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Let’s create a better future with Renewable Energy & Energy Efficiency!
Today, Renewable Energy (RE) has emerged as a promising solution to address the grim reality of climate challenge and energy security. India is positioned to maximize the gains from large availability of solar, wind, biomass and hydro energy sources. As of now, India produces around 14,775 MW of grid interactive power from wind, biomass, hydro, etc., which is equivalent to about 10 percent of the total installed power generation capacity of 1,52,360 MW. The 11th Five Year Plan (2007-2012) has targeted capacity addition of 14,000 MW from grid interactive and distributed RE power generation. Out of this, the share of Biomass and Bagasse Cogeneration power is around 2,100 MW. A sizeable biomass power potential is still waiting to be tapped for a variety of barriers present.

With due recognition of such barriers, the Ministry of New and Renewable Energy (MNRE) is currently implementing a UNDP/GEF supported project on, “Removal of Barriers to Biomass Power Generation in India”. The core objective of this project is to lay a sound framework so as to catalyze a sustainable growth of the biomass power sector within the country through a series of technical, financial and capacity building measures. Dissemination of broad based information to the stakeholders is one of the important activities of the present project. In that direction, this quarterly magazine entitled “Bioenergy India” is being brought out under this project. It is intended to cover technological, operational, financial and regulatory aspects of various biomass conversion technologies such as combustion, cogeneration, gasification and biomethanation.

Biomass specific project perspectives, technology innovations, industry/market outlook, financial schemes, policy features, best practices and successful case studies, etc. would also be included for publication. This inaugural issue includes an overview of UNDP/GEF Biomass Power Project, two articles each on biomass combustion and cogeneration, besides GE experience on large capacity producer gas engines, details on new policy initiatives, news snippets and books reviews etc.

This magazine is available on MNRE (www.mnre.gov.in) and UNDP (www.undp.org.in) websites. We hope that you would find this publication useful. I request you to share interesting information, which has bearing on the project development in biomass sector, to supplement our efforts. I also look forward to receiving your response and suggestions for making this newsletter more relevant and valuable, as we move along together.

(K.P. Sukumaran)
Adviser &
National Project Director
MESSAGE

I am happy that the Ministry is bringing out a quarterly “BIOENERGY INDIA” focusing on activities and issues related to the Biomass Power Sector including Bagasse Cogeneration.

In recent times, the Ministry has made significant progress in catalyzing generation of Grid Interactive as well as Decentralized Distributed Power based on surplus biomass as well as in evolving a conducive policy framework. There is, however, a need for even greater thrust in this area in order to further facilitate the removal of existing barriers.

I hope that this Magazine will not only disseminate useful information but will also provide a useful platform for experts, investors and other stakeholders to exchange their experiences and expertise and to discuss issues related to harnessing biomass energy in an efficient and cost effective manner.
MESSAGE

The United Nations Development Programme (UNDP) is supporting the Government of India in promoting sustainable environmental management. The thrust is on building national capacity for environmentally sustainable development, promoting best practices and supporting strategically selected interventions. Countering climate change is one of the important focus areas of UNDP for supporting adoption of clean and environment-friendly technologies.

I am pleased that the Ministry of New and Renewable Energy (MNRE) is bringing out this quarterly magazine – Bioenergy India – to disseminate information related to biomass power sector under a project supported by the UNDP and the Global Environment Facility (GEF). The key objective of the project titled “Removal of Barriers to Biomass Power Generation in India” is to accelerate the adoption of environmentally sustainable biomass power technologies by removing the identified barriers, thereby, laying the foundation for the large-scale commercialization of biomass power through increased access to financing. I hope that the experience and learnings emerged in implementation of the project will influence formulation and/or revision of policies of the Government of India in this sector. This magazine will be an important tool to communicate the outcomes of this project for wider dissemination.

I extend my best wishes to all those associated with the publication of this magazine and hope that it would benefit all concerned in this field.

Patrice Coeur-Bizot
UN Resident Coordinator &
UNDP Resident Representative
MESSAGE

With the growing concerns for Climate Change, Energy Security and Rising Cost of Fossil Fuels, the Renewables assumes a vital role in the total energy mix, not only in the developing economies like ours but in the entire world. India, currently generates over 14,775 MW of grid interactive power from renewables which accounts for nearly 10 percent of the total installed power generation capacity in the country, besides over 1,500 MW towards captive/combined heat and power/ distributed renewable power.

