

Techno-economic Assessment of Bioenergy in India

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Technology Information Forecasting and Assessment Council (TIFAC) under Ministry of Science and Technology awarded IRADe a project “**Techno-economic Assessment of Bioenergy in India**” to prepare a report reflecting on various issue of bio-energy in India.

The paper will bring out the objective to prioritize investment opportunities for technology development and its market adaptation and appropriate policy focusing on the following:

- Potential resources in India
- Status of technology in terms of cost and performance - in India and abroad, which would also include life cycle costing
- Barriers and constraints – both technology and market
- Technology interventions required – latest state of the art with identification of specific investment opportunities and relevant centers in the country with level of technology development required e.g. R&D, demonstration or commercial
- Policy interventions required
- Recommendations and action plan

Chapter 1- Introduction>>Background >> Introduction>>Objectives

Chapter 2 – Biodiesel >>Introduction >> Oil seed Species >> Status of Technology for Oil Production >> Biodiesel Production Process >> Transesterification >> Biodiesel Technology Development in India >> Biodiesel Technology Development in Abroad >> Economics of Biodiesel Production >> Biodiesel Storage and Stability >> Barriers and Constraints >> Policy interventions >> Recommendations and Action Plan

Chapter 3- Bioethanol >> Introduction >> Feedstock for Ethanol Production >> Ethanol Production and Sugar Industry >> Process Diagram of the Ethanol Production >> Status of Technology in terms of Cost and Performance in India >> Technology and Economics of Ethanol from Sugarcane-Sugar Molasses >> Ethanol Production from Sugar via Sugarcane >> World- Status of Technology for ethanol Production >> Distillation of Raw Material and Wood >> Economic Valuation of Ethanol Production from Sugar via Sugarcane >> Technological and Market Constrains in Ethanol Production >> Latest Technological Intervention >> Policy Interventions for Bioethanol Production >> Recommendations >>

Chapter 4- Biomass Gasification >> Biomass Gasification >> Gasification in India >> Gasification Technology >> Gasification Process >> Design of Gasifiers >> Next Generation of Biomass Gasifiers >> Cost of Electricity Generation by Biomass-based Power Stations >> Thermal Application of Gasifiers >> Institutional Experiences >> Barriers for Biomass Gasification >> Case Study: Problems encountered at Hosahalli >>

Abbreviations , Annexure, References

Executive Summary

Energy, especially from fossil fuels, is a key ingredient for all sectors of a modern economy and plays a fundamental role in improving the quality of life in less developed economies. In 2001, India was ranked sixth in the world in terms of energy demand; accounting for 3.5% of total energy consumed, and is expected to grow at 4.8% in the future. India imports 70% of the oil it uses, and the country has been hit hard by the increasing price of oil, uncertainty and environmental hazards that are concerned with the consumption of fossil fuels. In such context, bioenergy constitute a suitable alternative source of energy for India, as large amounts of raw material are available to be harnessed.

Among various options available for bioenergy, biodiesel, bioethanol and biomass gasification are three major options, which have huge potential in India to develop as energy sources and where investments made would be economical. India has approximately 50 million hectares of degraded wasteland that lie outside the areas demarcated as national forests, and another 34 million hectares of protected forest area, in much of which tree cover is severely degraded. A massive programme is needed to develop energy plantations consisting of oil seed species for biodiesel production and fast-growing tree crops for a national network of small, decentralised biomass gasifiers power plants. The irrigated cropped area could be used for sugarcane growing for bioethanol production.

The present report reviews the status of technology in terms of cost and performance for biodiesel, bioethanol and biomass gasification in India and abroad. It also highlights barriers and constraints and technology interventions required for the development of these bioenergy options. It suggests policy interventions and action plan for the development and promotion of bioenergy in India.

Chapter 1 ‘Introduction’ presents an overview of national energy scenario and bioenergy option, its importance and viability in the present context and also puts across the objectives of the report and its scope. It outlines the need for bioenergy and highlights the three major options of bioenergy in India.

Chapter 2 ‘Biodiesel’ deals with oil seed crop, cultivation practices, technology for oil processing, R&D work, economics of biodiesel production, barriers and constraints and policy framework and action plan for feasibility of biodiesel in India.

- For mass cultivation, *Jatropha* and *Pongamia* are well-established species for biodiesel production but *Jatropha* has wider adaptability and multiple benefits. Other oil seeds may be considered, if suitable to specific agroclimatic conditions.
- The cost of *Jatropha* cultivation could be reduced by agroforestry interventions and raising seedling in nursery beds instead of polybags.
- The biodiesel production process consists of mainly two steps, the oil extraction and the conversion of oil to biodiesel i.e. processing of oil.
- The general biodiesel process and the transesterification process are described. Though batch and continuous processes are used for commercial production of biodiesel, in general, intermittent supplies of oil seeds suggest the use of batch systems. Continuous systems generally requires the operations on a 24/7 basis, requiring larger capacities to justify larger staffing requirements and also require a more uniform feedstock quality.
- Three scenarios with purchase price of *Jatropha* seed as Rs.4, 5 and 6 per kg have been evaluated. It was found out that to get 15% return on investment; biodiesel can be produced at Rs.18.1 20.7, 23.3 per litre at the seed price 4, 5, and 6 Rs/kg respectively. However, this assumes that byproducts viz. glycerine and oil seed cakes are sold at reasonable prices i.e. Rs. 30/liter and Rs. 1/kg, respectively.
- The seed price and byproducts sale price are the major factors affecting price of biodiesel. Management of byproducts will be the most important factor for the economic viability of biodiesel production. The concept of biorefinery is suggested to make use of every byproduct after some value addition.

