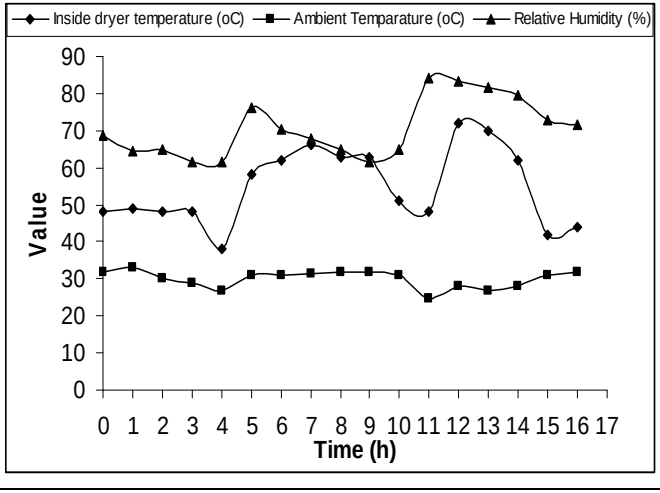


Fig. 3: Drying conditions in a medium size solar dryer

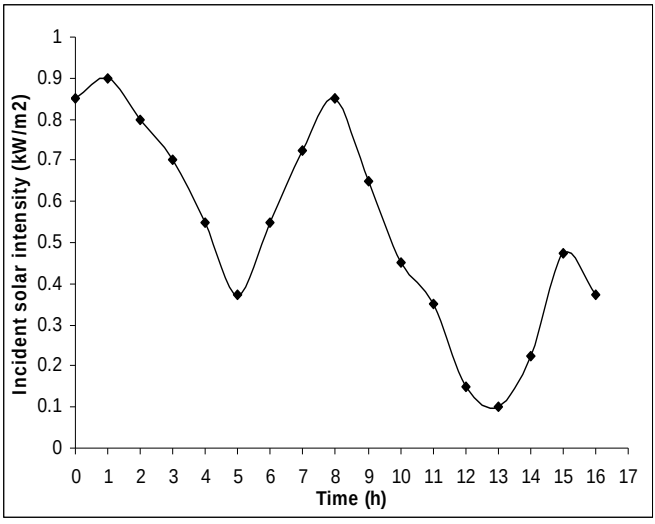
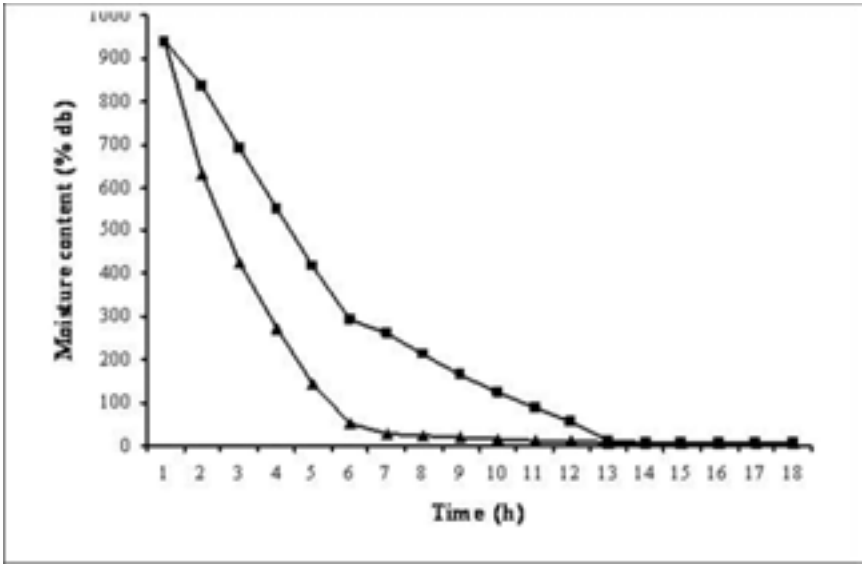


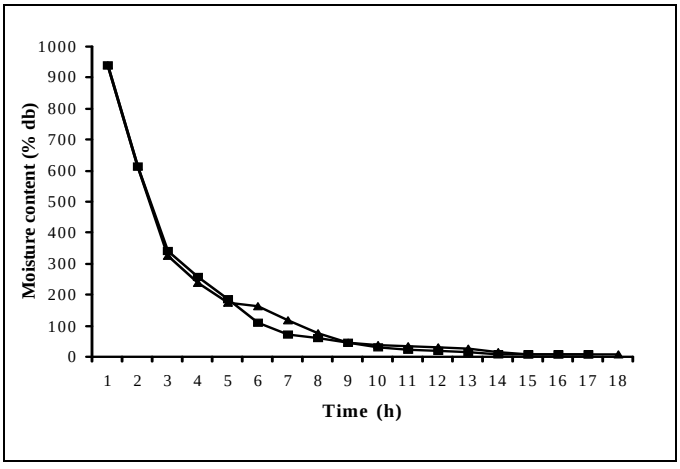
Fig. 4: Incident solar radiation on medium size solar dryer

Relation between Moisture Content and Drying Time

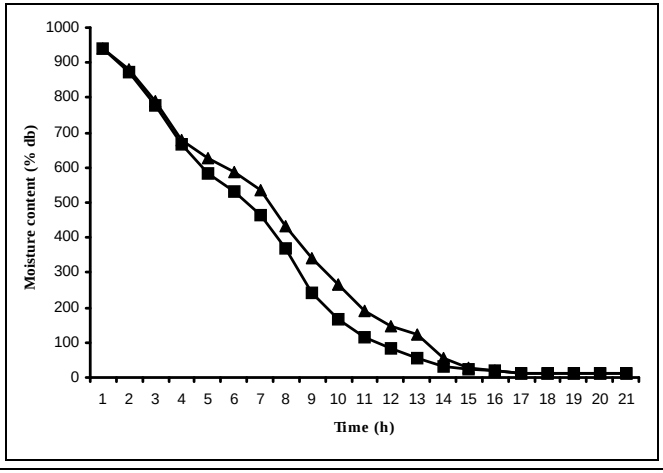
The change in the moisture content of mushrooms with drying time for all drying techniques was studied. The moisture time relationship is non linear, the decrease in moisture is being larger initially as compared to the later part of the drying. Solar drying required 13 to 14 h drying time, whereas open sun drying required 19-20 h drying time (Table 1). Lesser time for drying in solar dryers is due to the higher air temperature and less relative humidity inside the dryer. The moisture content (%db) vs drying time (h) curves for different type of drying methods is given in Fig. 5.



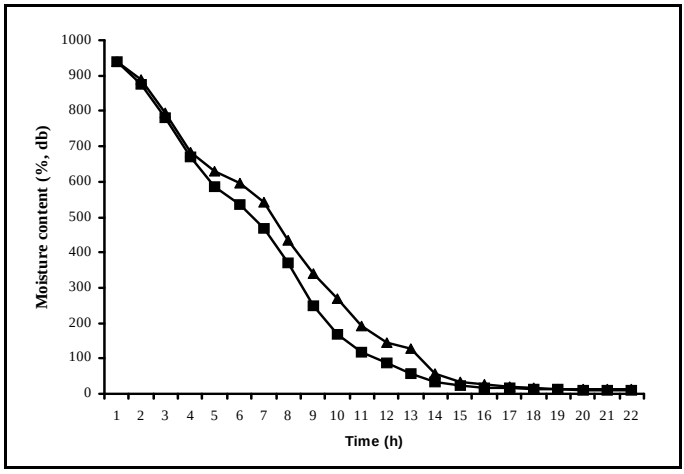
a) Domestic solar dryer



b) Medium size solar dryer



c) Open sun drying using black polythene

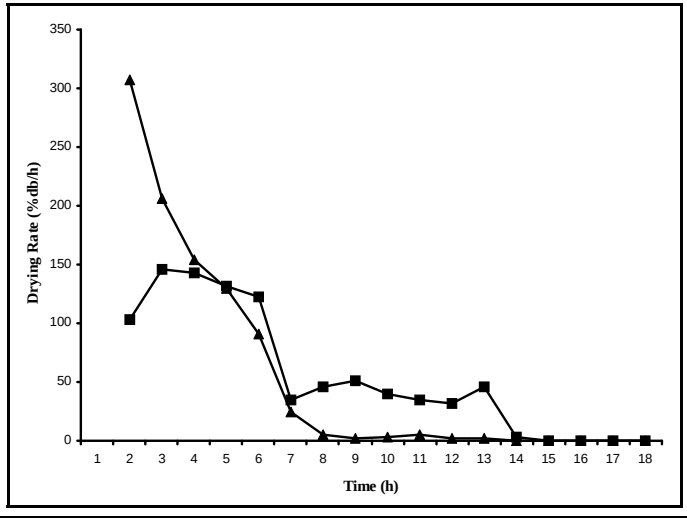


d) Open sun drying using transparent polythene

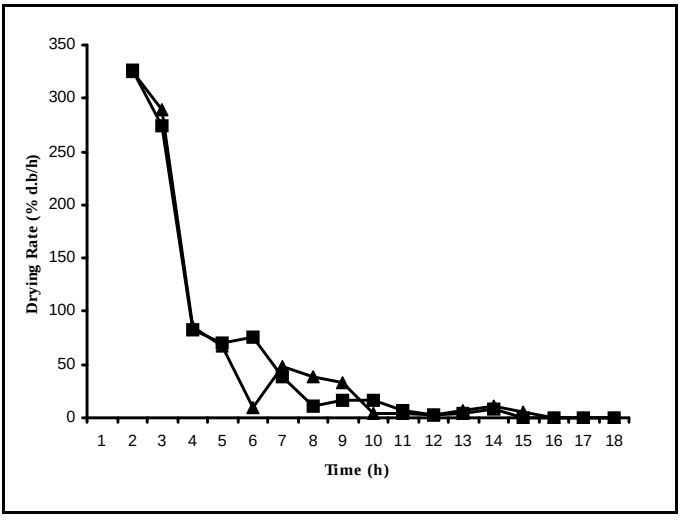
Fig. 5: Moisture content vs drying time trends for different type of drying (——— Control; ▲——— Treated)

Relation between Drying Rate and Drying Time

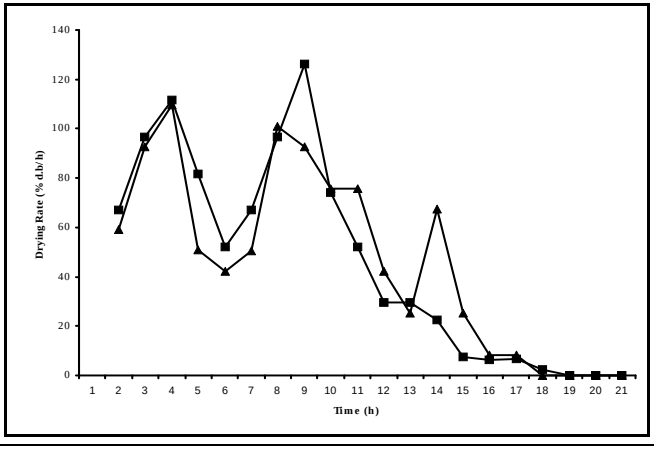
The plots between drying rate vs drying time were made for different type of drying techniques (Fig. 6). The drying occurred in falling rate period and constant rate period could not be observed for different drying methods. In open sun drying, there were more fluctuations because when the cloudy condition prevails, the surrounding atmosphere became cooler and the drying rate slows down rapidly. All the three pretreatments witnessed nearly same drying rate trend. Initailly the drying rate was in the range of 140-160 (% d.b./h) which came down to about 10-15 (% d.b./h) after 13 h for all the pretreated samples. In case of solar dryers the heat remain entrapped inside the dryer during the cloudy conditions which helps in removing the moisture at a subsequent rate and the drying rate does not slow down at high rate.



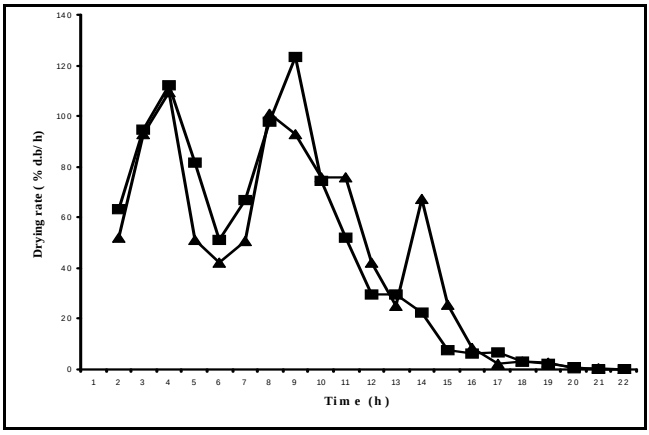
a) Domestic solar dryer



b) Medium size solar dryer



c) Open sun drying using black polythene sheet



d) Open sun drying using transparent polythene sheet

Fig. 6: Drying rate vs drying time trends for different type of drying (——— Control; ——— ■ Treated)

Table. 1: Quality parameters for different type of drying

Type of drying	Pre-treatment	Drying Time (h)	FMC (%db)	Colour	RR	COR
Domestic Solar Dryer	Treated*	13	7.72	L=31.1 a=4.0 b=7.9	2.39	0.25
	Control	12	8.23	L=29.3 a=3.7 b=7.5	2.20	0.23
Medium Solar Dryer	Treated*	13	6.86	L=52.8 a=4.9 b=15.1	2.98	0.31
	Control	14	8.25	L=48.7 a=4.4 b=15.1	2.56	0.27
Open Sun Drying	Treated*	19	10.27	L=27.9 a=3.3 b=4.0	2.43	0.25
	Control	20	11.14	L=25.6 a=3.6 b=3.4	2.26	0.24

*1.0 % potassium metabisulphite

Selection of Drying Method

Pairwise comparison of different drying methods was done statistically; data for mean differences for different quality parameters is shown in Table 2. Pairwise comparison of different drying methods shows that methods A-B differs significantly at 5% level with respect to ΔE and difference with respect to ΔE and final moisture content was significant at 5% level between the methods A-C and B-C. The values of mean difference at 5% level for methods A-B and B-C with

respect to ΔE was much higher, which suggest that method B is significantly better than method A and method C. So, it is clear from the above discussion that drying using medium size solar dryer produced best quality dried mushrooms.

Table 2: Statistical analysis on the basis of quality of the product

Methods		FMC (CD=1.515)	ΔE (CD=3.340)	RR (CD=0.3514)	COR (CD=0.040)
I	J	Mean difference (I-J)	Mean difference (I-J)	Mean difference (I-J)	Mean difference (I-J)
A	B	0.3620	19.6210*	-0.2487	-0.0098
A	C	-2.8200*	-5.1600*	-0.0887	-0.0050
B	C	-3.1820*	-24.7820*	0.1600	0.0148

A: Drying using domestic solar dryer; B: Drying using medium size solar dryer; C: Open sun drying
*indicates significant at 5% level of significance

CONCLUSION

From the study it may be concluded that solar drying took minimum effective time for drying followed by sun drying. The samples deteriorated by the insects and rodents in open sun drying. The drying rate was also very slow and final moisture content was above the recommended limit, so the open sun drying method was not suitable. The mushrooms sample dried in domestic dryer under shading plates gave poor quality parameters as compared to those which are dried under direct sunlight in medium size dryer. This implies that the shade drying of mushrooms is not recommended. The mushrooms dried in medium size dryer using pretreatment of 1.0 % potassium metabisulphite gave the maximum values of L i.e. whiteness, rehydration ratio and coefficient of rehydration. The drying time and final moisture content was also comparatively less than the mushrooms dried under shading plates and open sun drying. Based on the results of the study and statistical analysis, it can be concluded that solar dryer particularly medium size dryer with samples treated with 1.0 % potassium metabisulphite gave the best results and the shelf life of the mushrooms could be extended by the farmers' at the farm without using any sophisticated equipments.

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Design and Development of Energy Efficient Improved Biomass Sigri (Grill) for Roasting of Fresh Maize Cobs for Sikkim and NEH regions

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ABSTRACT

Maize or corn (*Zea mays*) is a plant belonging to the family of grasses (*Poaceae*). In Sikkim the Maize is one of the most important cereal crop during the Kharif (rainy/summer) season as rainfed crop. The season starts with February-March and ends with July-September depending upon the altitude. It is grown over an area of about 36,000-40,000 hectare with the production of 64890 t which is about 35-40% of total cultivable area. Roasted maize selling is one of the main sources of earnings for livelihood for the poor farmers and many others. At present, the farmers use fuel-wood in the traditional chulhas. Introduction of an energy efficient improved fuel-saving sigri (grill) will be highly benefited to those involve in selling of roasted maize cobs to earn their livelihood. In the present study, an attempt has been made to design and develop an improved type of Sigri (grill) for the roasting of freshly harvested maize cobs. Further its effectiveness and efficiency over the conventional method of direct roasting in open flame or heated charcoal has also be evaluated. The unit consumes 1kg wood charcoal to roast 25-30 cobs per hour. For determining the economic efficiency, cost analysis has been done. It is seen that the improved Sigri (grill) is found to be more economical than the conventional method as it is 22-25% more efficient than the conventional one. Also the improved Sigri (grill) using wood charcoal, briquettes and small wood chips require smaller storage space and deliver better performance. The benefit cost ratio for improved Sigri was 1.47 times with increase of 26% profit on sale of maize cobs for the income generation with this energy efficient improved biomass sigri/grill.

Key words: Biomass grill , solar drying, maize cobs

INTRODUCTION

Maize or corn (*Zea mays*) is a plant belonging to the family of grasses (*Poaceae*). It is cultivated globally being one of the most important cereal crops worldwide. The maize crop is harvested (Fig.1) after normal maturity with the objective to remove maize cob and straw without loss. Optimum harvesting moisture content for maize is 25-35% (w.b). Harvesting of the maize crop is traditionally done by manual methods of using a plain sickle. In Sikkim, it is one of the most important cereal crop during the Kharif (rainy/summer) season as rainfed crop. The season starts with February-March and ends with July- September depending upon the altitude. It is grown

over an area of about 36,000-40,000 hectare which is about 35-40% of total cultivable area. The production of maize was 64890 t in 2006 – 07*(FSAD Annual Progress Report -2006-07)*..

Maize or corn (*Zea mays*) is a plant belonging to the family of grasses (*Poaceae*). In Sikkim the Maize is one of the most important cereal crop during the Kharif (rainy/summer) season.

Maize cobs roasted in fire pits (Fig.2) , was the main business during the season as cash crop to earn money which involves village women's in Sikkim. More than 60 people sell roasted maize along the National highway between 9th mile and 32nd mile (near Gangtok) in June till September under temporary sheds. The forest department provide special permit to the maize sellers to setup their sheds and for the use of forest wood on the recommendation of the village Panchayat. Farmers purchase green maize cobs @ Rs5.0 per piece and sell about 150 to 200 numbers roasted maize cobs @Rs10.0 per piece at road sides of NH-31A connecting Gangtok, Sikkim from Siliguri, West Bengal to the tourists since morning 6am to evening 6pm. **(A- Maiz-ing story, Sikkim Express daily).** In season, freshly roasted *bhutta or corn on the cob*, daubed with a mix of lemon, salt and chilli, is the most tempting street food. For roasting they use high volume of forest wood near the road sides. The loose fuel wood emits high level of smoke in and around the areas. There is no control on burning of fuel. Large amount of fuel wood is wasted. Thus, the design and development of energy efficient improved biomass Sigri for roasting of freshly harvested maize cobs will be highly beneficial to the people of Sikkim and others parts of hilly region where the green cobs are consumed extensively as the main food both in the roasted and steamed forms.

Fig.1: Fresh maize cobs for sale Fig. 2: Traditional practice for roasting maize cobs

Primary Fuel:

Wood was the primary fuel source and took months to dry and the larger logs needed to be set ablaze by smaller ones, which in turn needed to be lit by twigs. Once the little twigs were lit it took quite a while until the logs were hot enough to cook anything with. It took still longer time for the wood to burn completely. Often after a fire, instead of ashes, there would be partially consumed logs that were blackened and charred. Often after a fire, instead of ashes, there would be partially consumed logs that were blackened and charred. They seemed used up but the truth was that they still had a lot of burning potential left in them, and they could burn quite hotly if

reignited. This charred wood was the basis for the first charcoal, which started down the path to the charcoal grills we have today.

Scientific Utility:

- In season, freshly roasted *bhutta or corn on the cob*, daubed with a mix of lemon, salt and chili, is the most tempting snacks of street food.
- The traditional roasting of fresh maize cob involves drudgery and is labour intensive.
- Roasted fresh cob sold at road side to earn money during maize harvesting season.
- High volume of fuel wood utilized in open pit with the high level emission of smoke.
- No control of fire during off time hence high level energy loss.
- Need to develop energy efficient biomass Sigri (grill) to roast fresh maize cobs with controlled emission

Traditional Practice:

- Fresh maize cobs roasted in fire pits that utilize high volume of forest wood (5-10kg/hr) with increased emission of smoke in surrounding areas.
- Maize cobs roasted over wood charcoal placed in meson pot, small charcoal Sigri with the starring of hand fan/paper board for forced air to burn charcoal i.e. labour intensive work with increased emission of smoke.
- Use of saw dust sigri to roast fresh maize cob.
- To cook maize cobs in boiling water.

Scientific Utility for Design and Development of Sigri for Roasting of Freshly Harvested Maize Cobs:

- Sikkim and NEH region, the green cobs are consumed extensively as the main food both in the roasted and steamed forms.
- Design is beneficial to the people dependent on maize growing areas to earn money by selling roasted cobs in season.
- Energy efficient design increased profit after sale and save forest wood used for roasting in high volume.
- Require less space with clean smokeless environment.

MATERIAL AND METHOD

The Design and Fabrication work was carried out in the college workshop under Department of Farm Power and Machinery.

Design of the Improved Sigri (grill)

A study was carried out on a prototype improved sigri(Grill) for roasting of multi-cobs of maize along with the possible solution. These possible solutions are as follows:-

1. A movable Bio-mass Tray (with wood handle).
2. A manual operated Blower.

3. A movable ash tray.
4. Air control valve.
5. Insulation with (clay/soil).

And the possible design was drawn in the AutoCAD software along with the parameters, as shown in Fig.3.1 &3.2.