Biomass Power Generation including Bagasse Cogeneration has continued to increase both in large and small scales, with an estimated addition of around 700 MW of power capacity during 2008-09, bringing the aggregate biomass power capacity to over 2,200 MW.

While implementing various schemes and programmes of the Ministry, certain barriers were experienced which impend faster realization of the available potential for variety of end-use applications. Studies on different aspects of biomass utilization for generation of energy and/or power commissioned under the UNDP/GEF Biomass Power Project will be useful in evolving an integrated policy for optimum utilization of biomass which will take into account the economics of scale, comparative merits of various options -distributed vs large biomass power plants -including the possibility of use of biomass at the point of consumption, preferably at the tail end of the grid, technology options for various end uses etc. The Model Investment Projects (MIPs) proposed to be established in different part of the country will be able to demonstrate the viability of new investment and financing model for mainstreaming the biomass sector. These MIPs are expected to act as the “Best Practices” and also to facilitate in developing comprehensive mechanism for management of field distributed as well as captive biomass/crop residues so that secured fuel supply linkages could be established for sustained operation of the plants at the planning stage of project development. The experience gained, I hope, would be helpful in formulating a mission mode implementation of biomass programme.

I have no doubt that the publication of the quarterly Magazine “Bioenergy India”, which encompasses the full spectrum of biomass energy sector related information, will prove useful in creating awareness and dissemination of information.

(Deepak Gupta)
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An Overview of UNDP / GEF assisted Project on “Removal of Barriers to Biomass Power Generation in India”

Background
The Ministry of New and Renewable Energy (MNRE) is implementing a scheme for the promotion of Grid Interactive Power Generation Projects based on Renewable Energy Sources that covers projects based on biomass. Fiscal incentives such as accelerated depreciation, import duty concessions, excise duty exemption, tax holiday for 10 years etc. are being provided, besides capital subsidy for power generation projects based on biomass and bagasse cogeneration. The State Electricity Regulatory Commissions (SERCs) in Andhra Pradesh, Haryana, Punjab, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu, Gujarat, Kerala, Punjab and West Bengal have announced preferential tariff for such power projects, in addition to announcing RPOs. In the last 10 years, about 221 projects aggregating to 1,904 MW have already been commissioned in different parts of the country. The states which have taken a leadership position in implementation of biomass power projects are Andhra Pradesh, Karnataka, Tamil Nadu, Chattishgarh, Maharashtra and Rajasthan.

While implementing the Program, certain barriers were experienced which impede faster realization of the available potential for a variety of end-use applications. Some of the major barriers experienced were inadequate information on biomass availability, existence of non-formal biomass markets, problems associated with management of biomass collection, transportation, processing and storage, problems associated with setting up large size biomass plants, non-availability of cost effective sub-MW systems for conversion of biomass to energy, non- versatility of boilers being able to take a variety of biomass stocks simultaneously, lack of capability in some sugar mills to generate bankable projects on account of financial and liquidity problems, low capacity factors of some existing biomass projects etc. Therefore, there was a need to address these barriers to achieve the target of 2,100 MW from biomass and bagasse cogeneration out of the total renewable based grid interactive power generating capacity of 14,000 MW planned during the 11th Five Year Plan (2007-2012).

UNDP / GEF Biomass Power Project
The Ministry is currently implementing a UNDP / GEF assisted project on “Removal of Barriers to Biomass Power Generation in India.” The total outlay of the project is USD 10.89 million (equivalent Rs. 54.45 Cr.) in which UNDP/GEF contribution is USD 5.65 million. The remaining USD 5.24 million is from GOI / MNRE.

Key Objectives of the Project
The key objective of the project is to accelerate the adoption of environmentally sustainable biomass power technologies by removing the barriers identified, and thereby laying the foundation for large scale commercialization of biomass power through an increased access to financing. The biomass conversion technologies that are proposed to be deployed are combustion, gasification and cogeneration using different type of captive and distributed biomass resources. Various other objectives are:

- Technical Assistance (TA) for the barriers removing activities which impede large scale deployment of the technology.
- Increased access to financing by creating contingent funds for Investment Risks Mitigation and for setting up of Model Investment Projects (MIPs), which would act as “Best Practices” for faster replication of biomass power in other states; and
- Projects to be undertaken in three different contexts – cooperative sugar mills, agro processors and biomass producers, and distributed or decentralized biomass.