- The toxicity of oilseed cake restricts its use as manure and animal feed. Research and development needs in this area should be addressed at the earliest.
- MOEF should identify areas for *Jatropha* cultivation among forest areas at the earliest and process the mechanism for its availability to JFM committees/societies.
- The declaration of Minimum Support Price of *Jatropha* seeds by MOA will encourage farmers to undertake plantation.
- The research and development are strongly needed for producing elite planting material and standardisation of agronomic practices for different agroclimatic conditions so a national coordinated research project by ICAR is advocated.
- For raising plantation on community land, a cooperative model (e.g. Amul, IFFDC) may be most suitable. Forest Department should be strengthened to undertake *Jatropha* plantation on forestlands themselves or through JFM societies.
- A nodal agency is suggested to identify and cater all research and development needs on commercial biodiesel production and also coordinate among all institutes and organisations for this purpose.

Chapter 3 ‘Bioethanol’ *describes the different sources and routes of bioethanol production, technology and market interventions needed, economics of production through molasses and cane juice and recent advances in the direction of bioethanol production.*

- Sugar, starches and lignocellulose are three major sources for bioethanol production worldwide. Molasses from the sugar industry is the most commonly used raw material for the production of ethanol in India.
- India has huge area under sugarcane (nearly 4.63 mha in 2004-05) and annual sugarcane production was around 333.3 mt in 2004-05. But in the absence of a well-knit policy in the past for purchasing and blending ethanol, not many distilleries have been producing ethanol.
- Enzymatic and non-enzymatic route of bioethanol production are described. A study shows the amount of ethanol produced from bagasse is more in the case of enzymatic process (0.238 Kg ethanol/Kg bagasse) than the two-stage dilute acid

process (0.186 ethanol/kg bagasse) clearly indicating superiority of enzymatic process.

- No comprehensive study has been done till now on the economics of ethanol production from sugar via sugarcane, however a study shows that comparative value added benefits are more (\$9.36/mt) in route from sugarcane to sugar as compared to \$ 5.66/mt in sugarcane to ethanol process.
- Keeping in view the huge availability of raw material and ethanol demand, Acid Catalyzed Organosolv Saccharification (ACOS), the only known wood hydrolysis process capable of total (residue-free) dissolution of any wood or agricultural residue could be a good option for distillation of biological material and wood for ethanol production.
- Central government tax policy, clearance on capacity addition of sugar mills by states, fixing prices by tendering are considered as major market constraints.
- The lower plant capacity, use of batch process technology, inefficient pollution control technologies and non-economic returns from co products and effluents are among major technological constraints.
- Biotechnology applications to increase the sugar/starch content in the crops through bioengineering will result in better recovery and lower down the cost of ethanol production. Besides this, expanding capacity of plants for production and use of latest techniques like use of membranes and microbes are technologies interventions for increasing the production of ethanol.
- Several policy issues at national and state level are discussed and an action plan for bioethanol production and its phase wise expansion is suggested.
- It is suggested to provide bioethanol all incentives similar to that availed by other renewable sources of energy, in terms of reduced taxes, duties etc. along with streamlining state policies for molasses and other substrates.

Chapter 4 ‘Biomass Gasification’ deals with potential of gasification in India, designs of gasifiers, new generation gasifiers, power generation and cost of electricity generation and thermal application of gasifiers. It also reviews existing policies at national and state level and provides recommendations and suggestions for policy issues.

- Biomass gasifiers capable of producing power from a few kilowatts up to 500 Kw have been successfully developed indigenously and are also now being exported to the developing countries of Asia and Latin America, and also Europe and USA. India has potential to become world leader in the field of small and medium biomass gasifiers.
- Design of gasifier depends upon type of fuel used and whether gasifier is portable or stationary. In Indian market, generally downdraft gasifiers are available due to utilization of mechanical mode.
- A summary of latest research and technology development and demonstration for next generation biomass gasifiers has been presented, which are broadly representative of the current status of biomass gasifiers worldwide.
- Most of the industry linked gasification plants are likely to provide a commercially acceptable ROI and IRR over a 10 or 15 year financial evaluation period, with quite a short stabilisation period. The profitability of retrofitting gasifiers to existing IC engines is even better.
- The potential of thermal application of gasifiers as industrial furnaces, fired heaters, dryers, oven, small boilers, kilns in various industries like silk, textile, agro processing and small chemical industries are explained in detail with case studies.
- The integration of process and equipments of gasifiers with small-scale industries require system engineering and is major technical barrier. There is hesitation among small industry users and conventional financial institutes in investing in this new technology.
- Besides these, the lack of in house capabilities of small and medium industry users in solving operational and maintenance problems poses a significant barrier in promotion of technology.
- The existing and suggested policy frameworks for all stakeholders like government; industry, financial institutes and end users are explained in detail suggesting an action plan for the promotion of biomass gasifiers in India.