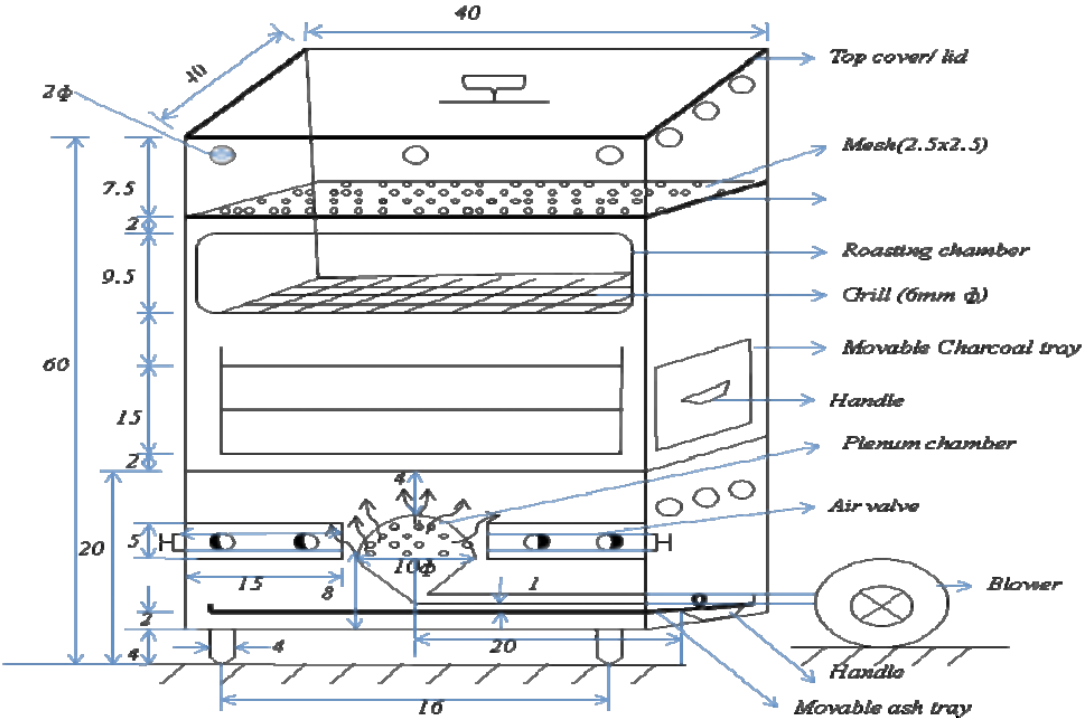


Fig. 3.1 Modified design for the improved biomass Sigri (grill)

The prototype design (Fig.4) was prepared and one unit of improved design was fabricated at college workshop. The required material for fabrication of prototype was purchased from local market. Total cost of fabrication of improved sigri (Grill) was Rs 2450.00 per unit including Input material cost, fabrication cost and Rs.850.0 as cost of hand blower.

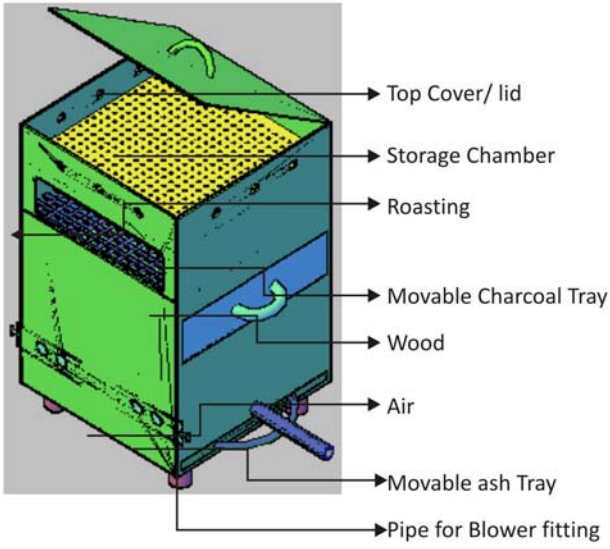
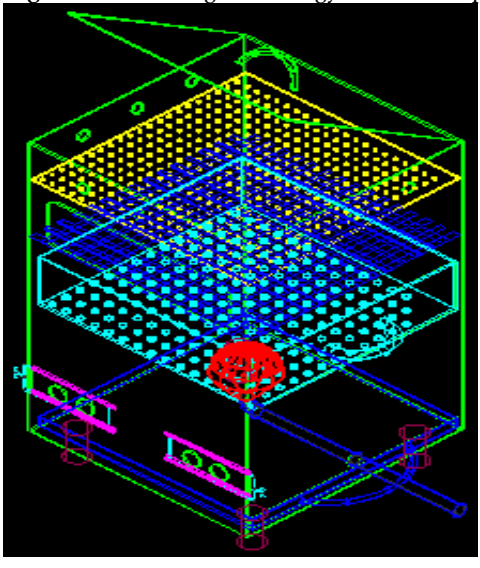


Fig. 3.2: CAD design of Energy Efficient Improved Bio-mass Sigri (grill)



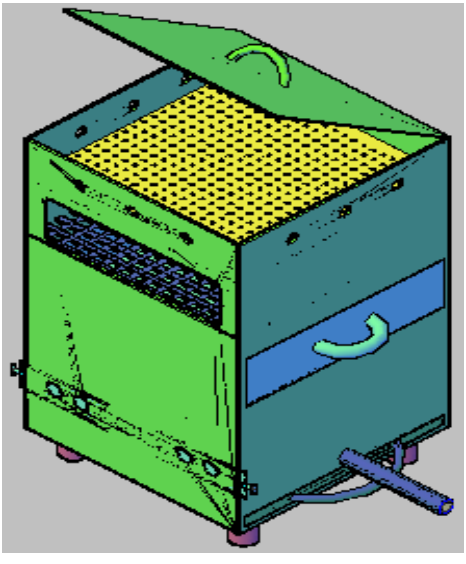


Fig. 4: Prototype design of improved sigri/grill for roasting of fresh green maize cobs

Testing of Sigri (Grill):

Survey was conducted at the Radong and Namin, village of East Sikkim during the peak season of selling of roasted maize cob. There was 15-20 numbers of temporary sheds/ stalls engaged for selling of roasted green maize cobs over fuel woods burnet in open pits under smoky environments.

Required Data has been collected as :

- Cost of green maize cob: ₹ 5.00/piece

- Cost of fuel wood: ₹ 5.00/kg
- Cost of end product: ₹ 10.00/piece
- Sale period: 6 am to 6 pm

Cost of wood charcoal: ₹ 10.00/kg (Singtam)

Cost of hand made briquette: ₹ 5.00/kg (Charcoal dust + Rice husk + cow dung)

The unit was tested to roast green maize cobs with wood charcoal and Briquettes. The designed prototype saves fuel for roasting of fresh maize cobs with low emission of smoke @ 4 maize cobs at a time. A hand blower was connected at bottom for initial ignition of fuel. The unit consumes 1.0 kg wood charcoal to roast 25-30 green cobs per hour. The improved Sigri (Fig.5) was demonstrated on Radong village for roasting of fresh maize cobs. Freshly harvested green Maize cobs during the first three weeks of June used for the sale as raw milky soft sweet maize cobs either boiling over the top compartment of improved Sigri in boiling water or roasting in grill compartment. The Burning capacity of fuel, heat utilised and power output rating was determined as per standard test procedure and guidelines (Indian Standard on Solid Biomass for Chulha-Specification IS 13152)

Fig. 5: Testing of improved sigri/grill for roasting of fresh maize cobs

The Comparative performance of Improved Sigri(grill) for roasting green cob with traditional and Improved Sigri/ Grill is presented in Table.1.

Table 1: Comparative performance of Improved Sigri (Grill).

Parameter	Traditional Practices	Improved sigri (Grill)	
	Fire wood	Wood- charcoal	Briquette
Roasting cost per cob ₹	0.85	0.27	0.30
Fuel used per cob (g)	28	28	63
Cost of green cob ₹ (150 No's)	750	750	750
Fuel cost ₹ (150No's)	300	120	90
Input Cost per day(150 cob) ₹	1050	870	840
Profit per day ₹	450	630	660

Net Profit per month ₹	13500	18900	19800
Calorific value Kcal/kg	2950	6930	3266
Thermal efficiency,% (Average)	08-10	20-23	18-21
Fuel Consume per Month (kg).	1800	360	540

The analysis showed that roasting 150 no's of green cob in improved Sigri (grill) saves 1800 kg of fuel wood. The increase in profit after sale of roasted cob @Rs 660.00 per day is to pay benefits to farmer as Rs 19800.00 per month. The cost of roasted cobs was Rs 10.0 per cob using home-made briquettes prepared from wood charcoal left over after use as by product of traditional chulha in rural areas. The benefit cost ratio of improved Sigri was 1.47 times with increase of 26% profit on sale of roasted maize cobs for the income generation.

CONCLUSION

In Sikkim and others parts of North Eastern hilly region the green maize cobs are consumed extensively in the roasted and steamed forms. This design was beneficial to the people dependent on maize growing areas to earn money by selling roasted cobs in season. Energy efficient design increased profit after sale and save forest wood used for roasting in high volume and require less storage space for fuel with clean smokeless environment.

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Indian Standard on Solid Biomass for Chulha-Specification IS 13152.BIS,New Delhi

Further Suggested Readings

http://www.sikkimexpress.com, Published on 16/06/2011.

http://sikkimagrisnet.org/General/en/Maize.aspx

http://en.wikipedia.org/wiki/Barbecue_grill

Agricultural Products Solar Drying Scenario

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ABSTRACT

Agricultural products are essential food items as they play a vital role in the human diet. Fresh agricultural products are bulky and highly perishable commodities due to presence of high moisture contents. Transportation to distant places is costly for agricultural products. Hence, much effort is required in the area of developing efficient, cheap drying technologies and methods by which loss of agricultural products can be minimized. Solar drying techniques enhance the shelf life of agricultural products. This review article focuses upon conventional and new solar drying technologies which are being attempted by various researchers for drying of various agricultural products.

Keywords- solar drying, agricultural products; solar dryer; greenhouse dryer; mixed dryer

INTRODUCTION

Fruits and vegetables are gift of nature for better health as they are rich source of minerals and vitamins. India is the third largest producer of vegetables and fruits in the world. The presence of higher moisture contents (about 70% to 95%) is one of the major reasons for the spoilage of various consumable products. About 50% of products losses occur due to improper handling, storage and poor knowledge of solar drying techniques. As a result the wastage in monetary terms is to the tune of ₹ 2500-30,000 crores. This problem can be overcome up to certain extent by minimizing the moisture contents by its drying with the help of proper solar dryer (http:/www.inseda.org/ , 2009). High energy consumption is one of major reasons influencing the development of the drying product industry, while solar energy is a clean and cheap source of renewable energy. The use solar energy for agricultural products drying can save a large amount of fossil fuel energy. Solar drying process involves wide fields of national economy. The demand of fruits and vegetables will rise due fast growth of population. Peoples are focus more on safety and quality food due to improvement of living standards. Natural drying of agricultural products is cheap but not completes the demands due to low efficiency. Hot-air drying process is expensive as it requires large energy. But our purpose is to obtain better drying quality and minimization of drying cost. The temperature for agricultural products drying is generally 50 °C to 60 °C. Therefore, use of solar energy for agricultural product drying can solve this problem up to certain extent (Yanlai *et al.* 2011; http:// www. Timesofindia.indiatimes.com/, 2012). Solar energy is inexhaustible source of energy which could supply all the present and future energy needs of the world (Sukhatme, 2001). Agricultural products drying by using solar energy is environmental friendly and cheapest method (Bala, and Janjap,2009). . People have been drying agriculture products for decades by placing crops, fruits and vegetables on ground surface in open air.

Generally, open sun dried products do not meet the international quality standards and therefore, it cannot be sold in the international market. The main disadvantages of open sun drying are contamination, theft or damage by birds or insects; slow drying, no protection from rain, encourages mould growth and may result in relative high final moisture content; low and variable quality of product due to over or under drying; direct exposure to sunlight reduces the quality of some fruits and vegetables (Ong, 1999).

The purpose of this paper is to draw attention towards the opportunities in India for solar drying of various agricultural products such as fruits, vegetables, spices, medicinal plants, fish and grains.

SOLAR DRYING AGRICULTURAL PRODUCTES

Various methods, drying techniques and dryers are being used for drying of varieties of agricultural products under different drying conditions. Solar Drying conditions for different varieties of agricultural products are listed in the Table 1

Table 1: Initial and final moisture content and higher temperature of various agricultural products (Yanlai *et al.* 2011; Ramos, 2003 ; Tiwari, 2006),

Sl. No.	Variety of Agricultural Products	Initial Moisture Content (%)	Final Moisture Content (%)	Higher Allowable Temp. (^{0}c)
1	Apples	80	24	70
2	Apricot	85	18	65
3	Bananas	80-90	10-15	70
4	Brinjal	95	6	60
5	Black	80	4	65
6	Cauliflower	85	15	55
7	Corn	24-70	5-14	50-75
8	Coffee	80	5	--
9	Carrots	8-70	5-18	65-75
10	Cabbage	80	4-6	55-65
11	Chillies	80	5	65
12	Chips	24-95	7-11	50-60
13	Fig	80	15	70
14	Garlic	80	4	55
15	Grapes	70-80	15-20	65-70
16	Green beans	70	5	75
17	Green peas	80	5	65
18	Guavas	80	7	65
19	Ginger	71	13	--
20	Hot pepper	80	3	--
21	Maize	35	15	60
22	Oil seed	20-25	7-9	40-60
23	Okra	80	20	65
24	Onions	80-85	4-10	55
25	Paddy, row	22-24	11	50
26	Paddy	30-35	13	50
27	pineapples	80	10	65

28	Potatoes	20-75	13-16	45-75
29	Pulses	20-22	9-10	40-60
30	Pea	80	15-20	--
31	Pepper	35	15	60
32	Rice	24-75	7-11	50-55
33	Sweet potato	75-80	7-10	65-75
34	Tea	75	13	50
35	Tomatoes	80-96	5-10	60

PROCEDURE FOR SOLAR DRYING OF AGRICULTURAL PRODUCTS

Dried fruits, vegetables and agricultural products quality depend upon drying method, cleanliness and quality of fresh product use. Solar drying process involves various steps as mentioned in Figure 1 which is self-explanatory (Wakjira , 2010).

Fig.1: General procedures of solar drying of agricultural products.

TECHNIQUES FOR AGRICULTURAL PRODUCTS DRYING

Drying techniques are broadly classified into three categories includes solar drying, open sun drying and machine drying (Fig. 2). Open sun drying and solar drying techniques uses solar energy for drying. In the machine drying technique, either fuel or electricity is used. The choice of fuel depends on cost of fuel. The choice of drying technique depends upon type, size of product, type of energy source, and final quality required in dried products (Tiwari, 2006 ; Sagar and Kumar 2010).

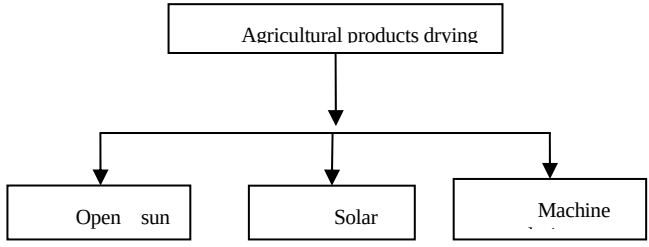

Fig. 2: Types of solar drying technique.

A. Open Sun Drying Technique

Open sun drying is the most widely used and simplest method of product drying in which the products are directly exposed to the solar radiation. The schematic view of open sun drying technique is shown in Figure 3. The rate of drying depends on number of external parameters (solar radiation, ambient temperature, wind velocity, and relative humidity) and internal parameters (initial moisture content). In this process free convection will take place. The circulation of air is caused due to the difference in temperature of the surface and atmospheric air. Considerable losses can occur during open sun drying due to various reasons such as contamination by foreign materials like dust, dirt, insects, insufficient drying and over drying as well as discolouring by ultra-violet radiation. Product dried in open sun drying does not meet the international quality standards and therefore it could not be sold in the international market. It is a free of cost technique but it requires large horizontal ground area (Szulmayer, 1971 ; Prasad, 2009 ; Togrul, 2005 ; Akpinar, 2004 ; Holman, 1992 ; Tiwari *et al*., 2006 ; Anwar, and Tiwari, 2000 ; Kumar *et al*.,2011).

B. Solar Drying Techniques

In the solar drying technique, different types of solar dryers are used. Solar dryer is a close unit and its operating cost is lower than machine drying. Solar dryer protects the agricultural products from unexpected rainfall, dust, animals, and insects. In the case of solar dryer, complete drying of agricultural products is possible due to faster rate of drying and higher drying temperature. Solar dryers save energy, time, occupies less area, and improves product quality. Agricultural products are dried in dryer fit for national and international quality standards with zero energy costs (Ogunkoya *et al*. 2011 ; Pangavhane and Sawhney, 2002).

The classification of solar dryer is shown in Figure 4. In passive dryer, a natural circulation is used to circulate air through the air collector to the product; solar heated air is circulated through the drying product by buoyancy forces as a result of wind pressure. But in active dryer, a fan or blower is used to circulate air through the air collector to the drying products. Therefore, active dryer requires other non- renewable energy sources such as electricity and fans for forced circulation of air, in addition to solar energy. The different classes belonging to both active and passive solar drying technique are explained below (Ogunkoya *et al*.,2011 ; Kassem *et al*. 2011).

1). Tunnel Dryer: The advantages of this dryer are simple, low cost fabrication, shorter drying period, and no energy cost. It is suitable for drying small quantities of

agricultural products. The solar tent dryer is made up of two parts. The upper part is a wooden frame with an inverted V-shaped top, covered with transparent polythene sheets. The bottom structure consists of a metal wire mesh fixed in a wooden frame on which a black plastic sheet is spread over which the products are placed for drying. The schematic diagram of tent solar dryer is shown in Figure 5 (Pangavhane and Sawhney 2002).

2). Greenhouse Dryer: A greenhouse is made of three main parts: the transparent cover, frame material and absorbing or soil surface. The transparent sheets are fixed on steel frame support with bolts, nuts, and rubber packing to prevent humid air leaking into chamber. The transparent (polyethylene, PVC, glass) film cover acts an interface between inside and outside climate. Greenhouse dryer leads to reduction of the drying time up to 50% as comparison to open sun drying. Air flows through bottom side by natural convection through the material and finally leaves through the air vent provided at the upper part of the greenhouse. Greenhouse dryer schematic diagram is shown in Figure 6. Greenhouse works on natural as well as forced convection modes (Tiwari *et al*. 2006; Berroug *et al*. 2011; Kamaruddin *et al*. 2001; Kamaruddin *et al*. 1999).

3). Cabinet Dryer: Cabinet dryer fabricates with a glass cover, drying chamber, an absorbing surface, wire mesh, wooden frames. The design of cabinet dryer is simple, and its cost is low. Ventilation holes in the base and upper parts of side walls maintained a natural air circulation. Agricultural product temperature rises due to absorption of solar radiation. The vapor formed due to evaporation, is taken away by the air entering into drying chamber box from below and leaving through another opening provided at the top side. It is suitable for drying small quantities of agricultural products. The schematic diagram of cabinet solar dryer is shown in Figure 7 (Medugu, 2010).

4). Mixed Or Hybrid Dryer: The hybrid dryer consists of solar collector and drying chamber having electric air heater. The purpose of hybrid dryer is to obtain higher drying rate of products. This dryer improves the quality of dried agricultural product by the controls of thermal drying condition. The wall of solar collector insulated with glass wool builds with metal plates and are painted with black colour. The solar chamber covers with glass. A chimney is installed on top of drying chamber for drying air exit and trays put inside the drying chamber. A sensor fits in the chimney to control outlet air flow temperature inside drying chamber. When solar radiation falls on glass cover, it heat up the inlet air by natural convection. Moisture removes from the products when hot air passes through the drying trays. This moist air goes through chimney as shown in Figure 8 (Mohanraj and Chandrasekar, 2009; Khan *et al.*2011; Gewali *et al.* 2005; Folaranmi, 2008 ; Ferreira *et al.*,2007).The comparison of various dryer is summarized in Table 2.

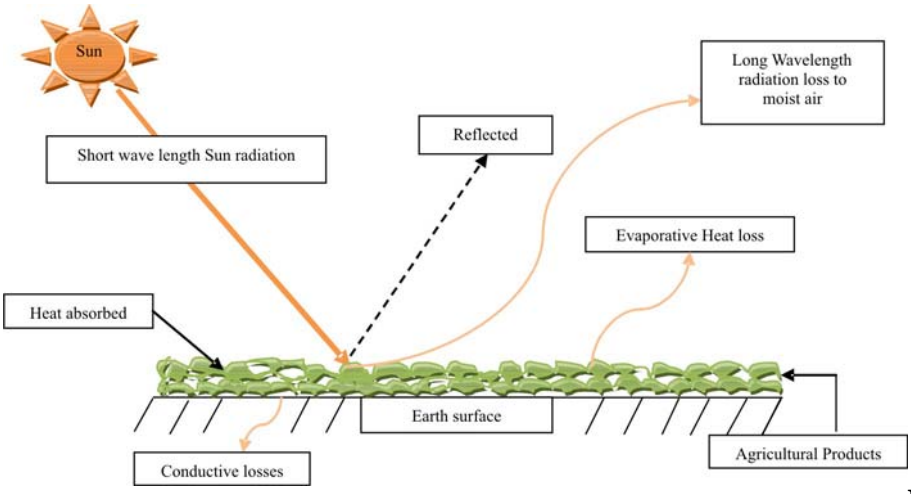

Fig. 3: Schematics of open sun drying technique.

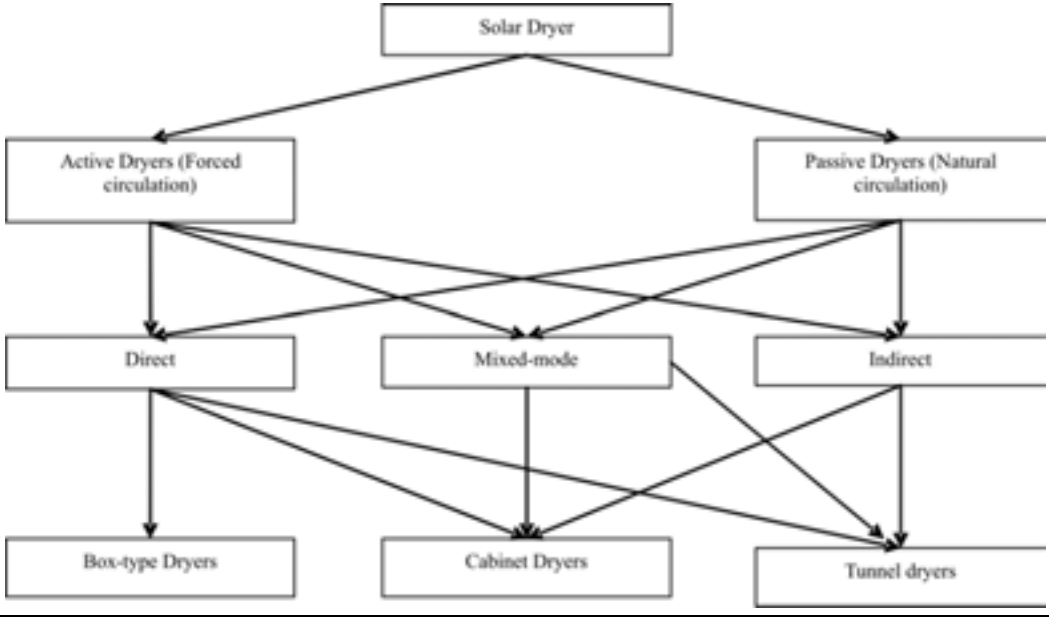

Fig. 4: Solar dryer classification.

C. Machine Drying Techniques

Machine drying technique is used in industries which dry the products with fast rate in comparison to open sun drying and solar drying technique. This technique allows better control over drying rate of agricultural products. Machine drying technique requires less land area and gives better product quality. This technique uses either fuel (oil, coal, gas) or electricity as the energy sources to heat up the incoming air. Fans or blowers are used to circulate air through the drying products (Farkas, 2011).

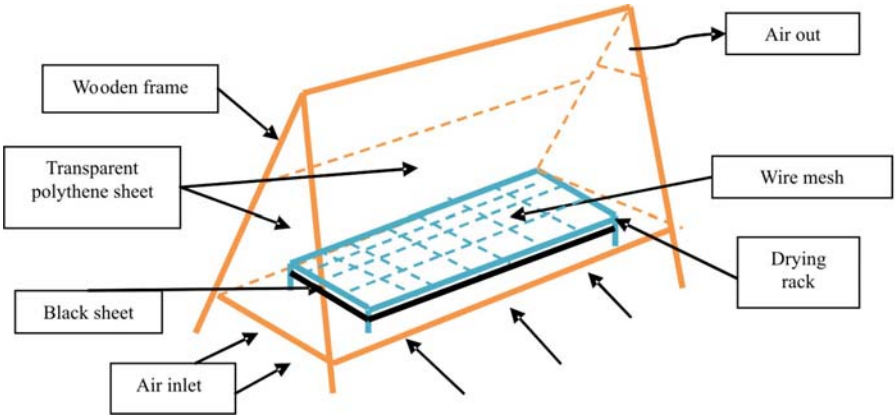

Fig. 5: Schematic view of a Tunnel dryer.

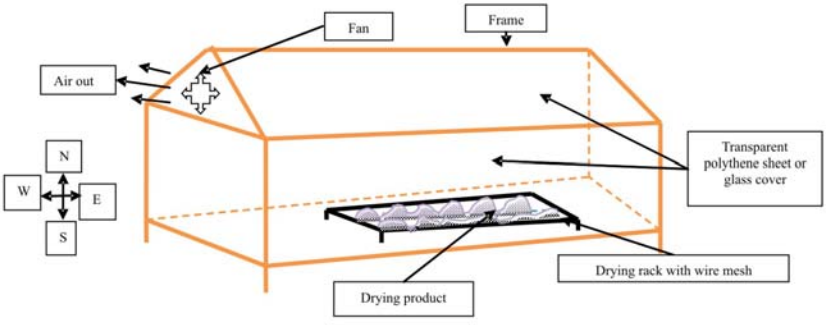

Fig. 6: Schematic view of Greenhouse dryer (forced type).

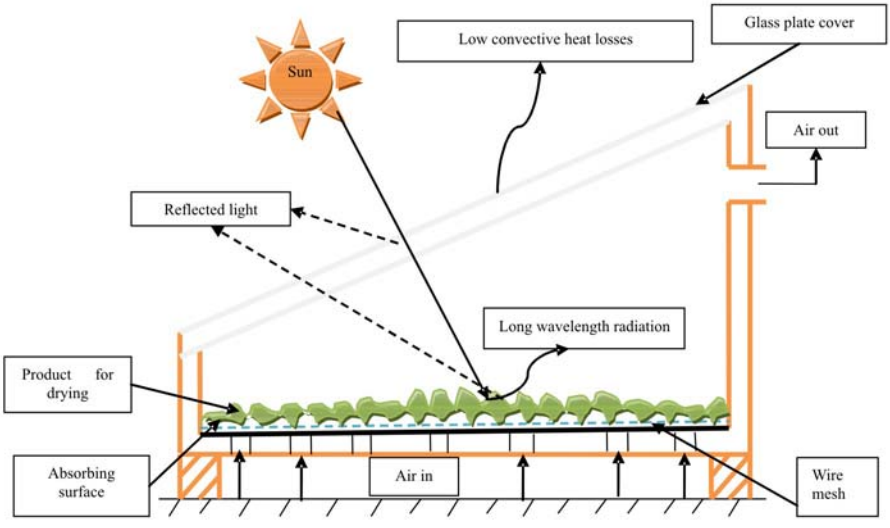

Fig. 7: Schematic view of a Cabinet dryer.

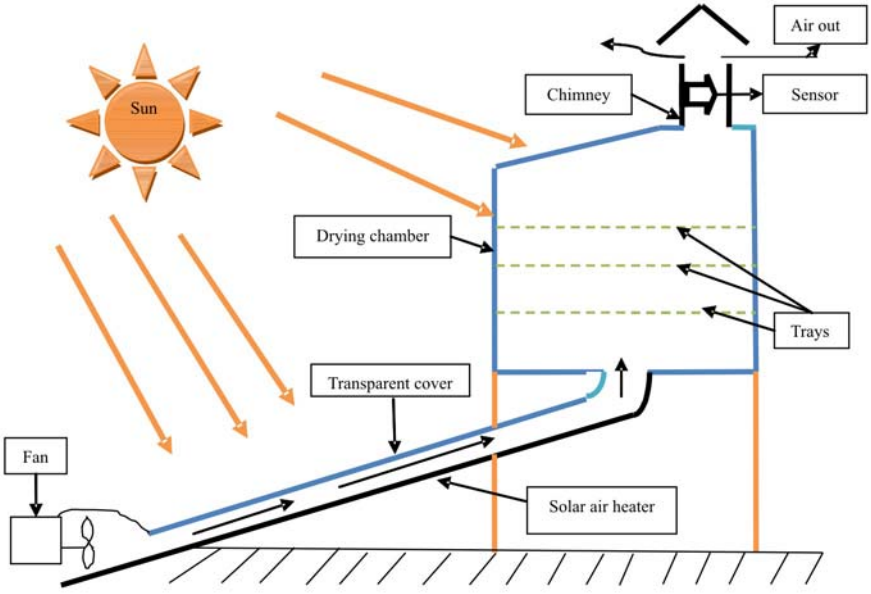

Fig. 8: Schematic view of a Mixed or hybrid solar dryer.

Table 2: Comparison of different types of solar dryer [20-32]

Sl. No.	Criterion for comparison	Tunnel dryer	Greenhouse dryer	Cabinet dryer	Hybrid dryer
1.	Modes of drying	Natural or forced convection	Natural or forced convection	Natural convection	Forced convection
2.	Capacity	10-15 Kg in one time	Depend on size	10-20 Kg in one time	Large capacity depend on size
3.	Materials used	Hard and softwood, transparent polythene sheet, wire mesh, drying rack, black sheet.	Aluminium or stainless steel or wooden frame, transparent polythene or glass sheet, wire mesh, fans, drying rack, black mat.	Wooden frame, transparent glass sheet, wire mesh.	Sensor, transparent glass sheet, aluminium metal sheet, chimney, fans and trays.
4.	Source of energy	Solar energy	Solar energy	Solar energy	Solar energy with electricity, oil, coal, gas use for heating.
5.	End users	Cooperatives, villages groups and families.	Farmers, cooperatives, nursery.	Group of women, individuals.	Industry.
6.	Products dried	Fish, fruits and vegetables chips.	Small size or	Small and medium size	Every type of agricultural products

			thickness agricultural products.	fruits and vegetables.	by controlling drying condition.
7.	Cost of drying	Zero or less cost.	Zero or less cost.	Less cost.	Higher cost.

PRESENT FOREIGN DRYING SITUATION

A large numbers of research on solar drying are under processing in all over world. The research and promotion of solar drying technology have been developed in many countries such as USA, France, Australia, Germany, Canada, Japan, New Zealand; Africa etc. These countries use various experimental devices for the testing of solar dryer and drying techniques under different conditions. In USA small size dryers are most popular for drying of various products (Yanlai *et al.,* 2011). In Thailand and Bangladesh different solar dryer for crop drying are being used (Bala and Janjap, 2009). In Nigeria different types of solar dryer such as chimney and cabinet dryer for drying of various agricultural products (Ogunkoya *et al.* , 2011 ; Medugu, 2010) are being used. In Indonesia, greenhouse is being used for drying of cocoa, coffee, chilli, berry, banana and wood etc. (Kamaruddin *et al.* , 2001; Kamaruddin *et al*., 1999). In China greenhouse dryer are being used for drying of fruits, vegetables, spices, vegetables and medicinal plants continue after 1980s. In Hungary integral solar energy for crop drying [22 [22] (Farkas, 2011) is being utilized. Solar crops drying are a good alternative for farmers in Kenya. They use different dryers for high air temperature and low relative humidity for the drying of crops (Ronah *et al*.,2010). In Malaysia forced convection solar dryer for drying of chilli and other agricultural products (Mohanraj and Chandrasekar, 2009) are used. In Iran mixed mode of solar dryer for rice drying (Zomorodian *et al*.,2007) are employed.

The price fluctuation of petroleum and coal requires alternative energy source. Therefore, solar energy is being used as alternative energy source. Under these circumstances, the application of solar drying technology should be adopted for the economic development of any nation.

CONCLUSION

This paper focuses upon solar dried products, drying processes/techniques, and solar dryers used for drying of various agricultural products. The use of solar dryers is economical, reduces the drying time, and improves the quality of product with zero pollution level. Solar dryers can be constructed very easily by the use of materials available in local market. India has to use these opportunities to minimize the loss of agricultural products by which multiple benefits can be achieved.

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Renewable Energy Issues in Germany

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ABSTRACT

The use of renewable energy resources has gained increasing importance in Germany in recent years. Its contribution to the total energy consumption has increased from 2000 to 2010 by two and a half times amounting to a share of some 11 percent. It is planned to increase this share to 18 percent by 2020. In 2010 the use of renewable energies has reduced CO_2 emissions by 12 percent.

Germany has several options to use renewable energy sources: Bio-energy, wind, solar energy, water energy and geo-thermal energy. The most important and most versatile renewable energy source is bio-mass. In 2010 some 71 percent of the renewable energy has been provided by different sources of bio-mass supplying an amount of 195 billion kilowatt hours. Bio-energy contributed 5.5 percent of the total electricity consumption, 8.7 percent of the total demand for heating and 5.8 percent of the total fuel consumption. The main sources of bio-energy are wood and wooden products. Agriculture also contributes to the energy market, mainly in the form of grains and garbage of biogenic origin for the production of bio-gas. Grains, seeds, sugar beet and ligno-cellulose biomass are used for the production of bio-ethanol and oil seeds for the production of bio-diesel.

Germany is one of the leading nations in the use of wind energy. Wind energy provided by inland and off-shore wind parks contributed in 2010 six percent of the national electricity consumption. It is planned that this sector will continuously grow.

The sector with the highest growth rate is solar energy. Installation of photovoltaic collectors has facilitated harnessing solar energy which accounts for two percent of the energy consumption. The production of energy out of water powered energy plants and tidal power plants contributes three percent of the total energy supply. Geo-thermal energy is yet to be tapped to an appreciable extent. The advantages of renewable energy can be summarized as: Reduction in the use of scarce resources, reduction of energy imports, less dependence on energy supplies from instable export countries, reduction of CO_2 emissions, employment creation, transferof knowhow to other countries, energy self-sufficiency and independence of villages and households from central power supply systems. The paper reviews the implications experienced in the promotion of renewable energy.

Key words: Renewable energy, biomass energy, wind energy, solar energy.

INTRODUCTION

The use of renewable energy resources has gained increasing importance in Germany in recent years. Its contribution to gross end energy consumption has increased from 2000 to 2010 by two and a half times amounting to a share of some 11 %. It is planned to increase this share to 18 % by 2020 and to 60 % by 2050 (BMU a, 2011, p. 6). By the end of 2011 renewable energies provided

122 bill kWh electricity amounting to 19.9 % of the electricity consumed. This is larger than the share of nuclear energy which contributed 17.6 % (AGEB b, 2012, p. 25).

Germany is one of the leading industrial nations of the world with the third highest energy consumption per capita. Its main energy sources were in 2011 mineral oil with 33.8 %, gas, 20.6 %, hard coal, 12.6 %, brown coal, 11.7 %, renewable energy 10.8 % and nuclear energy 8.8 % (AGEB a, 2012, p. 1.1). The share of nuclear energy had gradually been reduced during the last decade. As a result of the Renewable Energy Act of 2000 electricity production out of renewable energies has more than tripled since 1999 from 30 bill kWh to more than 110 bill kWh in 2010 (BMU c, 2012, p. 35).

Table 1 Consumption of primary energy by sources, Germany, 2011

Source	Bill kWh	Percent
Mineral oil	1,263.7	33.8
Natural gas	764.5	20.6
Hard coal	468.1	12.6
Brown coal	435.9	11.7
Renewable energy	402.5	10.8
Nuclear energy	328.3	8.8
Other sources	60.5	1.7
Total	3,723.5	100.0

Source: AGEB a, 2012, p. 1.1

Following the March 2011 Fukushima nuclear disaster the government has decided to permanently shut down eight of its reactors and pledged to close the remaining nine by 2022. This change of policy has significant consequences for the production and use of renewable energy sources and for the supply of industries and households with energy. In order to prevent potential power failures the government is intensifying its efforts to promote alternative energy sources.

To this effect it has reinforced the Renewable Energy Act in 2011 (BMJ, 2011). The Act guarantees producers of renewable energy fixed tariffs for environmentally friendly electricity varying between 17.94 and 24.43 €ct/kWh. This provision has led in 2010 to increases in the cost of electricity for private users by 2.3 €ct/kWh (BMU b, 2011, p. 39).

RENEWABLE ENERGY RESOURCES

Germany has several options to use renewable energy sources: Bio-energy, wind, solar energy, hydro energy and geo thermal energy. The most important and most versatile renewable energy source is bio-mass. In 2011 some 60.6 % of the whole end energy out of renewable energy sources have been provided by different sources of bio-mass amounting to 244.7 bill kWh (AGEB b, 2012, p. 31). Bio-mass energy contributed in 2010, 5.5 % of the total electricity consumption, 8.7 % of the total demand for heating and 5.8 % of the total fuel consumption (BMU a, 2011, p. 15). The main sources of bio-mass energy are wood and wooden products. Agriculture also contributes to the energy market, mainly in the form of grains and garbage of biogenic origin for the production of bio-gas. Solid, liquid and gaseous bio-mass produced 36.7 bill kWh electricity. It is planned to increase this share to 50 bill kWh by 2020. Grains, seeds, sugar beet and ligno-cellulose biomass are

used for the production of bio-ethanol and oil seeds for the production of bio-diesel. Energy generated out of bio-mass has, as compared to wind and solar energy, the advantage that it is not affected by the availability of wind and sun.

In order to reduce and eventually replace the use of fossil fuel two main types of bio fuel were introduced in Germany: Bio diesel and bio ethanol. Bio diesel is produced out of oil seeds, mainly rape and sun flower seeds. Some 75 % of bio fuel is biodiesel. Bio ethanol covers 24 % and is produced out of grains, seeds and sugar crops. In 2011 bio fuel provided 33.7 bill kWh, constituting 8.3 % of renewable energies.

Already in 2006 the government passed the Bio-Fuel-Quota Act according to which the mineral oil industry has to put into circulation fuel with a fixed percentage of bio fuel amounting in 2010 to 6.25 % of the total fuel consumption (BMJ, 2006). However, in 2010 the share of bio fuel related to the total fuel consumption was only 5.8 % of the legally fixed quota (BMU b, 2011, p. 45). Since early 2011 a new type of gasoline, called E-10, was introduced. It contains 90 % gasoline and 10 % ethanol and is 2 to 3 €ct/liter cheaper than normal petrol which contains 5 % ethanol. However, E-10 fuel is boycotted by many regular consumers who prefer to fill their tank with the more expensive super gasoline. The main reason for the reluctance to use E-10 fuel is the assumption that it may cause damage to the engine. Both government and the mineral oil industry have neglected to provide the customers with the necessary clarification.

Germany is one of the leading nations in the world in the use of wind energy and one of the major exporters of wind energy plants. In 2011 a total of 22,300 wind energy plants provided with 46.5 bill kWh 7.6 % of the national electricity consumption (AGEB b, 2012, p. 25). It is expected that this sector will continuously grow. Two large offshore wind parks with a capacity of 155 MW are currently in operation and the construction of further 29 wind parks has been approved. Their capacity would be equivalent to the capacity of 8 to 10 nuclear power plants. The generation of electricity out of wind energy is cheaper than that by photovoltaic sources.

In recent years bio-waste has become with 7 % of renewable energy consumption an important energy supplier. It comprises waste originating from plant and animal sources, created by households or enterprises and includes municipal waste, food waste, sewage and biodegradable plastics. Bio-waste excludes waste created by agriculture and forestry which is classified as bio-mass.

The energy sector with the highest growth rate is solar energy. In 2011 some 880 000 photovoltaic plants produced more 19.5 bill kWh electricity which is an increase of 67 % compared to 2010 (AGEB b, 2012, p. 25). They have a capacity of 25 bill kW at full solar radiation which is equivalent to the capacity of 18 nuclear plants, however, the power supply by solar energy is not stable since it depends on daytime and seasonal fluctuations.

The main reason for the rapid growth of solar energy is the strong support by the government. It has decreed that everyone who produces electricity on the basis of renewable energy is entitled to sell it to the national grid at a price fixed for 20 years.

Although Germany lies in the zone with a limited number of days with sunshine the installation of photovoltaic collectors has increased at a larger scale than expected. While the government had foreseen the installation of plants for the production of between 2,500 and 3,500 MW, in 2011 more than 7,500 MW were produced and delivered to the national grid so that at the end of 2011 photovoltaic plants with a capacity of 24,900 MW have been installed. It is planned to

establish by 2020 plants with a total of 34,000 MW. This implies a reduced increase rate, since until this time only 9,000 MW, will be installed, i.e. less than 1,000 MW annually.

While the promotion of photovoltaic was sensible in principle, it had led to an imbalance between the fast growth of photovoltaic energies and the economic and secure provision of energy in general. While one half of the renewable energy levy is invested in photovoltaic, only 3 % of the electricity produced originates from solar energy sources. The Ministry of Economics has recognized this situation and has suggested that it would be more reasonable and more economic to invest in wind parks (BMWI, 2012, p. 8).

Photovoltaic energy contributed in 2011 18.9 bill kWh amounting to 4.7 % of the total energy consumption (AGEB a, 2012 p. 34).

Table 2 Consumption of renewable energies by sources, Germany, 2011**Source**	**Bill kWh**	**Percent**
Bio-mass	244.7	60.6
Wind	46.4	11.5
Bio fuel	33.7	8.3
Bio-waste	28.2	7.0
Hydro power	19.4	4.8
Photovoltaic	18.9	4.7
Geo thermal	6.4	1.6
Solar thermal	5.6	1.4
Total	403.3	100.0

Source: AGEB b, 2012, p. 34

Solar thermal energy, also called concentrated solar power (CSP) refers to the collection of energy through parabolic troughs. It is mainly being used for heating purposes. In 2010 solar collectors were covering an area of 14 million square meters. They produced 5.6 bill kWh contributing 3.9 % of all renewable energy for heating purposes. In recent years the installation of power plants which provide warm water and heating has increased.

The production of **hydro energy** powered by hydroelectric power plants and tidal power plants contributed in 2011 one percent of the total energy supply and 4.8 % of the renewable energy supply. The installation of run-of-the-river power plants has been initiated, but is still in its infant stages.

Geo thermal energy has not yet been developed to a level that it can play an important role for energy generation. It amounts to 6.4 bill kWh, i.e. 4.4 % of the renewable energy used for heating. The Renewable Energy Act foresees the promotion of relevant research activities (AGEB b, 2012, p. 34).

The use of renewable energies:

The major part of renewable energies produced, i.e. 56 % is converted into electricity. In 2011 renewable energies produced more electricity than nuclear energy. The share of electricity out of renewable energy has doubled between 2005 and 2011 (Lichtblick, 2012).

In 2011 the electricity generated out of renewable sources and refunded through the Renewable Energy Act was on average still more expensive than that produced by fossil and nuclear sources (BMU b, 2011, p. 38).

The highest increase in renewable energy production was achieved by wind energy. In 2011 this increase was one quarter higher than in 2010 and amounted to 46.5 bill kWh electricity, i.e. some 7.6 % of the electricity produced. Bio genetic energy sources contributed 37.7 bill kWh, i.e. 6.0 % of the total electricity generated; photovoltaic sources 19.0 bill kWh, i.e. 3.1 % and hydro power energy sources 19.5 bill kWh, i.e. 3.2 % (AGEB b, 2012, p. 27).

Bio-energy is a major energy producer for heating purposes amounting in 2011 to 144.7 bill kWh. Some 92 % of the heating energy are produced out of bio-mass and bio-waste, while 5 % originate from geo thermal and 4 % from solar thermal sources (AGEB b, 2012, p. 34).

During the last few years "Lichtblick", the provider of electricity generated by renewable resources, and Volkswagen has started to install home power plants. These mini power stations supply buildings with heat and at the same time electricity for the public grid. A gas engine activates an electricity generator. The heat created by the engine is being used for heating and hot water, while the electricity is fed into the public grid. It is expected that the electricity will be collected in a virtual power station with a capacity of 2,000 MW, i.e. a capacity like two nuclear power plants (Lichtblick, 2012).

The use of renewable energy in the form of bio fuel amounted in 2010 to 5.8 % of the total fuel consumption. In 2010 the use of renewable energies had resulted into savings of fossil energy imports in the amount of 23.0 bill kWh and reduced costs of fossil energy imports amounting to 0.8 bill € (BMU b, 2011, p. 33).

IMPLICATIONS OF THE ENERGY CHANGE

The increased use of renewable energies finds the broad support of the general public and is supported by appropriate political decisions. Renewable energies have a wide range of advantages such as the reduction of nuclear energy, the protection of the environment, reduction of CO_2 emissions, reduction in the use of scarce resources, reduction of energy imports, less dependence on energy supplies from instable export countries, employment creation, export of technology and knowhow, creation energy self-sufficiency and independence from central power supply systems of enterprises, villages and households.

However, the generation of electricity, heat and fuel out of renewable energies is a complex process and not without difficulties. They can be summarized as follows:

Technical issues: The exceptional growth of renewable energy originating from several thousand wind wheels and solar panels as well as hundreds of small bio energy plants spread all over the country constitutes special challenges for the power grid and for energy storage. In order to reach the goal of 18 % of renewable energy consumption by 2020 it is essential to transport the energy created by off shore wind parks and by decentralized power plants to the industrial centers where energy is most needed. This requires the construction of a grid of some 3,500 kilometers high-tension lines, whereas during the last five years only 90 kilometers have been installed (Buhl, 2012). In early 2012 the German grid disposes of storage and pump storage power plants with a capacity of 10,000 MW. It is planned to raise the storage capacity to some 13,000 MW (BMWI, 2012, p. 1).

A major concern of the German public is the unresolved problem of storing highly radioactive nuclear waste. No solution has been found for the storage of several thousand tons of this dangerously toxic material with a half-life of more than half a million years.

Economic issues: The immediate economic advantages of the use of renewable energy are primary energy savings. They amounted in 2010 to 402.6 bill kWh equal to 6.7 bill €. Savings in imports of fossil energies were composed of 2.5 bill € for electricity, 3.3 bill € for heating and 0.8 bill € for traffic (BMU b, 2011, p. 33).

The promotion of solar energy is costly and has raised the electricity bills for consumers. In 2012 the price for the regular end user of electricity amounts to 25 to 26 €ct per kWh. According to the German Energy Agency it is expected that the application of the Renewable Energy Act and investments in infrastructure will lead to substantial increases in electricity costs. It has been estimated that the cost for grid construction and energy storage will result in an increase of electricity cost of 20 % by 2020 (Buhl, 2012). In 2011 the price of one kWh electricity for households amounted to 24.0 €ct which is composed of 14.0 €ct for production, transport and delivery, 3.8 €ct turnover tax, 2.3 €ct renewable energy fee, 2.0 €ct for electricity tax and 1.8 €ct for concession fees (BMU b, 2011, p. 39). Since then the levy for renewable energy has been increased to 3.53 €ct/kWh (BMWI, 2012, p. 8). This increase has further raised the prices for electricity at the household level. The share of taxes and government levies constitutes 45 % of the electricity costs for households.

As the cost of energy created through renewable energy is higher than that of other energy sources the difference in price is added to the cost of electricity the average consumer has to pay. In view of this development the government has taken fiscal measures to reduce the further expansion of the solar industry. At the end of February 2012 the cabinet passed a bill according to which the reimbursement for the electricity feed-in will be reduced by 30 %. Especially affected will be open space solar plants. Instead of 17.94 €ct per feed-in kWh they will receive only 13 €ct. The compensation for fed-in solar energy created on solar panels on house roofs will be reduced by 20 %, i.e. from 24.43 to 20.00 €ct. This decision is, however, strongly rebuked by the opposition that criticizes that Germany's leading role in solar energy will get lost and that the confidence in planning and investment in solar energy will suffer.

In order to avert negative consequences of the expected price increases the government has decided to exempt 570 industrial energy intensive enterprises such as steel industry, chemical industry and mechanical engineering plants from grid utilization fees (BMU b, 2011, p. 50). The reduction of the energy costs is meant to secure the competitive power of the enterprises concerned, facilitate the formation of new ventures and the creation of employment.

Renewable energies have become an important economic feature with lucrative growth rates. In 2010 some 27 bill € have been invested in renewable energy enterprises, the major part of it, some 77 % in solar energy and 10 % each in bio-mass and wind energy (BMU c, 2011, p. 33). It is expected that in the long run the economies of renewable energy will improve. Because of reduced investment costs and increasing petrol costs the government presumes that by 2025 there will be no more difference in costs between renewable and conventional energies (BMU b, 2011, p. 56).

Social issues: According to a recent survey 95.2 % of the German population concur that the use of renewable energy should be intensified and enlarged (AEE, 2012, p. 1). Two thirds of them welcome the expansion of renewable energy and are ready to pay an increased price for it (VKU,

2012, p. 16). This attitude is rather significant since electricity prices have increased since 2010 by ten percent. On the other hand critics have a rather reserved attitude towards renewable energy promotion saying that the average citizen has to pay the main burden of the energy change, both in the form of higher energy prices and the acceptance of necessary infrastructures (Buhl, 2012). Furthermore, there are between 600,000 and 800,000 households, i.e. more than one percent of all households that have been cut off the electricity supply because of their inability to pay their bills (Jalsovec, 2012).

The renewable energy sector is a growing factor for the creation of employment. In 2010 some 367,000 persons were employed in the renewable energy sector. Some 122,000 persons were employed in the production of bio-mass, 120,000 by the solar energy sector and 96,000 persons by the wind energy branch. The generation of renewable energy out of geo thermal sources and hydro power plants provided employment for 13,000 and 8,000 persons, respectively (BMU b, 2011, p. 36). It is envisaged that by 2030 500,000 persons will be employed in the renewable energy sector.

Environmental Issues: The general support for the increased use of renewable energy reaches its limits when it touches the immediate surroundings of affected population. The installation of inland wind parks has caused protests by people living in their immediate surroundings because of noise harassment and deterioration of the landscape and the environment. This attitude finds its expression in the term "nimby", i.e. not in my backyard. Protests against off shore wind parks originate from environmentalists who fear negative consequences for marine life and birds.

The increased use of bio-mass will require more intensive feedstock cultivation which in turn will have the following negative effects: loss of biodiversity as more set aside land is brought into production, increased demand for water as fast growing species are brought into production and destruction of the natural habitat. The intensification of land use on arable land, pastures and forestry will lead to increased CO_2 emissions. As the expected increased demand for renewable raw materials cannot be met with present day production methods it will encourage the production of energy crops on arable land and pasture which will no longer be available for food production. This may in turn lead to price increases in food and feed. On the other hand in certain regions energy crops may contribute to maintaining agricultural marginal land in production, which may help prevent floods and landslides.

An important consequence of the increased use of renewable energies is the reduction of CO_2 emissions. In 2010 greenhouse gas emission abatements amounted to 118 million tons of CO_2 equivalents, in the electricity sector 75 mill tons were avoided, in the heating sector 38 mill tons and in the fuel sector 5 mill tons. Without the use of renewable energies the emissions of green house gases would have been 12 % higher in 2010 (BMU b, 2011, p. 24). Even after the closure of eight nuclear plants and the substantial growth of the economy green gas house emissions have decreased by 2.4 % between 2010 and 2011.

CONCLUSION AND OUTLOOK

The issues concerning the support of renewable energies can be summarized as follows.

There is strong support from both government and the general public for renewable energies and a general apprehension about the depletion and loss of non-regenerative energy resources.

The unresolved problem of storing nuclear waste and the incident of Fukushima have created a country wide protest movement against nuclear power plants which in turn favors the desire for alternative energy sources.

The introduction of renewable energy mechanisms meets, however, some reservations among persons who are negatively affected by the increased cost of the new energy and by persons who deplore the transitional cost increases for consumers.

Measures should be taken to reduce the negative effects of increased feed stock cultivation.

The energy change and in particular the closing down of the eight nuclear plants were implemented rather expeditiously, yet it did not cause any impasse in energy supply. On the contrary, Germany has exported 6,000 GWh in 2011.

It is expected that with growing experience and more advanced technology current issues will be resolved and the economic efficiency of renewable energies will be improved.

+) Slight inaccuracies in figures quoted are due to the use of different official sources

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Conventional Energy Uses: Ethiopian Scenario

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ABSTRACT

In the 6 subchapters with question and answer, an approach is attempted to explain "conventional energy-use" taking the Ethiopian example. This contribution also tries to clarify some aspects of the role of education in the process of sustainable development. The needs and possibilities in the educational "curricula" of incorporating the topic "sustainable use of nature" has to be brought to the attention of school teachers and higher authorities in the Ministry of Education. Awareness of energy-use in Ethiopia is primordial for the society at whole and the educational system is crucial in opening the eyes of both youngsters and adults.

Key words: Conventional energy sources, Ethiopia , sustainability

INTRODUCTION

Is conventional energy-use a blessing or a curse? Does it help to carefully and sustainably treat the environment, or is it a matter of wastefulness and lack of planning for the future?

In many countries, especially African countries (foremost the Sahel countries), there is a lack of timber due to natural conditions and man-made interference into nature: there is a bottle-neck of firewood and charcoal supply for peasants as well as for urban households. Ethiopia, as another example, is hit by deforestation. The previous and actual Ethiopian Governments took, and take, measures to control wood-cutting, allowing only the cutting of small branches for household-needs, so that the tree can regenerate. Large-scale afforestation and terracing have been practiced traditionally and as recent innovation measures to prevent soil erosion.

"Modern " alternatives are kerosene or cylinder-gas. Theses alternative energy-supplies are imports from various countries. Gas could be obtained from endemic (non-nutritional) plants to supply a relatively small part of the population with basic energy-needs – needs that are growing daily in the context of rapid urbanization, but also due to the demands of people in rural areas who need dispensaries, schools, improved infrastructure and social institutions in order not to aggravate the push-factors of emigration to towns and to the capital city.

In the central part of this paper, I shall pose a number of questions that might stimulate more of a clarification of terms in general use, than of an analysis of realities behind these terms. "Conventional energy-use" here means "customary methods" of energy harnessing and use without outside development inputs.

Is Conventional Energy-Use "Traditional"?

We are coming round in a circle. So many terms refer to almost the same phenomenon! Whether "conventional", "customary" or "traditional", we have the same problem as with institutions which were installed long before any colonial, or, in the case of Ethiopia, antecedents of feudal laws (see Hinz. 2010).

They are either called "indigenous", "autochthonous" "customary", "traditional" in the context of "informal" conflict resolution but mostly set in opposition to the "modern". Conventional energy use is not necessarily "traditional" - this depends only on the time - span of the investigation, e.g. the "Malagasy " stove replaced other "systems" of traditional uses of stoves of various types made of clay or metal that were manufactured in West African countries – some imported as prototypes – like the "Madagaskar" stove propagated in the 1970s intended to spare the quantity of charcoal, or the "tekalign" stove in Ethiopia intended to use different agricultural coffee- or maize-residues instead of charcoal. New types of cooking-stoves came up after the introduction of aluminum for corrugated iron for roof covers and their by-products in the form of stoves .

From different sides, especially NGOs , concerning the "stove-landscape", came into play that you can hardly know what is "conventional", or "traditional". Conventional are all the devices in the household-energy-sector which have a certain "antiquity" of use. The clay-plate heatened from beneath has been replaced by an electric stove ("mitad"). Do we find a time-barrier between the introduction of the "mitad" on the basis of electricity? There are many topics which could be investigated through house-hold surveys. When did you introduce the electric "mitad" in your household? How many times did you have to exchange it, because it failed to function? How many times did your stove fail because of shortage of energy? Conventional use looks at contemporary harnessing and ways of using energy, describing actual situations, whereas "traditional use" wants to communicate something about the evolution of certain forms, their stability and eventual changes in the course of time.

All the stoves and other devices used in energy-transformation, especially for nutritional purposes, become – sooner or later – "conventional" – as the users don't ask anymore whether they have inherited them from their grandmother or remote ancestors. They simply ask about the costs in energy-supply, eventually also about the time – costs spent in front of an energy transforming device. "Do I spare money, do I spare time"? "In case of sparing time, do I have to invest additional labor?" "Can I afford to give more labor input to a certain undertaking, at the dispense of other important, e.g. family obligations?" A colleague in Mali commented when I presented a manually dynamo operated flashlight: C'est économique, mais fatigant". Here, the idea is to invest manual labor as compensation for electric devices, whereas the flash-light outcome might not be adequate with the humans energy invested.

Living "specimens" of indigenous" human beings are often discriminated and marginalized. But these "indigenous" people form internally well organized communities. Contact with the outside world is forced upon them by the outside world itself, and, as a rule, this contact is detrimental to them, both as communities and as individuals... (see: Tewelde Berhan Gebre Egziabher, 1996, in: The Movement for Collective Intellectual Rights: 26).

Is Conventional Energy-Use "Indigenous"?

The preferred stove in the countryside of Ethiopia is still the one with three stones to place a clay-pot on a small elevation, so as to push wooden sticks in between the stones. The fire is not lighted in any "traditional" way, but with the help of matches of local or imported production (e.g. Al-Mehdi, Match Makers or Scissors Safety Matches, produced in Ethiopia). Several other types of stoves made of clay or metal are in use in the countryside, mostly manufactured in Ethiopia with the exception of simple stoves distributed by NGOs of "improved cooking-stoves", like the "tekalign" - stove intended for the use of agricultural residues from coffee, maize instead of charcoal. Charcoal is still produced and sold in large quantities for the market.

A "big" long debated topic nowadays still is the question about the contribution of local indigenous or traditional knowledge to the world community of scientists. There are several questions linked with this topic: 1. Can indigenous knowledge already contribute to international scientific knowledge? 2. Is "indigenous" knowledge exploited in many ways, especially through pharmaceutical firms? 3. Is there any relation between "indigenous" energy-use and future possibilities of energy-sparing?

Is Conventional Energy-Use "Time -Consuming"?

- Yes, it is! If we consider the traditional measures and some ideas of modification of "traditional" stoves, one still has the problem of whom to place in the center of the duty. In the case of the modified "tekalign"-stove, which was used for some time for soap production, women were the producers. This is positive in so far as women from the streets got a regular (very small) income and could enhance their self-esteem.

Women are fetching water, collecting firewood, growing spices in nearby gardens and finally cooking for the family, caring for the children and washing, looking after the animals once they are driven home – among many other duties.

The "traditional" methods are extremely time consuming if one includes the fetching of water and the collection of firewood, including all these "preparatory" measures in the cooking process. Responsible for these processes are the women. These everyday duties are so time consuming that women have to stop school attendance, early marriage ensues, and women are trained to care for the "time-consuming" household and for the next generation.

Unfortunately, until now, no exact figures are given for the workload of women compared to men in the various ethnic groups of Ethiopia. What can be read out of the sparse account is that woman have a workload of 16 hours from 6 a.m. to 10 p.m., whereas men work only 8 hours (industrial workers) or farmers from 6 a.m. to 4 p.m. (with a break – the wife or children are supposed to bring a meal to the field).

There are many good ideas to alleviate the cooking process, but these are mostly not considering the preparation. The " tekalign" stove, e.g. needs the filling process: the result is time-and-money-sparing, but the filling is time-consuming. One could, of-course, separate the duty of the filler from that of the user, which might provide additional jobs. Nowadays, one can buy a pressed charcoal-block for cooking at the price of 3 Birr, which corresponds to 13 € cents. It has a weight of 650 gr., a diameter of 12 cm, height 8 cm, 19 cylindrical holes; the combustion time is around 3 hours. This cooking device is more and more accepted in Ethiopian towns, but here we need to compare average salaries with the price of the (external) producer: a wage laborer earns

some 500 Birr a month, a private guard 400 Birr, a female household-keeper 600 Birr, a policeman 650 Birr (oral communication), and an Addis Ababa beggar gets 6 Birr per day on the average....As mentioned above, with the rapid urbanization of Ethiopia, the "traditional" clay-plate staple-food on the basis of teff -

– an endemic cereal only cultivated in highland Ethiopia – is more and more replaced, in urban areas, by an electric " stove fulfilling the same purpose. In addition, there is an enormous need of energy-supply. The possibility of biogas like in India, China and some West-African countries has not yet been considered on a larger scale in Ethiopia.

Is Conventional-Energy-Use a Waste of Energy?

All the "traditional" stoves in use, from the simplest one to the electric "mitad" are wasters of energy! They deliver more energy to the surroundings than they consume for their proper business – which is food – or any other relevant preparation for the family. Unfortunately – not like in the case of West Africa, these in- and outputs in energy have not yet been studied accurately. This would need a close collaboration of engineers, technical scientists and anthropologists. We can only assume that a lot of household-energy is absorbed by the atmosphere.

One mitad-constructor had the idea of reusing the heat developed by this electric oven (project proposal to the Department of Electrical Engineering). As mentioned above, the improvements through biogas and solar energy are in their infancy in Ethiopia.

All of the questions posed so far concerning a "Waste of Energy" have to be answered positively: yes, they are a waste of energy! Beginning with the wood-consumption, charcoal-consumption, destruction of the atmosphere, destruction of the natural surroundings, it all means a waste of energy.

Is Conventional Energy-Use "Sustainable"?

It is not possible to change the attitudes of peasants or pastoralists from one day to the other. These groups of people need inputs from their nation-states to find alternatives, but not directed from above, rather developed in close contact with the concerned people and their aspirations.

The sustainability-concept came up in 18th century in Europe to designate the replacement of cut trees by new plantations. Originally this concept was bound to aspects of nature. Nowadays, we attribute it as well to nature as to culture: How much do we influence the destruction of nature, to which extent do human beings in small or global scale destroy the survival on the planet earth? I am here concentrating on Conventional Energy-Use in Ethiopia. There are a few possibilities of sparing, especially for rural regions, but this will not solve the problem.

Can the Sustainability Concept Become Part of an Educational Project?

As far asI am I concerned, I would like to enumerate what should be done in schools to educate the young people towards an understanding of:

- of their environment,
- The conservation and protection of their environment,
- The history of their region,
- The changes (observation!) going on.

- How can the teacher introduce a topic like "Sustainability" in his/her teaching?
- The teacher has first to introduce the "sustainability-concept" in history and actual meaning.
- He/she then has to explain the effects of human intervention in the surrounding nature (cutting of wood). What could be sparing alternatives?
- Special attention should be given to the role of women in the conservation of the surroundings and in the careful use of all the energetic sources available.

Here we have to differentiate between the "sustainability" concepts of various types of surface uses. We have to differentiate between the integrative link of indigenous knowledge in the education of pastoral people (Oganda Ogachi. 2011), Adult's Learning (Rogers. 1992), Children's Learning (Holden and Clough 2003) and, of course, the peasents' education in developing countries, described in the literature with many different approaches (Sjoström and Sjoström. 1983).

The teachers should include the "sustainability"-concept in their history teaching and into all the other disciplines related to geography and sociology. As in the early times of pedagogy, one should start the teaching method with a narrow span of individual experiences of the youngsters, complemented day by day by the enlarging of the experiences, taking the class to forests, shrubs, rivers, bare places etc.. Let them discover their world by gradually discovering their surroundings ! (Benzing, 2011).

CONCLUSION

The question of "traditional" forms of energy-use remains relevant in urban and rural areas of Ethiopia. Different types of "traditional" stoves remain in use. Even if "improved", the "traditional" stoves are not bringing relevant solutions to the countrywide energy problems.

Biogas is still not adequately disseminated in Ethiopia, though, according to the Indian and Chinese examples, one could provide not only households, but hospitals and military stations with this kind of technology. Improved oil- and gas-use does not solve the problem. On a larger scale, only water energy through the erection of big dams may bring the solution and wind- and solar energy (not yet sufficiently tackled) could be of use additionally.

One of my conclusions is to bring together the sustainable aspects of traditional ways and modern forms of harnessing energy in a smooth, coordinated way.

The other issue is to bring sustainability into the urbanizing process, without neglecting the small-scale "players".

Education could play a major role to connect large-scale sustainability aspects and small-scale projects.

In elementary schools, the basics of use of energetical possibilities should be taught with experiments and demonstrations, followed by more analytical steps on the secondary level.

On University level we need more M.A. or B.A. works on the workload of women in the different regions, on their daily agenda, on women's specific conception of the environment, in short the daily work schedule, as comparatively investigated in many West African ethnic groups and countries.

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Ethiopia's Changing Energy Paradigm Under Historical Perspectives

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ABSTRACT

Culture thus become primarily a mechanism for harnessing energy and of putting it to work in the service of man, and secondly, of channeling and regulating his behavior not directly concerned with subsistence and offense and defense. Social systems are therefore determined by technological systems, and philosophies and the arts as it is defined by technology and refracted by social systems. The substitution of manual and animal labor by devices generating energy enabled agricultural societies to leave behind their fate embedded in a subsistence economy. This paper deals with changing energy paradigm in Ethiopia under historical perspectives.

Key words : Energy, Ethiopia, hydro power ,

INTRODUCTION

There are many factors attributing to the poverty and economic backwardness of nations. Nevertheless, especially the invention of James Watt in 1769 and further inventions of generating energy from fossil energy and its availability became a key factor determining the economic and social progress of nations. In other words, the substitution of manual and animal labor by devices generating energy enabled agricultural societies to leave behind their fate embedded in a subsistence economy.

Culture thus become primarily a mechanism for harnessing energy and of putting it to work in the service of man, and secondly, of channeling and regulating his behavior not directly concerned with subsistence and offense and defense. Social systems are therefore determined by technological systems, and philosophies and the arts as it is defined by technology and refracted by social systems (White, 1959)

In analyzing societies in historical perspective considering the availability and magnitude of energy supply, an understanding of the socioeconomic condition of a nation is possible. In fact, in our modern world, the price of energy in its various forms - especially the price of crude oil on the world market has become a clear indication of economic growth or recession at a global scale. Extreme fluctuations of the price of crude oil have become an important issue during evening TV-news. It was the Club of Rome, an independent and non-commercial organization which for the first time alerted the world by its report "The Limits of Growth", published in 1972 and since then has triggered more and more publications leading to a new discourse of how to challenge population growth, climate change in the face of decreasing availability of energy at a global scale. As a result apart from the classical energy sources derived from combustion of oil, research have

been put in place to make efficient use of alternative energy sources like solar and wind. This paper deals with changing energy paradigm in Ethiopia under historical perspectives.

HISTORICAL BACKGROUND

Ethiopia, since the end of World War II has experienced in a span 60 years three economic systems: feudal, socialist and free-economy, which each on its own has contributed to the socio-economic status of Ethiopia now prevailing. A great portion of the Ethiopian society has experienced in its own life theses periods with different affiliations, but mostly to the socialist one. But a common denominator for the majority today is the belief that ideology should play a lesser role in combating poverty. By the end of 1990 issues related to the Federal System which was adopted by the EPRDF or questions revolving around development and overcoming poverty dominated the debate. The Ethiopian Diaspora began returning home benefiting from the government's inherited policy under which every Ethiopian was eligible for a piece of land to build his residence. For the first time in Ethiopian history private banks were established which now provide loans leading to an unexpected boom in real estate. The thousands of very small enterprises producing furniture, doors and windows, cupboards, gates, kitchen equipments which are seen alongside roads, but also restaurants and big companies were frustrated by the fallout of electricity sometimes for days. The ever expanding capital city of Addis Ababa and its increasing population every day in search of work led to a collapse with economic consequences for those relying on electricity. For many Ethiopians it became evident that electricity in a modern world, especially in one of the fastest growing cites in the world((TheDailyBeast: World's Fastest Growing Cities) determines the economic potential of a country. Banks, government institutions now computerized had to give excuses for not processing people's applications because of electricity fallouts. Still Ethiopia was suffering with lingering small output of energy for private households, let alone meeting the demand of the industry. Newspaper announced schedules in the capital city Addis Ababa announcing which part of the town and at what time it will get electricity.

GDP tells only half the truth

Though GDP per capita can be taken as a clear indication of a society's economic status ,energy consumption in relation to GDP can additionally show the magnitude of economic stagnation in the case of Ethiopia. Before setting GDP in relation to energy consumption let us see the correlated figures between GDP and population size of three neighboring countries – Egypt, Ethiopia and Sudan depicted in Fig. 01. Ethiopia with a population of 93,8 million has a GDP of 18,81 % of Egypts's GDP. With 34,2 million inhabitants Sudan produces approximately the same GDP like Ethiopia with 93,8 million which can be explained with the oil fields discovered in the Sudan. But when we compare the consumption of energy between these three countries and divide the GDP by the amount of the available energy one can get an index for further elaboration to study poverty or economic levels of nations under energy perspectives.

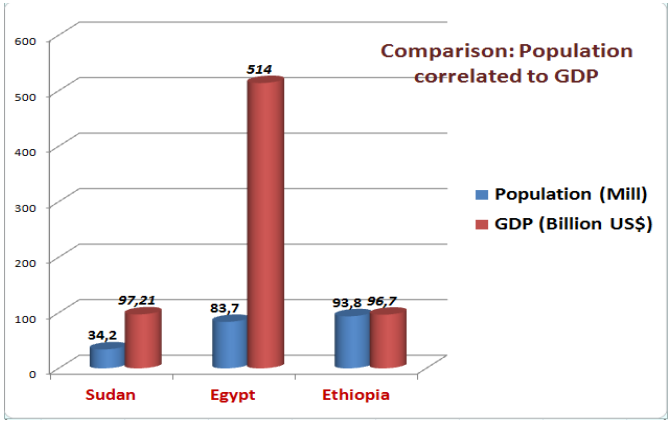

Figure. 01. Population Correlated to GDP

But first let us see the energy amount of 4 countries – Ethiopia, Kenya, Sudan and Egypt (Fig.02) which gives somehow an account of their economic streghth, only taking volume of generated energy as a criterion. Ethiopia with a population of 93,8 million is consuming approx. 2,9 % of the energy that Egypt has at its disposition, a figure indicating the intensity of poverty attributed by the lack of energy. In fact the situation of Sudan is similar with less intensity because of their population size.

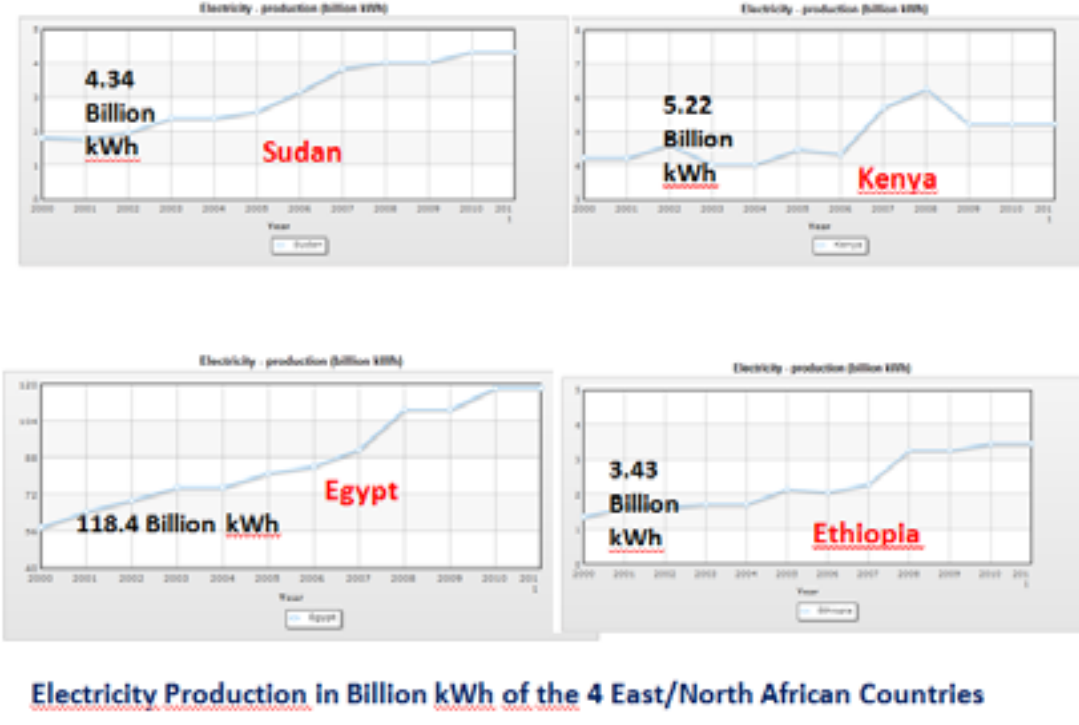

Figure. 02. Electricty Production in sudan, Kenya, Egypt and Ethiopia

But the figures resulting from the ration GDP/kWBillion for the three countries –Egypt, Ethiopia, sudan (Fig.03) reveals a fact for further thoughts to define the "hidden energy" allowing the ratio to raise.

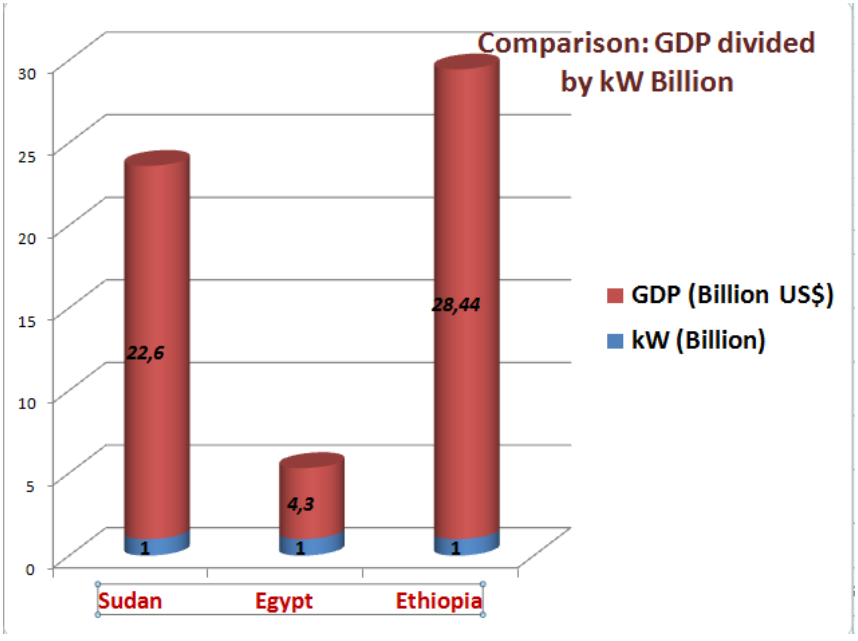

Figure. 03. GDP / Energy Ratio

The ratios show that Ethiopia with one Billion available kW produces 6, 5 time as much GPD (28,44) as Egypt (4,3) . This is also true for Sudan which per unit of energy produces 5 times more GDP than that of Egypt. This does not show efficiency but the "hidden manual labor and animal force" are not included in the contribution to the national GDP.

The only explanation for the higher ratio for Ethiopia and Sudan is that the human power and force supplied by animals used for ploughing, harvesting, threshing, transportation etc are not considered in the overall calculation of the energy estimate. Still in Ethiopia agricultural processing like threshing, ploughing and most activities related to plantation and their care are done manually. Also transport of cereals and consumer goods are carried by donkeys and mules that all in the final end contribute to the GDP.

The Average power per capita (watts per person (Wikipedia: List of countries by electricity consumption) with 5 watts per person: Ethiopia ranges among the lowest sharing similar ratio like, Sierra Leone 1, Haiti 4, Central African Republic 4, Madagaskar 5, for comparison USA 1363, European Union 609, China 389, India 107, Republic of Congo 17, the highest index in Africa being South Africa with 416 watts per person. Electrcity consumption per capita in Ethiopia was 46 kWh in 2009 (Fig.04) which is very much lower than Egypt and India.

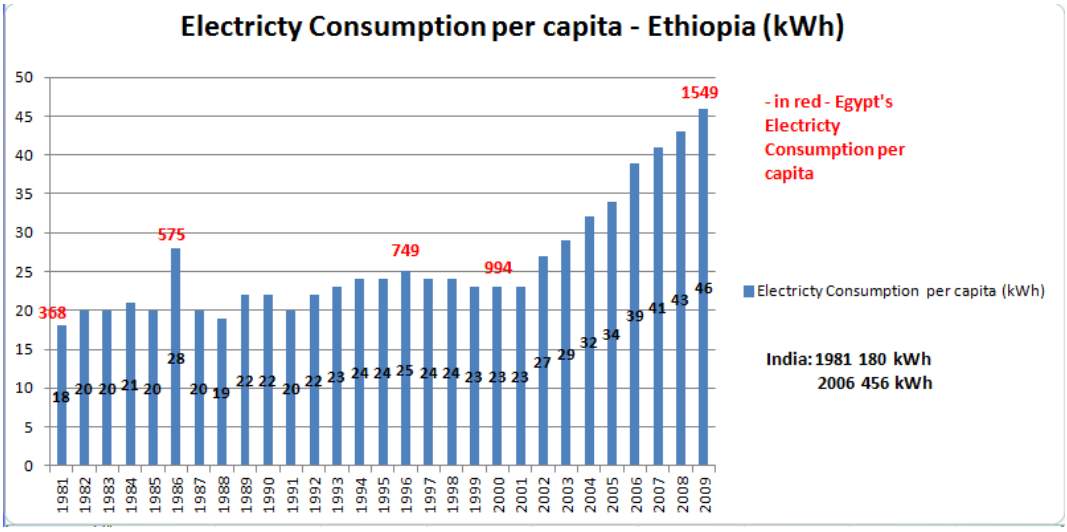

Figure 04. Consumption per Capita 1981 - 2009

For a country with over 93 (CIA - The World Fact Book.) million of inhabitants this number clearly shows that only through an accelerated increase of energy wealth can be created and that unless this energy crisis is solved, subsistence economy will prevail like the past decades and centuries.

Figure 05 gives us a final glimpse on the labor force((Index mundi. http://www.indexmundi.com/africa.html).With 85 % of the labor force in the agricultural sector in Ethiopia it exceeds the number in Egypt being only 14 % and in Sudan 44 %. From these numbers it can be deduced that in the coming years and decades urbanization in Ethiopia which at present is 17 %, but increasing urbanization rate of 4% yearly, will grow rapidly demanding high amount of energy.

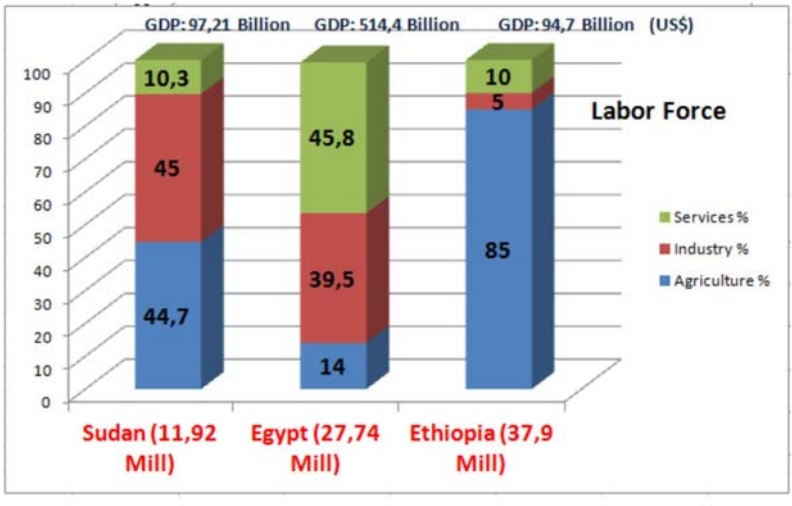

Figure 05. Labor Force in Sudan, Egypt and Ethiopia

When we compare the labor force of Sudan, Ethiopia and Egypt it becomes clear that most of the GDP is produced by the agricultural sector in Ethiopia where 85 % of the existing labor force is engaged. For Egypt only 14 % of labor force is to be found in the agricultural sector, whereby 39 % is in the service sector indicating the highly developed tourism industry there.

Energy Generation in Ethiopia

Let us now have a look at the rate of increase and quantity of electrical generation in Ethiopia until 2009 clearly showing a paradigm in the availability of energy.

It began with 6 MW power generation and ends in a huge dam (Millennium dam) under construction (Millennium dam. http://grandmillenniumdam.net/) with 6000 MW overshadowing all dams in quantity, a dam fully financed by the Ethiopian Government and with great financial participation of the people. It is considered as a national project for which every individual Ethiopian is called upon to contribute. The Great Millennium Dam will provide Ethiopia with more electricity and is expected, with the already constructed dams, to have a positive impact on the ongoing transformational policy's implementation. In fact the deepening energy crisis not only would have hindered a sustainable economic development, but would have worsened the fate of the fast increasing number of the Ethiopian population. Now, through the sale of electric power to neighboring countries, already so to Djibouti, and planned supplies to Kenya and South Sudan the Ethiopian Government can rely on a regular input of monetary resources to partially cover its budget rather than borrowing. Further, Ethiopia has attracted many investors from countries like China(Ethiopia's partnership with China , 2011)India (India Investment In Ethiopia) Turkey (Turkish Business Delegation to Visit Ethiopia) , Saudi Arabia (Saudi Billionaire's Company) and Egypt (Egypt's Assets in Ethiopia) to mention some few countries in the industrial, mining and agricultural sector. Alone in 2012 30 % more tourists have visited Ethiopia. This development would have been impossible without a steady growth of energy production, energy which is still cheap in Ethiopia but becoming increasingly expensive in the world and being reflected in rising commodity prices.

The reliance on wood for cooking rather than electricity for a population of over 93 million has led to a deforestation intensity leaving Ethiopia with 4% covered area with trees in the 1980s. Figure 06 shows the accumulated destruction since the 1930s in the light of stagnant energy production and growing population, a vicious circle which provokes soil erosion, food insecurity and poverty.

Between 1953 and 1990 (Fig.06) the increase of hydro power generation was slow in a country with 3 % of population growth. In 1984 the population of Ethiopia was 42 million, increasing to 93 million in 2012. In 1990 the power generated in Ethiopia was 343 MW which could have by no means reached the population of 51,7 million by then. Firewood is until today amounting to 90 %, the main source for Ethiopians used for cooking.

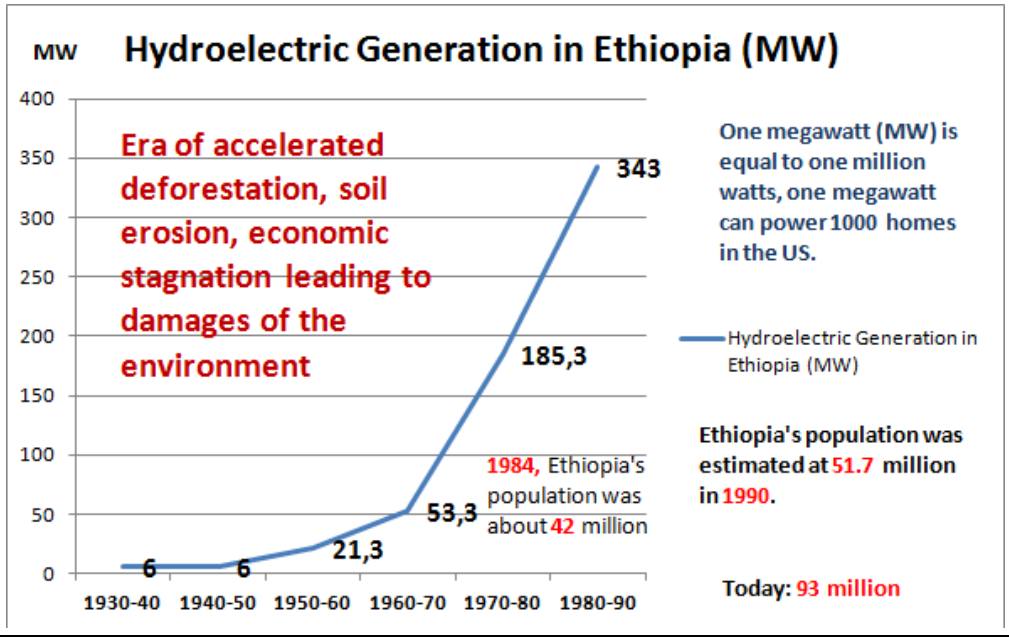

Figure 06. Hydroelectric Generation in Ethiopia

Its impact on the environment was catastrophic – accelerated deforestation resulting in the forest coverage decreasing from 40 % in the forties to 4 % in the nineties. The radical measure taken by the socialist oriented government to stop the uncontrolled cutting of trees by monopolizing the trading of wood and charcoal was a measure taken out of despair. Tree cuttings by individuals, even in one's garden needed permission. With afforestation programs the government tried to regulate the trade in a sustainable way. It also introduced small stove from China which used kerosene still existing and being used. The present government has continued supplying customers with kerosene sold at gasoline stations throughout the country. The use of firewood and charcoal is still used not only in low income households but also in middle income households, the reason being the scarcity of electricity but also its price. Interestingly 50 % of the firewood used in households is used to bake the traditional Ethiopian bread *injera* which consumes a huge amount of energy. The baking procedure needs for every single bread an opening of the stove and preparing it for the next one, by that time energy is dissipated. Most NGOs dealing with alternative energy in Ethiopia were concerned about how to efficiently use firewood. The method was developing a closed stove instead of three stones which causes a huge energy loss.

What alternatives did Ethiopia have?

In 2010, when Somalia was hardly striken by drought and hundred thousands of people were affected again under the guise of hunger in East Africa pictures taken in Ethiopa decades ago were being shown, though this time Ethiopia was partly affected but had enough food reserves for her people. On the other hand when it comes to the energy production estimated having a very high potential for producing hydro power no advocacy was voiced and Ethiopia's rights was relinquished favoring Egypt. As shown earlier the total annual production of hydro-power in

1990 was 343, but when comapred to 45.000 MG which Ethiopia could produce the whole thing becomes a riddle. But first let us see what the geological and climate conditions are which allows the prediction of such amount of electricity to be possibly generated. As Figure 07 shows between, between July and October a huge amount of water from the rainfall in the Ethiopian Highlands flow into the Nile from the River of Abara, the Arab call the Black Nile and the Blue Nile which Ethiopian call Abbay contributing all in all to 85 % of the Nile water reaching Egypt.

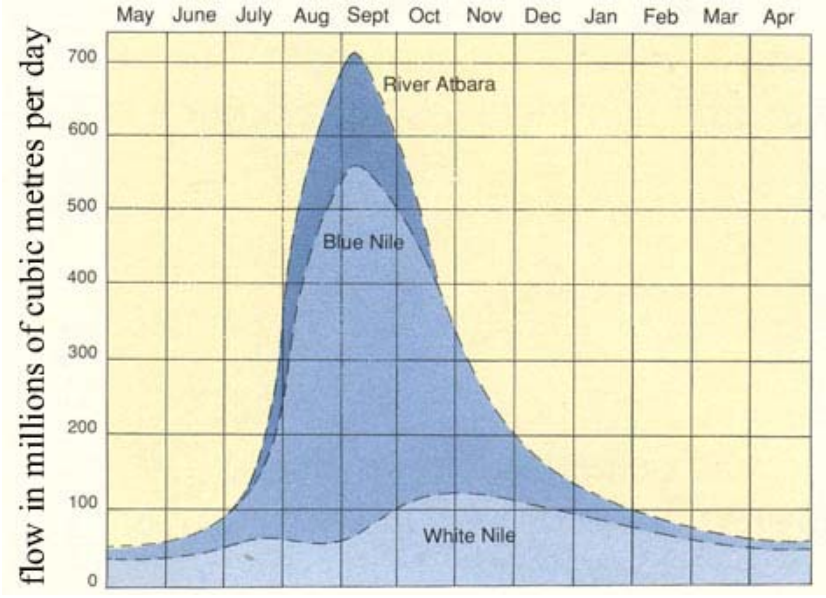

Figure 07. Rainfall Distribution in Ethiopia

The reason why such amount of rain fall in Northern Ethiopia during what is called the African Monsoon is because of the high mountain forcing the water evaporated from oceans and seas and being carried as clouds to condense. Geographically Ethiopia can be divided into 4 parts: Western Highland with mountains ranging up to 4000 meters wher annually high rainfall is registered as shown above. Western Lowland, region towards the border of Sudan with heights around 1000 m above sea level where it is too hot for dense population. The Eastern Highland is similar to the Western Highland but samller in size. Then we have the Eastern Lowland which is mostly desert. In between is the rift Valley which is wide in the North and flat and becoming narrow passing through Ethiopia, where rain water flows from the mountains into rivers partly to strand before reaching the Red Sea due to extreme evaporation.

Ethiopia has the highest number of rivers in Africa and their pecularity lies that especially in the Northern Highland of their cascading types flowing through rugged mountains considered to be the biggest in the world and having the potential of 45000 MW hydro power generation.

The Ethiopian Highland is also considered for hydro power generation to be a place where it is relatively cheaper to develop than in the whole of East Africa. According to a study made in the 1960ies 33 projects were identified as feasible. The only project implemented was the dam construction at Fincha with 100 MW completed in 1973 giving Ethiopia a small relief. Many other

projects are either being implemented or will be implemented in future depending upon support from international financial institutions.

CONCLUSION

After years of economic stagnation and at the forefront of nations suffering from the Cold War, Ethiopia's economy is now at growing at an astonishing rate. Though still combatting poverty more and more Ethiopians are getting employment, last but not least through a focus excersized by the government on the youth and peasants. By exporting electricty to neigbhoring countries to Djibouti, Kenya, Sudan and Egypt both Ethiopia and the recipients will profit by getting affordable energy in a world of soaring energy prices. As a consequence the gradual integration of the three countries, Egypt with her industrial potential, Sudan with available agricultural area and Ethiopia as a supplier for energy could successfully become prosperous in combatting food insecurity in a world endangered by climate change. Globalization and over population triggered pressure on these countries will force them to develop economic joint regional rationality rather than rationality based on national interest. And hopefully the Nile as an international water will - equitably distributed and managed - will revive the glory of the past and even become a model for integrating economies in Africa.

Electricity is common among city dwellers, but not so in the rural area, but for most of them with lower income electricty is only known as light and not as an energy source for cooking. Because of the restrictions regarding biomass in appartments owned by mostly young people coming from traditional households, they are forced to abandon the use of firewood and resort to the use of electricty. When paying their electricity bills customers can buy for a reasonable price three low consumption bulbs at a cheap price. But the fact remains that in many households, even with medium or high income, due to the high price for electricty, charcoal and firewood are still used and it remains to be seen when city dwellers shift increasingly to electricity giving relief and enabling ecological recovery. Indeed, the forest area is already grown and now has already reached according to the latest statistics 13 %. Ethiopia's urbanization which is 17 % now is growing by 4 % annually requiring electricity for the suburbs already being built. The increase of energy production in Ethiopia is vital also for the industry which needs e.g. cement production for the booming construction, textile industry for processing incountry growing cotton and also for the mining sector. As water is referred to life, energy can be considered as the soul for development.

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Need of Connecting Bio-Energy and Organic Input with Value Addition for Sustaining Eco-Friendly Growth of Agriculture and Rural Development in India

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ABSTRACT

The availability of unabated supply of power/energy remains elusive in remote rural areas of India. However, the availability of large live-stock population through producing huge amount of cowdung and in turn generating cowdung based bio-energy could play a critical role in achieving energy security in rural India. Currently about 1800 million tonnes of cow dung available in the country could generate around 120 million M^3 biogas per day, even if two third of it is utilized for biogas production. It is also expected to produce around 2.9 MT nitrogen, 2.75 MT phosphorous and 1.89 MT potash to support organic farming and in turn improved human and soil health as well as environment. The use of proper biofilters (reactors with iron mesh), slurry concentration (1:9; cowdung: water), additives and other techniques described in this manuscript could reduce the large HRT (Hydraulic retention time) and enhance biogas production remarkably. The other sources of organics (Night soil, poultry litter, municipal waste etc) and their utilization in the production of biogas and organic manure can also supplement the renewable energy and organic movement in the country. The most appropriate opportunity could be to reduce the dependency to some extent on chemical fertilizers, restricting GHG generating sources and expands the carbon sink within system to mitigate impact of climate change on agriculture. Thus, there is a need to encourage R&D institutions to develop frame work to monitor and measure carbon sink and generate carbon fund to finance the rural sector. The cowdung based gas companies should be encouraged to harness the potential of generating, cleaning and bottling of biogas to meet the multifarious needs of rural India. Thus, there is a need to pay sincere attention and concerted efforts to develop biogas based sources of energy and quality organic manure with multiple objectives for sustaining agriculture development, good soil and human health and better environment. This paper is aimed at to discuss the issues and problems associated with biogas based renewable sources of energy, quoted some success stories in this area and suggested technological and operational interventions for enhancing bio-energy and organic input with value addition for sustaining ecofriendly growth of agriculture and rural development in India.

Key words: Bio-Energy, organic input, value addition

INTRODUCTION

India's substantial and sustained economic growth, increasing prosperity, rise in per capita consumption and spread of energy access in rural areas are the factors which would require progressive increase in the total demand of electricity in the country. Currently, in the electricity sector, there is already official peak deficit of about 12.7% which will continue to increase in long term if other alternate sources of energy generation are not adequately developed. According to Ministry of New and Renewable Energy source (MNRE), the electricity installed capacity as on December, 2010 was 1,68,945 MW (MNRE, 2011). The fuel wise installed capacity breakup was 53.85% thermal, 22.12% hydro, 10.29% gas, 11.04% renewable and 2.7 % nuclear. In India, around 95000 villages have yet to be connected to the national grid due to their remoteness. For these communities, including others in rural and urban areas, the supplemental and cheaper sources of renewable energy both for cooking as well as for lighting the rural households would be required. India has got highest population of livestock (over 350 millions) in the world, including other sources of organic wastes and biomass which could be utilized for generating biogas and producing quality organic manure for achieving energy and food security in India.

Currently, about 1800 million tonnes (MT) of cowdung available in the country could generate about 120 million M^3 biogas per day, even if two third of it is utilized for biogas production (Ramesh and Rao, 2009). It is also expected to produce around 2.9 MT of nitrogen 2.75 MT of phosphorus and 1.89 MT of potash to support organic farming and in turn improved soil health and supply of quality food to the human population. The most appropriate opportunity could be to reduce the dependency to some extent on fossil fuel based chemical fertilizers and restricting emission of green house gases (GHG) to improve environment and mitigate the impact of climate change on agriculture. This paper is aimed at to report and discuss the various issues and technological interventions to overcome the problems for enhancing cowdung based biogas production and connecting it with organic product and value addition for sustaining good soil and human health and ecofriendly progress of agriculture and livelihood security of small land holders and other rural communities in India.

INDIAN SCENARIO OF RENEWABLE ENERGY

In India, the overall energy production is considerably less (12.7% deficit during peak periods) than its production (MNRE, 2011). In India, around 95000 villages have yet to be connected to the national grid and out of these, 18000 villages will never be connected to electric power grid due to their remoteness.

Table.1: Estimated potential of renewable energy sources in India (MNRE, 2008)

Source	Approx. Potential (MWs)
Biomass Energy	19,500
Solar Energy	20,000
Wind Energy	47,000
Small Hydropower	15,000
Ocean Energy	50,000

Table 1 lists the estimated potential of various renewable energy sources. However, for burgeoning rural sector in India, there is a great potential of biogas; the gas produced as a product

of anaerobic digestion of organic material (MNRE, 2008). There is huge amount of biomass available for production of biogas in the country (Tables 2, 3). Therefore, the bio-based supply of energy could be a great help not only to the remotely located communities but also to other peri-urban and urban population.

Raw Material Available for Biogas Production

Cowdung based biotechnology is a very promising technology in India due to very large livestock population and warm climate. Utilization of cattle dung is wide spread in rural and peri-urban areas and used either as energy source for cooking in rural households or farm yard manure. Biogas burners can achieve thermal efficiencies of 60% or above as compared to about 10% of cattle dung cakes based energy (Yadvika and Gupta, 2012). The population of cattle available for biogas production is over 350 million and even if two third of it is utilized for biogas production, it can generate about 120 million M^3 of biogas per day in the country (Table 2).

Table2: Raw material available for Biogas and Organic farming in India (Ramesh and Rao, 2009)

S.No.	Raw Material	Approx Quantity (MT)
1.	Agricultural Waste	700
2.	Animal Dung	1800
Biogas		120 Million M^3 Per Day
*Nutrients		
N		2.90 MT
P_2O_5		2.75 MT
K_2O		1.89 MT

Besides cattle dung, there are possibilities to operate poultry litter, night soil and food and vegetable waste based biogas plants which are being operated very successfully to supply energy and quality manure in several institutions, communities and rural households in the country (Table 3).

Table.3: Other perspectives of biogas and organic manure production in India.

Materials	Beneficiaries
Poultry Litter based biogas plant	1 Mwh project at Srikakulam, Vishakapattinam, Andhra Pradesh
Food and vegetable waste biogas plant	1 Mwh project at Srikakulam, Vishakapattinam, Andhra Pradesh
Night Soil based biogas plants	Vijayashanthi Builders Apartment at Chennai for 3000 Flats Vellalar Educational Institutions, Erode Jaya Educational Institutions, Chennai Indian Public School, Sembiyam Estate, Chennai Cotton Blossom, Thirupoor Raile Gaon, Maharashtra (Village of Anna Hazare)

Mixed municipal solid waste based biogas plants	Nisargruna Technology, developed by BARC has been distributed to 85 Private entrepreneurs for solid waste management and production of biogas and organic manure (www.green-ensys/site/Biogas-plant.html.)

All the institutions have hostels for their students, and are facing problem to dispose off the human excreta, food and vegetable waste, hand washing water, vessel washing water etc. Biogas plants can solve all these problems. Already the projects are running by so many companies and institutions by using other organic sources for the production of biogas and organic manure (Table 3).

Success Stories of Cattle Dung Based Biogas Plants

There are large numbers of cattle dung based biogas plants being operated in the country. However, only a few successful stories are quoted here. As Member of Farmers Commission, Govt. of M.P., Dr. D. P. Singh happened to visit some of the cow dung based biogas plants being operated by Public and Private sectors in state of M.P. The biogas plants at Govt. Phanda Farm with about 350 cows near Bhopal, Reliable Dairy with about 1500 buffaloes in Jabalpur under private sector, Deen Dayal Research Foundation with about hundred cows of local breed at Chitrakoot and R. S. Agro India Ltd near Bhopal with 60 buffaloes, are good examples for operating large size biogas plants very successfully. Also near Hisar, the Gaushala at village Ladva also has one of the large size cow dung based biogas plant in Haryana. They are also preparing quality vermicompost and other products based on cow dung and urine in these dairies. The other good examples for operating small biogas units by every household possessing even two to three heads of cattle can be seen in the clean village (Nirmal Gaon) "Mohad", Distt. Narsingpur (M.P.).

Recently, a complete analysis of a Community Biogas Plant (CPB) of 85 M^3 capacity operated by Surat Milk Union Limited (SUMUL) has been reported to supply biogas to 121 households at the rate of Rs 150/month. The society purchases cow dung@ Rs. 0.35/kg and sales vermicompost@ Rs. 3.5/kg. This unit is operated with the help of one supervisor + 4 laborers alongwith electricity and maintenance charges@ Rs. 8000 per annum. The major source of revenue and net income generation to the 121 beneficiary is through the vermicompost produced from cow dung slurry. As per economic calculations done by SUMUL of the Community Biogas Plant, it was able to generate over Rs. 10 lacs/annum net profit to the beneficiaries (Table 4: Nasery and Rao, 2011).

Table.4: Economic analysis of community Biogas Plant as per SUMUL (Nasery and Rao, 2011)

S.No.	Particulars	Design Capacity (yearly)	Actual Operations (yearly)	Cost Difference (yearly)
1.	Input cowdung	1643 MT	1278 MT	Rs. 127750
2.	Vermicompost production	592 MT	420 MT	Rs. 156000
3.	Operational cost	Rs. 556200	Rs. 428450	Rs. 127750
4.	Revenue	Rs. 1993800	Rs. 1477800	Rs. 516000
5.	Net profit	Rs. 1437600	Rs. 1049350	Rs. 388250

The GOI has sanctioned about 100 Biogas plants in the year 2010-11, and one of the plants has been commissioned in Tohana (Haryana). This plant has come into operation by using 300 kg of cattle dung per day by Shashi Energy Ltd as reported by the Plant Director Jyoti Media (Danik

Jagran, Dated August 18, 2012). In this plant, the cost of methane gas is expected to be cheaper than LPG, and efficiency of cooking will be about 10-15 higher than LPG. The R. S. Agro India Ltd, Bhopal has also started the bottling of methane gas for various purposes.

Similarly several biogas, small or big units based on other sources of organics could be seen in several parts of the country (Table 3). However, such efforts need repetition and more adoption by large number of households individually or on community basis to meet energy needs of rural households and periurban communities by incorporating the latest R & D technologies for further enhancing of biogas production from cattle dung and organics based biogas plants.

Enhancement of Biogas Production

There are some constraints in biogas production from cattle dung. These include design defacts, large hydraulic retention time (HRT: 30-50 days), non-adoption of latest R& D technology, transportation of cow dung and repair and maintenance of biogas plants. There is a need to overcome these problems through proper technological and operational interventions for enhancement of biogas production.

Technological Interventions

Anaerobic digestion of cow dung is a three stage process i.e. hydrolysis, acedogenesis and methanogenesis. The factors which affect these processes are detailed elsewhere (Yadvika 2005; Yadvika and Gupta, 2012). The potential of any substrate that can be degraded anaerobically is directly related to its Chemical Oxygen Demand (COD) content. Literature suggests that with 1 kg fresh cow dung about 40 litre of biogas is generated with 55-60% of methane gas concentration. This corresponds to about 24 liters of gas production per kg of fresh cattle dung. This criterion is used in the calculation of most of the biogas plants. However, the modified technique developed and standardized at IIT Delhi, which has higher consistency and accuracy, revealed the generation of 160-180 L COD that corresponds to about 63 L of methane production per kg of cowdung (Yadvika *et. al.* 2006). Thus, there is a need to modify the design criterion by using the latest modified technique of COD measurement.

The other major constraints of cow dung based biogas plants are large HRT (30-50 days) and low winter temperatures, especially in cool winters of North India. This results in low amount of gas production during winter season. The biogas production in these plants could be enhanced substantially by using proper bio-filters, slurry concentration and additives as per latest technologies (Yadvika, 2005; Yadvika *et. al.* 2006; Yadvika and Gupta, 2012). Yadvika *et al.* (2006) compared three types of reactors i.e. conventional reactors, reactors with stone chips and reactors with iron mesh. They found that the reactors with iron mesh produced about 17% more biogas than normal reactors. Yadvika (2005) also compared three slurry concentrations i.e. 1:1, 1:4 and 1:9 (dung: water) with 30 days HRT. The methane gas production averaged over whole year for 1:9 slurry concentration was about 3 times higher than 1:1 slurry concentration. Similarly, the use of proper additives has high potential for enhancement of methane in the biogas plants (Table5; Yadvika *et. al.* 2006). The results of different slurry concentration suggest that at 1:9 slurry concentration, the maximum yield of biogas as well as methane is obtained at 30 days HRT as compared to 1:4 and 1:1 slurry concentration (Yadvika *et. al.,* 2006). Nisargruna, plants based on solid municipal organic waste were able to reduce the HRT to about 20 days (Kale, S. P., BARC, Mumbai, Personal Communication)

Table 5: Effect of Additives on Biogas Production (Yadvika *et. al.* 2006)

Additives	Concentration (%)	Increase in Biogas production (%)
Distillery Spentwash	5	30
Press mud from sugar mills	1.5	50
Onion storage waste	1	60

The biogas plant of 50m^3 operated by R. S. Agro India Ltd. at Bhopal circulates the warm water generated from the electric biogas based generator sets directly to the biogas plant to maintain proper temperature during winter season. This biogas plant with the modified design developed by Er. Rajendra Singh at its own is operated from the dung of 60 buffaloes and meets full electricity requirements of 2 lacs poultry farm, refrigeration, cooling of the buildings, sprinkler irrigation of 60 acres farm, including the electric requirement of feed manufacturing unit for poultry and livestock within the campus. The maintenance of proper temperature could also be supported by installation of solar energy unit for circulation of warm water into the biogas plant during cool winters. However, there is also need to identify and develop the anaerobes which can do better fermentation and methanogenesis at low temperatures in biogas plants in winter months under North Indian conditions.

Operational Intervention

The other problems associated with cattle dung based biogas plants are transportation of cowdung and slurry, repair and maintenance of biogas units and suspected less benefit to the beneficiaries. There is no problem on these accounts, if the community biogas plants are operated on cooperative basis by the beneficiaries by employing skilled supervisor and skilled trained labors to run the big units. For example, the CPB of 85 M^3 of SUMUL is being operated by one supervisor plus four skilled labors to bring the cow dung to the plant from the 121 beneficiaries, including production and supply of biogas to each house hold and preparation and sale of vermicompost to generate major amount of income to the beneficiaries (Table 4).

In another case in clean village 'Mohad' in Narsingpur Distt. of M.P., the small biogas plants are commissioned at the outskirt of the house with cattle shed adjoining the house. The cowdung in the plant is put on daily basis manually, it supply the biogas to the house hold and the slurry and entire waste of house hold and cattle shed is utilized for preparation of vermi-compost and Nadep (aerated composting method) near the cattle shed. Skilled technicians are on job for repair and maintenance of individual biogas units in the entire village and each biogas unit is being operated in perfect conditions.

Antil (2012) suggested making two outlets connecting them with the two pits to accommodate the slurry of 6 months from both sides of the biogas plants in situ. In these pits, the crop residues and other organic wastes are also added for composting.

However, besides removing these hurdles, still more work and sincere efforts are required to attract the rural communities to switch over to utilize cattle dung for production of biogas and quality organic manure, instead of its burning and dumping in front of the houses or on both the sides of roads and on community lands. The various issues to provide more incentives and profit to the rural communities are discussed in the following section.

CONNECTING BIOGAS WITH ORGANIC INPUT AND VALUE ADDITION

Farmers and rural communities need motivation not to burn cattle dung and use it for biogas and quality organic manure production. It will only be possible through proper education, training and awareness, removal of pretty difficulties associated with day to day operation of biogas units, and most importantly the real benefits associated in terms of socio-economic returns, human and soil health and clean environment to the communities. In Indian context, connecting cattle dung based bio-energy with organic farming and value addition of agricultural produce could be beneficial to the rural and peri-urban communities in the following ways:

- To produce cattle dung biogas energy for multipurpose uses in rural and peri-urban areas.
- To increase the efficiency and sustainability of different production systems in irrigated ecosystems in general, and on marginal soils and fragile environment in particular through enhancement of organic carbon content of soils and providing different macro- and micro-nutrients to the plants.
- To generate carbon fund through carbon trading by restricting the emission of GHG and increase in carbon sink within the system.
- To increase in income and product value through proper processing of organic products which have higher market prices within and outside the country.
- To provide good soil and human health and clean environment.

The majority of Indian soils have low organic carbon content affecting hydrological and biological properties of soils adversely and in turn low input use efficiency of different production systems. Thus, it is an opportune time to motivate the rural communities not to burn the cattle dung cakes for cooking purpose but save it for production of bio-energy and quality organic manure, compost/vermicompost to enrich the organic carbon content and fertility status of soils.

The GOI is providing 67,198 crores subsidy (revised estimate for 2010-11) on chemical fertilizers to farmers and loosing lot of foreign exchange on imports of chemical fertilizers. If the farmers are motivated and also provided proper incentives to use cattle dung and other organic wastes for the production of biogas and organic manure, it will not only enrich the soils with organic matter, but would also add large quantity of macro- and micro-nutrients for enhancing the productivity of different production systems. The data in Table 2 reveals that even if two third of cattledung is utilized for producing organic manure, it can generate about 7.5 million tons equivalent of N P K to enrich the soils in terms of nutrients and organic carbon content.

There are also other possibilities to produce biogas and quality organic manure from food and vegetable wastes, poultry litter and night soil to help different communities. A few of the examples in this regard are listed in Table 3. The GOI could also take initiates to shift subsidy from chemical fertilizers to ecological fertilizers. As per press release on May 16, 2012 Greenpeace India welcomed the GOI plan to shift subsidies from chemical fertilizers to support ecological fertilizers. The statement from Union Agriculture Minister if translated into action can go a long way in addressing the soil health crisis of the country. The "Government of India needs to support grass root institutions and devise-farmer-centric incentive system to translate this statement into action on ground" said Gopikishna, S. R., Senior Campaigner, Sustainable

Agriculture Campaign, Green Peace India. The additional benefits which farmers could get from organic produce and value addition are discussed in the following section.

Organic Product and Value Addition:

Global demand of organic products remains robust with sales increasing over 5 billion US $ per annum (Ramesh and Rao, 2009). The Indian organic industry is estimated at US $ 78 million and is almost entirely export oriented. Among the Indian states, the state of M.P. has got highest area under organic certification (Table 6) and also recently approved document on "State Policy on Organic Farming in Madhya Pradesh 2010."

Table.6: Total area under organic certification process (certified and under conversion) during the year 2006-07 (Ramesh and Rao, 2009)

S.No.	State	Certified area (ha)	Area under conversion (ha)	Total area (ha)
1.	J & K	32541	-	32541
2.	Karnataka	8735	2976	11711
3.	Kerala	11631	3112	14744
4.	Manipur	913	5105	6019
5.	Maharashtra	41390	72238	113628
6.	Madhya Pradesh	87536	59875	147411
7.	Orissa	66625	7959	74585
8.	Rajasthan	15034	9697	24731
9.	West Bengal	7332	3147	10479
10.	Others	-	-	-
	Total	271737		528930

The Govt. of M.P. is consolidating the gains from existing certified areas by designing value chains, developing organic hubs and organics for hyper market. Several NE hill states Govts' have declared their states as organic states. In addition to the benefit of connecting biogas with organic farming, the comparative advantage for organic production is enormous as compared to other countries and a few important ones are listed below:

- India is strong in high quality production of certain crops like tea, some spices, rice specialties, ayurvedic herbs etc.
- India has a rich heritage of agricultural traditions that are suitable for designing organic production systems.
- Low consumption of fertilizers, especially in mountain and tribal areas, conversion to organic production is much easier.
- Compared to input costs, labor is relative cheap in India, thus favoring the conversion to less input-dependent, but more labor-intensive production systems, provided they achieve sufficient yields and proper value addition.
- The NGO sector is very strong and has established close linkages with a large number of marginal farmers and markets.
- The value addition and processing of organic produce can generate enormous additional employment and income.

The value addition and processing industry of organic produce has enormous capacity of better employment generation and higher returns, especially to small land holders. From brevity point of view, out of several examples, only a few are quoted here.

Deen Dayal Research Foundation at Chitrakoot (M.P) motivated by Late Nanaji Deshmukh is maintaining a herd of all national local breeds of Indian cows. With the help of their two KVKs, besides important work of soil and water conservation, the research foundation has encouraged the trivial people and small farm holders to cultivate medicinal plants organically, trained them for primary processing and bringing the produce to the foundation for sale at higher prices for preparing the valuable Ayurvedic medicines. In addition to processing of the medicinal plants for Ayurvedic medicines, the foundation is researching and preparing several products from cow urine and cowdung for export. As stated earlier, several villages in M.P. are developed as organic villages (Nirmal Gaon: clean villages) by connecting cowdung based biogas with organic farming. One of the organic village "Malgaon" was also visited by the former President of India, Dr. Abdul Kalam. In this village around Rs 20 lacs have been saved by not using the chemical pesticides. They are utilizing the slurry, household waste, and even *Parthenium* weed for preparing vermi-compost and compost through Nadep (method to prepare compost through proper aeration) for organic farming. The value addition and processing of organic produce, and their buyback, especially the medicinal plants produced by small land holders, the Institute has benefitted them in terms of soil, primary health care, and water conservation, nutrients enrichment of soil, more employment and higher returns for their livelihood security.

Even the simple conversion of cattle dung slurry to vermi-compost from CPB of SUMUL has generated 4 fold more net income to the beneficiaries (Table 4).

In NEH organic states, the processing of organic ginger can fetch about 2.5 fold more income than fresh ginger. (Table 7)

Table .7: Economics of organic processing of ginger in Sikkim, (Gupta *et. al.,* 2012)

Products	Organic Ginger slices and costs
Fresh Ginger	100kg (87% water)
Slices	95 kg
Dried Slices	15kg
Cost of fresh ginger	Rs.25 per kg
Cost of drying	Rs.2 per kg
Time of Solar drying	2-3 days
Mechanical drying	10 hrs
Production Cost of slices	Rs.170 per kg
Selling price of dried slices	Rs. 250-300 per kg

Thus, instead of selling 100kg of fresh ginger for about Rs. 2500, a farmer can fetch higher price by selling dry slices / powder for around Rs.3700 with an additional cost of processing and drying which comes out to be around just Rs. 200.At CIPHET-Ludhiana, the institute is selling the ginger powder at Rs.350 per kg. Thus, 15kg slices could be sold in the retail market for Rs.5250 in major cities of India. The dry slices sold at CIPHET are not 100% organic but slices prepared in Sikkim and North Eastern States are 100% organic and thus are more consumer friendly and could fetch much higher prices in the India and overseas markets.

Another example in this regard is Agriculture and Organic Farming Group (AOFG) India. One of the key areas of activity of the NGOs in AOFG is the promotion of organic farming, organic production, certification, value addition and marketing. To promote organic farming capacity building, quality training and skill development are focal to farmer centred activities (Annual Report 2011, www.aofgindia.com). AOFG India on its own with small and marginal farmer associations promoted six farmer limiteds primarily focusing on coffee, spices, vegetable, cotton, pulses, apple, other fruits as entry crops with quality production, procurement, value addition, storage and marketing. Farmer limiteds' are building and setting up value addition, processing and storage infrastructure at the production areas for gainful marketing and better economic returns. The farmer limiteds' have brought the market to the villages at production site and mainstreaming the small and marginal farmers in economic liberalization and market economy for better employment and income generation for livelihood security in the country. Such efforts need repetition more adoption at other places for better livelihood of resource poor small land holders in rural India.

Impact of Organic Input on Agriculture and Environment

The accumulation of Organic Matter (OM) in the soil is the key factor in lowering the amount of CO2, methane etc. in the atmosphere. Organic systems have 57% lower nitrate leaching rates compared with other farming systems, and zero risk of surface water contamination. In terms of benefits for climate change, various studies have shown that organic farming uses 20 to 56% less energy per unit produce of crop dry matter than conventional agriculture, and that organic fields sequester three to eight more tons of carbon per hectare. Thus, the accumulation of organic matter in the soil is the key factor in lowering the amount of CO_2 and methane in the atmosphere. In its policy document on organic farming (2010), the Govt. of M.P. emphasized the need to brand cowdung based biogas as KNG (Kamdhenu Natural Gas). The cowdung based biogas can be purified for the impurities like hydrogen sulphide (H_2S), excess water and other such contents impending its bottling for easy transportation and use it as and when required. The NGO, RS Agro India Ltd in Bhopal has already started the bottling of cattle dung based biogas for cooking and other consumption. The biogas producing companies should be encouraged to harness of such technological advancement and produce KNG for domestic and auto fuel. The GOI has also plans to set up about 100 cattle dung based biogas plants in India and one of such plant has come into operation in August 2012 at Tohana, Haryana. The GOI may also take initiatives to shift subsidy from chemical fertilizers to ecological fertilizers as per press release by Green Peace India in 2012. These steps would help the country to generate yet another account of CERs (Certified Emission Reduction) by saving fossil fuel based hydrocarbons and enrich the soil system with organic carbon content to improve its hydrological and biological properties and good human health and clean environment to sustain ecofriendly growth of agriculture in the country.

CONCLUSION

There is huge amount of cattle dung, human excreta and other sources of organic waste and biomass to supplement the fossil fuel based energy requirement of peri-urban and rural communities in the country. Connecting this important source of renewable energy with organic product and value addition will not only be useful to meet multi-purpose energy needs of different

communities, but also provide organic manure, quality organic food, good human and soil health and clean environment in the country. It would be helpful in mitigating the impact of climate change by restricting the emission of GHG, increase of carbon sink within the system and better incentives to stakeholders for carbon trading under different agro-ecological conditions. Finally, the production of biogas and organic food combined with value addition and processing could generate more employment and profit for small farm holders and other stakeholders due to their ever increasing demand of organic food and higher prices within and outside the country. However, there is an urgent need to create more awareness, skill development, continued R & D and bold policy initiatives with rewards and award systems to undertake biogas production and organic farming in mission mode to help different stakeholders in the country.

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Potentials for Beneficial Utilization of Coal Fly Ash for Biofuel Feedstock Production on Marginal/Degraded Lands

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ABSTRACT

According to current estimates by the US Energy Information Administration, coal generates 42% of the electricity in the US. Annually, this leads to production of about 130 million tons of coal combustion wastes (CCW) that require safe disposal to avoid threats to human and environmental health. Of the annual CCW production, 68 million tons consist of fly ash (FA), which are currently used in construction applications (26 million tons), stored in large , wet impoundments or disposed of in landfills. Increasingly high costs of management and disposal of FA has prompted growing advocacy for greater beneficial uses of the products, including their utilization in agriculture. Utilization of FA as soil amendment for plant growth possesses great potentials for increasing consumption of the waste products and thereby reducing significantly the amounts that must be disposed of in ash ponds and landfills. Fly ash possesses excellent physical and chemical characteristics such as water retention and storage, and it can supply several major and trace elements that are required for plant growth. Acceptability of agricultural uses of FA is in its ascendancy in some major coal-based power-generation countries as greater amounts of FA are produced in the face of dwindling disposal options. Currently, less than 0.4% of the annual generation of FA is used in agriculture in the US, largely because of real and perceived exposures of humans to hazardous substances in FA. A combination of the coming of age of bio/phytoremediation strategies on the one hand and other, a rapidly emerging focus on bioenergy offers opportunities for developing practices that will allow greater beneficial utilization of FA as soil amendment for biofuel feedstock production, especially on marginal lands. Amending such lands with FA can enhance biomass productivity, which in turn will serve as sustainable methods for FA disposals.

Key words : Fly ash; agricultural utilization; biofuel feedstock production; marginal lands, cellulosic herbaceous perennials, switchgrass; eastern gamagrass; big bluestem, bio/phytoremediation.

INTRODUCTION

Exact estimates of the amount of electricity generated in the US by burning coal vary depending on the organization reporting on the issue. For the example, according to the Union of Concerned Scientists, coal generates 54% of the electricity in the US (Union of Concerned Scientists http://www.ucsusa.org/clean_energy/coalvswind/c01.html). However, the US Energy

Information Administration reported that, '*in 2011, coal was the fuel for about 42% of the 4 trillion killowatthours of electricity generated in the United States*' (US Energy Information Administration.http://www.eia.gov/electricity/).

These details notwithstanding, the magnitude of wastes produced during the generation of electricity from coal is unquestionably immense. Figures from the American Coal Ash Association (ACAA) survey showed that in 2010, coal combustion produced 130 million tons (Mt) of coal combustion wastes (*CCP*) (Coal Combustion Products (CCP) Production and Use Survey, 2010]. Of these, 68 million tons consist of *fly ash* (*FA*), which is generally stored in large, wet impoundments or disposed of in landfills (US EPA. 2012).

Depending on the parent coal, combustion technology and storage conditions FAs can contain toxic substances; accordingly, their current storage in wet impoundments or in landfills has become increasingly unacceptable from the standpoints of economic, human and environmental health costs. According to ACAA the economic cost of FA disposal ranges widely depending on, among other things, transportation location and method, prevailing environmental considerations, regulatory requirements and potential for future use. However, the organization estimates that cost may range as low as $3.00 to $5.00 per ton at the lower ranges, to $20.00 to $40.00 a ton or even higher (Coal Combustion Products (CCP) Production and Use Survey , 2010) . However, this does not include the value of land affected by disposals and the health of communities impacted by these activities. These aspects of the FA disposal problems are addressed in a number of USEPA documents (US Evironmental Protection Agency. 2007a, b,c)

Catastrophic failures at ash impoundments over the last decade in the US

(http:wisconsin.sierraclub.org/Issues/OakCreekSpill.asp ; http:www.tva.gov/emergency/archive/ash_release_1-15-09.pdf , http://www.epa.gov/osw/nonhaz/industrial/special/fossil/surveys/index.htm ; Carmon, M. 2005,

and Wall, 2002 and recognition that contaminants are silently seeping surround coal burning facilities (Dewan, New York Times, January 7, 2009) have caused attention to be direct onto alternative and sustainable approaches for management of wastes arising from the production of this indispensable commodity.

One solution to the problem of FA disposal that has been gaining increasing attention over several years is greater beneficial utilization of the products (EPA Report No. 11-P-0173 , 2011, Iyer, and Scott. 2001). Historically, FAs have found beneficial uses mainly in the construction industry. For example, in 2010, ACAA reported the following uses of FA (million tons): concrete and concrete products (13), structural fills (4.7), waste stabilization/stabilization (3.3), mining applications (2.4) and road base construction (0.2) (Coal Combustion Products (CCP) Production and Use Survey ,2010) . Beneficial uses of FA in the construction and mining industries are subjects of several investigations and reviews (Feng and Clark. 2011, Korpa, et al, 2012. Ward et al 2006 , US Department of Energy 2012) and are not the focus of this review. However, these utilizations consume 38% of the 68 million tons of FA produced; accordingly, about 62% of the production (about 40 million tons) must be disposed of in ash ponds of landfills. Only 22,220 tons of the 68 million tons of FA produced in the US are currently used in agriculture; less than 0.4% of total production (Coal Combustion Products (CCP) Production and Use Survey,2010) .This is ironic; merits of FAs as soil amendment have long been recognized. The products impart to soil,

improved physical characteristics such as texture, structure, permeability, and water holding capacity (Lee, et al 2006, Rautaray et al 2003, Kishor et al 2010) . Additionally, they can be used for correcting soil acidity as well as alkalinity (reviewed in 23 Sharma, S.K., and N. Kalra. 2006). The lack of enthusiasm about use of FA in agriculture in the US is generally attributed to the toxic components and human health concerns that can be associated with the product (US Environmental Protection Agency. 2007a, c). In spite of such drawbacks, a large body of work continues to originate from some coal-based, power-generating countries, notably India, the largest generators of FA, and from Australia, touting greater utilization of FA in agriculture. These investigations and reviews support uses of FA on crops ranging from rice, maize, rice, maize, wheat, peanut, mustard and various legumes(Pandey et al , 2009, Pandey and Singh, 2010) and canola (Manoharan, et al 2010) . Additionally, the Australian investigators show strong support for regulatory standards that would ensure the 'safe and routine utilization' of FA in agricultural systems (Yunusa, et al 2012) . A significant legacy from the 1980-1990 environmental awareness era was the development of waste cleanup strategies collectively known as *bioremediation* (Vidali, 2001) and *phytoremediation* (Le, et al. 2011, Vishnoi and Srivastava. 2008, Dzantor, 2007) . Bio/phytoremediation strategies are now well established for mitigating environmental contamination and degradation from agrochemicals (Vishnoi and Srivastava. 2008) manufacturing industry contaminants, including PCBs (Dzantor and Woolston. 2001 , Dzantor et al 2000) , petroleum hydrocarbons including PAHs (Montgomery et al 2008) chlorinated solvents (Zalesny and Bauer. 2007) and defense industry contaminants such as TNT (Schnoor, 2011). In spite of such broad appeal and nearly three decades of intensive study, bio/phytoremediation strategies have not been systematically investigated for coal waste disposal. This is most likely due to the regulatory quandary over exemption of coal combustion wastes from Resource Conservation Recovery Act (RCRA) that regulates other solid wastes in the US (Luther 2010). Ironically, that exemption was passed by congress in 1980, at the same time that bio/phytoremediation strategies were emerging. Faced with mounting coal waste accumulations, the use of bio/phytoremediation strategies on FA management and disposal is increasing rapidly in many coal-based power-generating countries; in particular, the deployment of these strategies for restoration of ash disposal sites (Pandey et al 2009 , Bilski et al 2011 , Pandey, 2012, Haynes, 2010). Experiences from use of FA as soil amendment for producing the various crop listed above and knowledge gained from bio/phytoremediation for overcoming the physicochemical limitations of remediation at FA disposal sites (Pandey et al 2009, Haynes, 2010) present opportunities to develop strategies for neutralizing adverse attributes of FA so the product can be used routinely for enhancement of biofuel feedstock production.

This paper is aimed at providing state of a the knowledge mini review of the issues that need to be addressed in order to realize the potentials for using FA as soils amendment for biofuel biomass production especially on marginal lands, with concomitant disposal of the waste product.

FLY ASH : ORIGIN AND PHJYSICOCHEMICAL PROPERTIES

Fly ash (FA) is the by-product of the combustion of pulverized coal in electric power generating plants. It is the fine residue commonly collected by electrostatic precipitation in gas purification facilities (Luther, 2010). Fly ashes are one of the most complex anthropogenic materials in existence. Depending on parent materials from which they originate and on the technological processes for their combustion, they have been characterized to contain up to 318 individual

minerals and 188 mineral groups (Vassilev and Vassileva, 2007). Understandably, their complexity has led to different (approaches) for their classification, characterizations and uses. Physically, fly ash particles are generally spherical in shape and range in size from 0.5 μm to 100 μm (silt-sized and clay-size particles). Table shows a highly abridged version of the classification suggested by Vassilev and Vassileva (2007). In this classification, the chemical compositions of the major and minor elements were expressed as oxides in the order: O, Si, Al, Ca, Fe, C, K, Mg, H, Na, Ti, N, P and Ba and occasionally Mn, Sr, Sr, F and Cl. The authors also listed trace and minor concentrations of Ce, Cl, Cr, Cu, F, La, Mn, Pb, Sb, Sr, Th, U, Y, W, Zn and Zr.

Table 1. Abridged classification of constituents of fly ash (*after Vassilev and Vassilev,2007*)

Inorganic Constituents	Organic Constituents	Fluid Constituents
Non-crystalline—glassy particles *Crystalline*—crystals, grains, aggregates of minerals	Char materials—slightly changed, semi-coked and coked particles; organic minerals	Liquid, gas, gas-liquid inclusions associated with inorganic and organic matter

Vassilev and Vassileva,(2007) noted, almost in passing that FA could probably contain Ag, As, Ge, Hf, Mo, Sn and Va. Indeed the authors pointed out that '*FAs do not exhibit hazardous characteristics and they remain exempt from regulation in the USA*...'. Surely, as mentioned above, FAs are not regulated by RCRA as other solid wastes are; however, the statement that they do not exhibit hazardous characteristics is probably too sweeping and is not completely supported by other evidence. Just like all other aspects of FA, the specific coal bed makeup and combustion conditions determine exact FA compositions. However, in general, constituents may include one or more of the following elements or substances in quantities from trace amounts to several percent: As, Be, Bo, Cd, Cr, Co, Pb, Mn, Hg, Mo, Se Sr, Th and Va, along with dioxins and PAH compounds (http://wisconsin.sierraclub.org/Issues/OakCreekSpill.asp) , United States Geological Survey, 2002 , Sandelin and Backman, 2001, Kaakinen et al 1975). This list contains some the major culprits behind the USEPA's own determinations of the human and ecological risks on FA components (US Evironmental Protection Agency. 2007 a,b,c) the most important reason for the long-standing uneasiness about FA utilization in agronomic crop production.

A more utilitarian classification by American Standard Testing Materials, ASTM C618, defines two classes of FA: Class F and Class C based on their chemical composition resulting from the type of coal burned. Class F is fly ash normally produced from burning anthracite or bituminous coal, and Class C is normally produced from the burning of subbituminous coal and lignite. Class C fly ash usually has cementitious properties in addition to pozzolanic properties due to free lime, whereas Class F is rarely cementitious when mixed with water alone. This classification, including suggested uses is summarized in Table 2 (Manz, 1999).

Table 2. Summary of ASTM Classification of Fly Ash (FA) and Uses

Characteristic	Class F	Class C
Source	Anthracite and bituminous coal	Lignite and subbituminous coal
$SiO_2 + Al_2O_3 + Fe_2O_3$	>70%	>50%
Lime content	<20%	>20%
Cementing properties	Requires cementing agent	Self-cementing
Uses	High sulfate conditions	Not for high SO4 conditions
	Structural concretes	Primarily residential construction

	Useful in high FA content concrete mixes	Limited to low FA content concrete mixes

The essence of any classification scheme ultimately derives from their practical uses. In addition to proposing a classification based on origin, properties and behavior, Vassilev and Vassilev also reviewed other classifications of FAs and pointed out the importance of such schemes in the establishment of standards. Thus, they proposed standards that would facilitate uniformity of nomenclature, characterization and prediction of FA compositions. These standards should also assist in the elucidation of FA behavior during coal combustion and formation, processing, storage and utilizations. Finally, the standards should facilitate prediction, estimation, reduction or elimination of technological and environmental problems related to issues of utilization and potential environmental contaminations (Vassilev and Vassileva, 2007). Issues of standards were moved along further by Australian investigators, inasmuch as they pertain to agricultural uses of FA. In a recent publication, Yanusa et al., proposed criteria for selecting ashes for regulatory parameters that would ensure the safe and routine utilization in agricultural production systems (Yunusa, et al 2012). Considering the complexity of FAs, the current increasing advocacy of their agricultural uses and the large number of crops so far found to benefit from their uses, establishment of guidelines for FA utilization in agriculture could not be timelier.

FLY ASH : SCOPE OF PRODUCTION AND ENVIRONMNTAL CHALLENGES

Disposal of fly ash is a significant economic, health and environmental problem, not only for producing countries but entire regions and possibly worldwide. Global production of FA is currently estimated to be 750 million tons (Blissett and Rowson, 2012). Of this, more than 65% is disposed of in landfills and ash ponds. However, the actual amounts of disposals vary by country. For example, in the US, 60% of an annual production of 68 million tons i.e. 40 million tons is disposed in ponds and landfills (Table 3). In India, the largest fly ash producing country, 87% of the 112 million tons of annual FA production ends up in ash mounds, and lagoons covering several thousand acres of arable land and requiring high costs of environmental management. In Australia and Germany, only 15% of FAs produced are disposed of as waste (Table 3).

Table 3. Fly Ash Production and Utilization in Selected Countries[1]

Country	Annual FA Production (million tons)	Utilization (%)
India	112	38
China	100	45
USA	68	38
Germany	40	85
Australia	10	85

[1]/Sources: US numbers are from ACAA 2010 (Coal Combustion Products (CCP) Production and Use Survey ,2010) other members are summarized from http://www.tifac.org.in

Within the last decade in the US, catastrophic failures of FA impoundments have occurred in

Protecting Our Drinking Water from Toxic Coal Ash (http://wisconsin.sierraclub.org/Issues/OakCreekSpill.asp)

Wisconsin in 2011 (http://wisconsin.sierraclub.org/Issues/OakCreekSpill.asp), Tennessee in 2008 (Tennessee Valley Authority. 2009). twice in Indiana in 2007 and 2008 [USEPA , http://www.epa.gov/osw/nonhaz/industrial/special/fossil/surveys/index.htm.) ,

Pennsylvania in 2005 2005 (Carmon 2005) and Georgia in 2002 (Wall 2002) . The Tennessee ash spill in Kingston, TN, has been described as the largest of its kind and it caused tremendous degradation of land and water by 5.4 million cubic yards of impounded FA (http://www.tva.gov/emergency/archive/ash_release_1-15-09.pdf). A major reason for failures at ash impoundments is age. Nearly all the ponds that store coal wastes are 30-40 years old. The site of the Kingston ash release has accumulated ash sludge since 1952 (Luther, L. 2010). The age of the impoundments makes it unlikely that they would have the state-of-the-art-liners and adequate leachate monitoring systems (US Environmental Protection Agency,2007 c). Indeed, in the US, reports have concluded that gradual yet dangerous contaminants have been quietly seeping from many coal dumpsites nationwide. According to one study, there are over 350 coal ash sites nationwide with 1,300 coal ash ponds, each of which can reach up to 1,500 acres (Carmon, 2005). Not surprisingly, groundwater, wetlands, creeks or rivers at 31 sites in 14 states have been found to be contaminated with toxic CCW (US Environmental Protection Agency. 2007b). US Environmental Protection Agency's risk assessment estimates that up to 1 in 50 residents living near certain wet ash ponds could get cancer due to drinking water contaminated with As (US Evironmental Protection Agency. 2007a).

THE FLY ASH PARADOX

Issues concerning FA are full of with paradoxes but the fact that coal provides 42% of the electricity generated in the US is not one of them. The country sits on a quarter of the world's proven coal reserves; accordingly, it is a relatively abundant and inexpensive resource and it will remain the fuel of choice in the future. However, generation of electricity from coal comes with tremendous amounts of wastes including FA and other CCWs that are second in volume only to municipal wastes (US Environmental Protection Agency , 2000).

One irony is the fact that FA and other CCW are not considered as wastes by the USEPA, although the regulatory agency has documented human and environmental risks associated with FA. Another irony is the fact that fly ashes possess several functionally desirable physical and chemical characteristics that can allow their beneficial uses; however, there is low interest in the use of FA in agriculture because real and perceived high levels of toxic substances (Yunusa, et al., 2012).

Furthermore, uncertainty about classification of FA and regulations pertaining to their use in agriculture simply stymies greater utilization of products for enhancing crop production while providing solutions for the disposal dilemma.

As mentioned earlier, the beneficial uses of FA are mostly in the construction and related industries and to a lesser extent in the mining industry. However, explorations have been ongoing that capitalize on abilities of FA to sorb onto a broad range of materials and thereby neutralize undesirable substances from various matrices. For example, they have been evaluated as sorbents for SO_2, NO_x and Hg coming out from the very coal combustion process (Davini, 1996 , Rubio et al, 2007, López-Antón et al, 2008) ; toxic metals (BayatB. 2002 a, 52. BayatB. 2002 b) , gaseous organics (Rotenberg et al, 1991) and other organics, including persistent organic pollutants

such as PCBs (Noller et al., 2003) and dyes (Dizge, et al., 2008) from various industrial processes. An important emerging beneficial use of FA is in the synthesis of *zeolites*, a group crystalline aluminum-silicates with a broad range of industrial applications, mainly based on ion exchange, selective gas adsorption and water adsorption (US Environmental Protection Agency,2000) . For now, results from these alternative uses FA are encouraging; however, the market share for the consumption of FA is still quite small. Of the 68 million tons of the annual production of FA in the US, about 26 million tons found beneficial use in the construction, mining and emerging applications. Ironically, the remainder must be disposed in wet ponds and landfills.

BENEFICIAL UTILIZATION OF FLY ASH IN AGRICULTURE

An ever-growing world's need for food, feed, fiber and now, energy suggests that the largest untapped markets of sustainable disposal of FA could be their utilization as soil amendment in crop production; in particular, bioenergy feedstock production. Unlike construction markets that can become saturated or are vulnerable to economic downturn (Iyer and Scott. 2001) demand of agricultural markets will continue to be high to meet human needs. Surprisingly, only 22,220 tons of FA produced in the US are used in agriculture, less than 0.4% of total production [3 2010 Coal Combustion Products (CCP) Production and Use Survey 2010) . This is in spite of long recognition and promotions of merits of FA as soil amendment. As indicated earlier, the products impart to soil, improved physical characteristics such as texture, structure, permeability, and water holding capacity and they can provide macro- and micronutrients as a soil amendment (Lee, et al ., 2006 , Rautaray et al 2003, Kishor et al 2010 , Sharma and Kalra, 2006).

Interest in agricultural use of FA as soil amendment in crop production is rising rapidly, especially in India, the largest generator of the product. A large body of work continues to originate from Indian investigators about beneficial uses for FA as soil amendment for growing different crops. For example, conducted by Mittra et al., between 1996 to 2001 found that application of alkaline FA (pH=8.4) at a rate of 10t/ha in combinations with various organic amendments caused 25-30% increase in peanut pod and rice yields, compared to yields with chemical fertilizers at comparative agronomic application rates (Mittra et al., 2003).

In relatively more recent studies Singh et al., used a considerably higher rate of FA application in pots (120-180 t/ha) to show improvement of soil physical properties by FA amendment and concomitant enhancement of yield of selected legumes (Singh et al., 2011). In addition, Arivazhagan et al., reported that applications of 50 Mt/ha of an ash increased yield of cereal crops by 15-20%; sugar cane by 20-30% and maize by 40% (Arivazhagan et al., 2011). Patra et al (2012) reported that a onetime application of FA at a rate of 200t/ha in cropland increased yield of maize 28% and 34% over controls at two separate locations. Corresponding increases in yield of rice at the same locating were 40% and 13% respectively Perhaps more importantly, these studies were conducted on food crops without adverse human impacts reported.

Extensive reviews by Indian investigators have continued to dominate the literature on agricultural utilization of FA. For example, in 2006, Jala and Goyal reviewed of work that included application of FA for biomass productions in agriculture, forestry and wasteland reclamation (Jala and Goyal. 2006). Sharma and Kalra(2006) also reviewed the effect of FA incorporation on soil properties including physical, chemical and biological effects of FA additions on the soil environment and crop growth and productivity. In reviews cited earlier,

Pandey and co-workers summarized 78 FA investigation conducted between 1975 and 2007 with 62 of them by Indian investigators. The consensus of these reviews and ongoing investigations was an affirmation of the usefulness of judicious applications of FA to enhance crop production (Pandey et al, 2009 , Pandey and Singh,2010).

Australia is another coal-based energy-generation country with extensive investigations and reviews on beneficial utilizations of CCWs (Yunusa et al, 2012, Vidali, 2001, Manoharan, et al 2010 , Yanusa et al, 2006). Investigators in that country are leading proponents for changing the 'traditional and outdated interpretations of the word waste (Hendrick, 2011) seeking instead, effective classifications schemes for selecting ashes for regulatory parameters that would ensure the safe and routine utilization in agriculture (Yunusa et al., 2012)

Interest in FA utilization in agricultural production in the US is changing more gradually. In a 2009 memo to the Director of RCRA, the USDA Deputy Administrator noted that 'wise management of CCPs by industry and new beneficial uses will minimize the quantities of CCPs that must be disposed of and sequestered long-term in landfills and impoundment ponds....' The Administrator went on to recommend use of 'sophisticated risk assessment protocols to guide recommendations for uses of CCP in agriculture' http://peer.org/docs/usda/09_15_10_ARS_letter.pdf).

COUPLING ENVIRONMENTAL REMEDIATION THROUGH FA UTILIZATION TO BIOFUEL FEEDSTOCK PRODUCTION

The combination of well-tested bio/phytoremediation strategies, ongoing agricultural utilizations described above and the emerging global focus on bioenergy suggest strongly that markets are ready to exploit opportunities for cleaning up FA through beneficial utilization as soil amendments while producing biomass for biofuels.

First, the use of bio/phytoremediation strategies for FA management and disposal is receiving increasing and deserved attention in some parts of the FA producing world for restoration of ash disposal sites (Pandey et al., 2009 , Bilski et al. , 2011, Pandey, 2012,

Haynes, 2010). Bio/phytoremediation strategies originally emerged from the 1980-1990s environmental consciousness era and they have become the methods of choice for mitigating environmental contamination and degradation from a broad range of contaminants. However, they have not been systematically investigated for coal waste disposal, largely because of the same reasons suggested previously: ongoing debate about regulations pertaining to classification of FA as wastes. Faced with mounting coal waste accumulations investigators are modifying these strategies for FA management and disposals. For example, Pandey et al.,(2009) and Haynes , (2010) reviewed the factors that need to be taken into consideration for successful application of phytoremediation to the cleanup at FA disposal sites. Some of the key issues that need to be addressed include physiochemical conditions such as pH, soluble salts, toxic concentrations of metals, appropriate and adequate organic amendments, and microbial population size, composition and competence. Indeed, concerning the latter, several investigators listed mycorrhizal inoculation as important to success of bio/phytoremediation processes (Babu, and Reddy. 2011, Waoo et al 2011, Juwarkar and Jambhulkar 2008).

Secondly, in the focus on bioenergy in the US, attention has been directed onto conversion of biomass to ethanol. Currently, corn accounts for more than 90% of this biomass-to-ethanol

conversion. However, this is untenable as a long-term proposition. Expansion of corn production to levels needed to meet even a small fraction of the nation's future energy requirements will come with an unaffordably steep price in terms intensive inputs and attendant considerable environmental degradation (Koo-Oshima, 2007). Besides, a long simmering debate over land for food versus bioenergy appears to be gaining momentum (Rossi and Hinrichs, 2011) as world population continues to increase against the backdrop of shrinking prime croplands.

Accordingly, attention has been redirected on cellulosic herbaceous perennials (CHPs) for biomass-to-ethanol conversions. The CHP that has received the greatest attention in the US is switchgrass (*Panicum virgatum, L*), which, the US Department of Energy (DOE) selected as the bioenergy model based on desirable attributes of perennial growth, abundant biomass production, excellent nutrient use efficiency, wide geographic distribution and tolerance to abiotic stressors. With over 30 years of research behind it, a considerable knowledge base currently exists on the agronomy, management and breeding of switchgrass. This information can be found in the following references (Wright and Turhollow, 2010, Sanderson et al, 2007, Casler et al 2007, Fike et al 2006 and McLaughlin et al 1999).

High biomass productivity, prodigious nutrient-use efficiency and tolerances of harsh environments are just the right qualities that are required for using CHPs for simultaneous environmental restoration, including FA consumption, while producing biomass for biofuels.

Although switchgrass was selected as the poster child for bioenergy, several native CHPs of the tall grass prairie possess similar desirable qualities. First, they need to be evaluated in the same framework as switchgrass before they can be added to the collection of bioenergy feedstock. Some of the native CHPs that are currently under investigation for biofuel production include eastern gamagrass (*Tripsacum datyloides*) and big bluestem (*Andropogon gerradii*) (Anderson et al, 2008).

For example, a recent greenhouse side-by-side comparison between switchgrass, eastern gamagrass and big bluestem, in greenhouse pot study showed that switchgrass produced the highest biomass in a silt loam soil and it was also most tolerant to soil acidity (Dzantor et al 2011, Phenotype Screening Corporation, 2011).

These studies are ongoing to enhance biomass productivity of the grasses through traditional microbial inoculations, substrate amendments and use of FA (Pettigrew et al , 2013)

In the meantime, a more recent study by different investigators showed that eastern gamagrass had comparable cellulose, hemicellulose and lignin compositions to those of switchgrass. That study concluded that on the whole process of biomass-to-ethanol conversion, gamagrass could yield 13–35% more ethanol per gram of biomass than switchgrass, indicating that gamagrass has high potential as an alternative energy feedstock for lignocellulosic ethanol production (Ge, et al 2012)

Furthermore, a previous preliminary research utilizing consolidated bioprocessing indicates that big bluestem is a superior feedstock, and may offer accelerated development for big bluestem in the biofuels arena (Weimer and Springer 2007)

Clearly, it is still too soon to declare eastern gamagrass and big bluestem, or for that matter, any other CHP as complementary and/or alternative bioenergy feedstocks to switchgrass; however, the work in this direction has begun.

ENHANCING BIOMASS PRODUCTIVIY OF CHPS IN MARGINAL LANDS

An additional requirement that must be met to accomplish bioenergy goals is to extend biomass production to marginal lands as means for avoiding or modulating the food versus fuel debate (Rossi and Hinrichs, 2011). This debate was bolstered somewhat as food prices in the US rose precipitously in 2006 with part of that increase attributable to the corn-for-ethanol production (The Congress of the United States. April 2009).

Fortunately, the issue of food versus bioenergy can be modulated somewhat by the growing emphasis on the exploitation of *marginal land* as a resource for producing biomass for bioenergy. According to a much-cited study conducted by investigators at the University Illinois, if biofuel feedstock (low-input high diversity perennials) are planted on abandoned and degraded land with marginal productivity, an estimated 26 – 55% of the current world fuel consumption could be met without affecting crop and forage production (Cai et al 2011).

This is a welcome development; however, *first, it is necessary to enhance biomass productivity of CHPs under marginal/degraded land conditions.* Increasing availability of molecular tools is rapidly revolutionizing improvements in plant productivity. Some of the techniques that are being developed are meant to overcome various stresses that limit realization of crops' productive potentials. Techniques as proteomics and transcriptome analyses are at the very early stages of development to specifically address bioenergy biomass applications (

http://opnwetware.org/wiki/Texas_Switchgrass_Collaborative , Ghimire et al, 2009).

. These technologies hold promise for the future as they are developed, assessed and validated for field deployment for sustainable production of biomass feedstock on marginal lands. As a short to medium term measure, it is necessary to capitalize on traditional approaches for enhancing crop productivity including use of microbial inoculation processes. For example, mycorrhizae fungi (AMF) associations have been used extensively in the phytoremediation implementations on FA disposal sites that was described earlier (Hendrick, 2011, http://peer.org/docs/usda/09_15_10_ARS_letter.pdf ; Babu and Reddy, 2011)

Furthermore, studies have already demonstrated use of mycorrhizae inoculations to enhance biomass production by switchgrass. In one study, inoculation of switchgrass by the mycorrhizae fungus *Sebacia vermifera* produced as much as 75%, 113% and 18% more shoot biomass than uninoculatetd controls in the first, second and third harvest respectively. A most desirable characteristic of native CHPs is their ability to rejuvenate marginal lands. As aptly pointed out in by Ghimire et al., much of the great appeal of native grasses is derived from the fact that they can be grown in marginal soils, thus minimizing the use of arable cropland and helping to stabilize and replenish these depleted areas. Importantly, it is precisely in these deficient soils that the utilization of beneficial microbes, such as arbuscular mycorrhizae and amendments such as FA and can potentially have the greatest impact (Babu and Reddy,2011 ; Waoo, et al,2011 , Juwarkar and Jambhulkar, 2008)

CONCLUSION

In 2011, coal was the fuel for about 42% of the 4 trillion killowatthours of electricity generated in the US. Burning coal to generate electricity produces of large amounts coal combustion products

(CCWs). More than half of CCWs consist of fly ashes (FAs) which can be an environmental pollutant, when improperly managed. Thus, disposal and management of FAs are major economic, human, and environmental health concerns throughout coal-based power-production nations—and beyond. Because of ever-growing populations and attendant energy consumptions, demand for electricity is expected increase progressively in the future. In spite of the current intense national focus on renewable energy and environmental sustainability, coal will continue to play significant roles in the overall energy mix of the nation. Therefore, it is important to find safe ways to dispose of and manage FAs to reduce or eliminate their potential undesirable impacts.

Fortunately, fly ashes possess physical and chemical attributes allow their beneficial utilizations. However, most of these uses are currently in the construction industry. These markets can be volatile, saturated, or otherwise dictated by whims of economic times. In the face of increasing FAs accumulations and potential land degradations, attention has been redirected onto their beneficial uses in crop production. In contrast to construction markets, demands in agriculture markets should remain high to cater to steady population growth and increasing energy consumption. The reemerging utilizations in agriculture can capitalize on knowledge and experiences gained from bio/phytoremediation strategies developed in the 1980s and 1990s for neutralizing soil (environmental) contaminants.

The current global focus on bioenergy production, in particular biomass conversion to ethanol in the US offers excellent opportunities for extending knowledge and experiences on use of FA in agriculture for producing bioenergy feedstock, especially in degraded lands, can while cleaning up FA accumulations. Prospects for beneficial use of wastes from fossil fuels to produce renewable fuels are an unassailable concept.

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Renewable Energy Policy and Planning for Future

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ABSTRACT

This paper reviews the expected wide and profound impact of nanotechnology as non-conventional energy source. Emphasis has been laid to high light importance of nanostructured organic and inorganic photovoltaics , artificial photosynthesis , nanostructures for electrical energy storage, nanotechnology for thermal insulation, nanotechnology for hydrogen storage, clean energy sources, nanorobots, . basic research, directed research , development , investment and implementation strategies etc. It also focuses on future strategies and policies to make it a revolutionary energy source.

Key words: Nonotechnology, renewable energy, photovoltics, nanorobots

INTRODUCTION

The Nanotechnology operates at such a fundamental level that its technological impacts are wide spread and multifarious(Ratner and Ratner, (2003). Accordingly, its effects on energy generation, transmission, storage and consumption are numerous and diverse. Some will be incremental and some quite possibly revolutionary. As a whole, present technologies are either too limited in terms of resources, too inefficient, or too expensive to deploy on the massive scale that will be necessary in the coming decades. It is in this context that nanoscience and nanotechnology are poised to play a transformative role in providing clean and sustainable energy from secure domestic resources in future. The past decade has shown that the technological challenges of making energy conversion and storage more efficient and more affordable are intimately tied to our understanding and control of nanoscale phenomena. In the next decade, we envision that research in nanoscience and nanotechnology will enable realization of new technologies such as low-cost photovoltaic for solar power generation, new classes of batteries for both transportation and grid-connected energy storage, efficient low-cost methods of converting both solar and electrical energy into chemical fuels, new catalysts and catalyst systems. This futuristic field of science actually dates back to 1959, though most of the major advances in nanotechnology have come in the past two decades. Today, you probably come across nanotechnology in the form of composite materials like dental implants or baseball bats. This technology also helps manufacturers make your favorite electronics smaller more portable. But the most exciting applications of this technology have come in breakthroughs made in recent years, as scientists have developed ways to apply nanotechnology to fields like medicine, robotics and the environment.

ADVANCES IN LAST DECADE

Research in the period from roughly 2000 to 2010 has shown that nanotechnology is a powerful tool for a host of processes in support of efficient, sustainable energy conversion, storage, and conservation, in terms of:

- Tailoring the interaction of light with materials and enabling the processing of low-cost semiconductors into devices such as photovoltaic
- Making more efficient photo catalysts for converting sunlight into chemical fuels
- Developing new materials and membranes for the separations needed in many energy applications
- Converting chemical fuels into electrical energy (and vice versa)
- Improving energy and power density in batteries
- Improving efficiency in areas from displays and solid state lighting to thermoelectric and friction.

There are many promising research areas from the last decade could, with proper support, become transformative technologies in the coming decade. Advances in nanomaterial's synthesis, integration into devices, and characterization, along with modelling and understanding of nanoscale physical phenomena, have all contributed to significant accomplishments in these areas (Fung et.al., 2004 ; Peng and Cho,2000).

At the applications level, selected examples of the progress made in the last decade include those discussed in the subsections below.

A. Nanostructured Organic and Inorganic Photovoltaics

In the past decade, low-cost, nanostructured organic solar cells made from polymers like plastics have emerged as one possibility. Organic photovoltaics do not rely on conventional single p-n junctions for their function. Instead, a nano-structured donor/acceptor interface is used to dissociate excitons, while providing co-continuous transport paths for positive holes and negative electrons. The generation of photocurrent comprises four successive steps: generation of excitons by photon absorption, diffusion of excitons to the heterojunction, dissociation of the excitons into free charge carriers, and transport of these carriers to the contacts. Advances in colloidal synthesis have facilitated the use of inorganic nanoparticles as precursors for low-cost, solution-phase deposition of thin-film solar cells. Nanoscale size control offers the ability to tailor optical absorption and energy band alignments, as well as the potential to utilize more exotic phenomena such as carrier multiplication to increase photovoltaic performance.

B. Artificial Photosynthesis

Photosynthesis provides a blueprint for solar energy storage in fuels. Indeed, all of the fossil fuel-based energy consumed today is a product of sunlight harvested by photosynthetic organisms. During the past decade a number of research groups have prepared synthetic analogues of the principal nanoscale photosynthesis components and have developed artificial systems that use sunlight to produce fuel in the laboratory. Fuel production via natural or artificial photosynthesis requires three main nanoscale components: a reaction center complex that absorbs sunlight and converts the excitation energy to electrochemical energy; a water oxidation complex that uses this

redox potential to catalyze conversion of water to hydrogen ions, electrons stored as reducing equivalents, and oxygen; and a second catalytic system that uses the reducing equivalents to make fuels such as carbohydrates, lipids, or hydrogen gas. Dramatic improvements in efficiency, durability, and nanosystems integration are needed in the next decade to advance artificial photosynthesis as a practical technology for energy harvesting and conversion.

C. Nanostructures for Electrical Energy Storage

Along with energy production, renewable energy systems such as solar or wind require the ability to store energy for reuse on many different scales. Electrical energy, which offers the greatest potential for meeting future energy demands as a clean and efficient energy source, can be stored by electrically pumping water into reservoirs, transforming it to potential energy and back. However, this is only possible for very large-scale localized storage. As outlined in a workshop report from the U.S. Department of Energy (2005), the use of electricity generated from renewable sources, such as water, wind, or sunlight, requires efficient distributed electrical energy storage on scales ranging from public utilities to miniaturized portable electronic devices. This can be accomplished with chemical storage (i.e., batteries) or capacitive storage (i.e. electrical capacitors). Nanostructuring can increase the efficiency of both storage, release of electrical energy, and the stability of electrode materials against swelling-induced damage from ion uptake.

D. Nanotechnology for Thermal Insulation

Based on recent DOE Annual Energy Outlook reports, residential and commercial buildings account for 36% of the total primary energy use in the United States and 30% of the total U.S. greenhouse gas emissions. About 65% of the energy consumed in the residential and commercial sectors is for heating (46%), cooling (9%), and refrigeration (10%). In addition to developing new renewable sources of energy for heating and cooling, nanotechnology can play an important role in energy conservation. Nanoscale titania low-emissivity coatings made by sputtering or chemical vapor deposition are now commonplace on commercial and residential insulating glass units (IGU). Porous and particulate nanoscale materials are also crucial to advanced thermal insulation. Silica aerogels are exceptional thermal insulators because they minimize the three methods of heat transfer (conduction, convection, and radiation).

E. Nanotechnology for Hydrogen Storage

Overall during the last decade, significant improvements in nanoparticle purity and characterization techniques have allowed the field to arrive at a consensus that it is no longer worth investigating hydrogen uptake in pure CNTs for on-board storage applications. It is anticipated that the next decade will see new types of ultrahigh-surface-area nanoscale materials, like metal organic frameworks (MOFs) designed and developed for more efficient hydrogen storage. Continued improvements in battery technology are likely to place increasing pressure on hydrogen as an energy storage medium.

F. Clean Energy Sources

For centuries, people throughout the developed world have relied on coal, oil and other fossil fuels to supply the majority of energy used for power and transportation. But fossil fuels are in limited supply, and many believe they're simply not sustainable. And not only are coal, oil and

natural gas supplies fixed, their use also causes pollution and greenhouse gas emissions. While some people have turned to alternative sources like wind or solar power, these eco-friendly energy sources represent only a small portion of the world's total energy production.

New breakthroughs in molecular nanotechnology may be the solution to the world's dependency on fossil fuels. Using nanotechnology to modify materials at the atomic level has allowed scientists to produce solar cells that are five times more effective than traditional silicon-based units. While solar panels currently in use capture only about 6 percent of solar energy, new technologies allow panels to capture up to 30 percent of solar energy, including invisible infrared rays. Installing these new solar cells across just 0.1 percent of the earth's surface would supply enough energy to eliminate the need for oil. Even better, these small flexible solar cells could be woven into the clothes you wear to charge a cell phone or computer on the go. Solar cells in cars could even be used to charge your car battery, making gas stations obsolete.

Nanotechnology also allows scientists to make more efficient and affordable fuel cells to power portable electronics and even vehicles. Traditional fuel cells resemble a battery pack, but contain an internal membrane that allows only hydrogen to pass through to supply power. Using principles of nanotechnology, manufacturers can make this membrane even more efficient, resulting in lightweight, high-powered fuel cells.

G. Nanorobots

The concept of nanorobotics reads like something straight out of science fiction where microscopic assemblers work in mini, self-contained factories. These nanofactories would fit right on a standard tabletop and measure not much bigger than a breadbox. Carbon-based "robots" within the factory could not only produce consumer goods like hardware and electronics, but also self-replicate to create new robots to join the workforce. Some of these newly created assemblers would also be used in healthcare, and could be released into the human body to capture cell-level images, repair wounds or even fix damaged DNA.

Robots within the factory would build products from the atomic level up, creating an essentially perfect object. By eliminating flaws and creating high-quality materials without the need for human labor, nanorobots would produce objects quicker and at a lower cost than traditional manufacturing processes.

While nanorobots are likely several decades away at the earliest, recent advances in nanotechnology have helped pave the way for this type of technology. In 2006, the Foresight Institute awarded its annual innovation award to researchers who developed methods that will allow nanorobots to self-replicate using DNA. In 2010, IBM introduced a micro-milling process that's capable of etching 1,000 3-D maps of the world on a single grain of salt. New materials -- like graphene, which measures just one atom thick -- also promise to advance the development of nanorobotics.

PLANNING FOR FUTURE

There are three different levels at which the nanotechnology R&D infrastructure needs to be considered: basic research “directed” or applied research, and development.

A. Basic Research

It is assumed that most of the nanoscience basic research will be done in universities and in national laboratories, because the time-line for output is too long for industry. Funding for basic research needs to be enhanced both for single investigators or small groups of faculty members, and for centres or institutes that may be located at a single campus or laboratory or involve multiple universities and national laboratories.

B. Directed Research

The challenges of directed or applied research in the area of nanostructures are more difficult for the single investigator model; the model of centre activity is recommended as the more effective approach. Research fundamental to the integration of nanosystems is appropriate for this category. Collaboration between scientists and engineers in academe, private sector, and government laboratories needs to be integrated in the directed research programs.

C. Development

The development cycle for many "nanoproducts" is expected to be too long at this time for large companies and for venture capital to be able to support this research. Resources must therefore come from the Government, and the work must be carried out in university and national labs and in incubators. However, to optimize the eventual commercialization of ideas generated through this research, it is essential that relationships between universities, national labs, and relevant industries be strengthened. Nanotechnology partnership programs should be formed, small high-tech companies can fill this role. Early success is apt to be in sensor and instrument areas. Grants can help promote the programs. Incubator programs should be developed at universities that support large efforts in the field of nanostructure science and technology. The university or national lab makes infrastructure available to a small company for a start-up, often with a faculty member or members taking the lead in the formation of the company. The "incubator" is a temporary intermediate stage in the formation of these start-up companies.

INVESTMENT AND IMPLEMENTATION STRATEGIES

Nanotechnology research and development requires a balanced, predictable, strong, but flexible infrastructure to stimulate the further rapid growth of the field. Ideas, concepts, and techniques are moving at such an exceedingly rapid pace that the field needs coordination and focus from a national perspective. Demands are high, and the potential is great for universities and government to continue to evolve and transition this science and technology to bring forth the technological changes that will enable industry to commercialize many new products in all sectors of the economy. Even greater demands are on industry to attract new ideas, protect intellectual property, and develop appropriate products. Tools must be provided to investigators in nanotechnology for them to carry out state-of-the-art research to achieve this potential and remain competitive. Centres with multiple grantees or laboratories where these tools would be available for this support should be established at a funding level of several million dollars annually. In addition to university- and government-led centres and networks, co-funding should be made available to industry-led consortia that will provide a degree of technology focus and different areas of relevance that are not always present in academic-led consortia. These centres should also have diverse research teams that will be effective in different scientific disciplines. Funding is

needed for supporting staff to service outside users at existing and new centres. We should also investigate means to achieve the remote use of these facilities.

Funding mechanisms that encourage centres and university-national laboratory-industrial collaboration should be emphasized, as well as single investigators who are tied into these networks. Support to single investigators should provide a corresponding level of personnel and equipment support. University grants should encourage work among research groups to make maximum use of concepts and ideas being developed in other disciplines. The infrastructure must include building links between researchers, developers, and users of nanotechnology innovations. The focus must be on developing critical enabling technologies that will have significant value added in many industries.

It will also be necessary to fund training of students and support of post docs under fellowships that will attract some of the best students available. Students should receive multidisciplinary training in various nanotechnology fields. Both organizational attention and funding should also be devoted to ensuring the open exchange of information in multidisciplinary meetings and rapid publication of results through, for example, workshops and widely disseminated summaries of research.

In terms of investment and implementation strategies, broadly speaking, the funding of energy-related research at both the basic sciences and applied/translational levels needs to be commensurate with the scale of this challenge over a stable, long-term period, reflecting the long-term nature of the problem. Specific recommendations for improving the effectiveness of research dollars spent on energy include:

- Continue expansion of both student and postdoctoral fellowship programs. Nanoscience and nanotechnology fellowships in energy will train the next generation of scientific leaders, while enabling the best students to choose the most innovative projects and to explore creative research with more freedom than would be possible if the student/postdoc was funded through an individual principle-investigator (PI) or centre grant.
- Create a precompetitive "Energy Research Corporation."
- Borrowing ideas and "best practices" from the Semiconductor: Research Corporation model used by the semiconductor industry could create a framework for exploring ways to strengthen precompetitive research in energy science and technology while also building closer ties between academia and industry to accelerate the movement of ideas from the lab to real-world implementation.
- Realize improved synergy, cooperation, and integration between agencies. Due to the crosscutting nature of these problems, energy research will require less-exclusive "ownership" of ideas and programs than the historical norm from Federal sponsors. Leveraging support from multiple sources to achieve major programmatic goals should be encouraged.
- Increase both average award sizes and overall success rates. Many recent "special programs" for energy research have had success rates approaching 1%. On the positive side, this reflects the large number of ideas and untapped potential for addressing the energy challenge at all levels of science; however, the 1–10% success rates typical of many new programs result in significant wasted effort by proposers and reviewers and make it difficult for program administrators to pick the best proposals in an environment with a low-signal/noise ratio.

Within Federal agencies, subunits that fund disproportionate amounts of energy research should be targeted for appropriate shares of any increases in Federal research dollars.

- Sustain support for national energy research centers and hubs. Many large energy initiatives have recently been funded by DOE and other Federal agencies. These centres have the potential to achieve transformative breakthroughs, but they will need stable/predictable support over periods longer than a single funding cycle to achieve their ambitious long-term goals.
- Fund more small team awards over longer periods. The energy challenge is interdisciplinary, and building collaborations takes time. Small team awards can promote collaboration to tackle new ideas in a nimble fashion. Awards that encourage real connections and convergence between computation and experiment have good potential for high impact.

FUTURE OF NANOTECHNOLOGY

The future of nanotechnology is completely uncharted territory. It is almost impossible to predict everything that nanoscience will bring to the world considering that this is such a young science. There is the possibility that the future of nanotechnology is very bright, that this will be the one science of the future that no other science can live without. There is also a chance that this is the science that will make the world highly uncomfortable with the potential power to transform the world.

Even positive changes can make world leaders and citizens alike very nervous. One of the top concerns regarding the future of nanoscience includes molecular manufacturing, which would be the ability to bring materials to life from the simple molecular reconstruction of everyday objects. This technology could end world hunger. At the same time, this process could lead to experimental molecular manufacturing with live beings.

CONCULSION

During the last five years understanding and knowledge about the risks of nanoscale particles and nanotechnologies have increased substantially. Our approach needs to be careful and responsible. Instead of concentrating only on the conventional sources of energy, we can also think about the use of nanotechnologies in a positive way. We can set the targets and objectives of the research so that they can help us to solve the environmental challenges that we will have in front of us during the coming decades. We should develop new electronics materials that are easier to recycle and/or decomposable in biological processes, and optimize and minimize the energy consumption in the manufacturing of future materials and products. Let us set the targets right focus in the right set of technologies and introduce nanotechnologies into the public arena in a responsible way. Nanotechnologies can be one key solution towards sustainable future.

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