Institutional Arrangements - Though MNRE is responsible for an overall execution and implementation of this multi-dimensional project, a management structure as outlined below has been activated with its operational office within the Ministry itself:

Project Management Cell (PMC) - A dedicated Project Management Cell (PMC) has been established in the Ministry, which is responsible for all the actions. Shri K P Sukumaran, Adviser (Wind & Biomass) and Shri V.K. Jain, Director have been designated as National Project
Director (NPD) and National Project Coordinator (NPC) respectively for the same.

**Project Steering Committee (PSC)** - A Project Steering Committee (PSC) has been constituted under the Chairmanship of the Secretary, MNRE and members inducted from various concerned Central Ministries and UNDP. The PSC is to approve annual work plans and implementation arrangements, review project activities and decide on the proposals for extension, modification of the program. The NPD is a Member Secretary of the PSC.

**Project Executive Committee (PEC)** - A Project Executive Committee (PEC) has been constituted under the Chairmanship of the Joint Secretary, MNRE and includes NPD, NPC and UNDP as members. PEC is to conduct periodic review of the implementing activities and discussion on the issues requiring remedial measures that may arise during the course of project implementation.

**Flow of Funds** - Indian Renewable Energy Development Agency (IREDA) has been designated as the Fund Handling Agency (FHA) of the project. Funds are placed at the disposal of IREDA by MNRE and UNDP & disbursed to all concerned out of these deposits on receipt of Payment Release Advice (PRA) from NPD.

**Project Strategy and Implementation Approach**

The Project, specifically, has two components - (i) providing technical assistance for barrier removal activities to various identified stakeholders; and (ii) extending contingent support for demonstrating the Model Investment Projects (MIPs).

**Technical Assistance for Barrier Removal Activities:**

The Technical Assistance (TA) is for the activities that address barriers that are generic for the biomass sector. The major components of this assistance are clustered into four components designed to remove technology barriers; information, policy and regulatory barriers; institutional barriers to biomass power deployment and sustained fuel supply linkages. The support will therefore be utilized for identification of barriers and novel practices, capacity building of different stakeholders, knowledge-experience (performance) sharing for advocacy, and information dissemination. Specific support will also be provided to relevant stakeholders for reviewing existing project development and standardization of power purchase agreements, project appraisal guidelines, bidding documents, etc., besides establishing secured fuel supply linkages for sustained operation of the plants, such as setting up of biomass depots, entrepreneurs’ / farmers’ cooperatives, which will lead to rural employment generation, particularly of women, and reduction in poverty.

**Contingent Financing for Model Investment Projects (MIPs)**

As part of this project, it is envisaged that 8-10 MIPs be established for generation of grid interactive and decentralized distributed power. The aim is to showcase the viability of new investment and financing models for mainstreaming the biomass power sector, and these are also expected to act as the “Best Practices” for faster replication in other states. As such, these projects will be representing a cross-section of the type of technologies, feedstock, and regional diversity considered essential for stimulating the range of biomass options found within India.

In the biomass sector (other than the sugar mill sub sector), the MIPs are categorized into less than 1 MW and greater than 1 MW of installed plant capacities. While MIPs with less than 1 MW are to be based on gasification technology, others may be based on cogeneration or combustion technologies. Thus the MIPs would reflect the specific characteristics of these sub-segments in addressing the barriers and would correspond to different approaches adopted for each biomass sector.

To promote investment through conventional financing channels, a special provision through a ‘Flexible Framework’ of contingent financing has been proposed. This framework would address barriers and risks that are incremental in the three identified biomass sectors. The support in establishment of the MIPs will have two components – Technical and Financial Assistance as outlined below:

**Technical Assistance for MIP’s:**

The Technical Assistance (TA) focuses on activities that address barriers specific to the MIPs. Technical support to investors will be provided for project development, project appraisal, for verifying biomass assessment and depot mapping to ensure secured supply of fuel.
The TA funds for MIPs will be a one-time grant to the development and successful commissioning of MIPs, which will enable all the stakeholders to learn about the intricacies of the project and related investments.

Financial Support for MIPs
A customized, restructured financial model defining quantum and mode of financial incentives for these MIPs is currently under development. It is expected to have one or more components of grant and/or loan to support towards equity, securities/guarantees for raising loan from FIs, for bridging viability gaps, etc, besides incentives/support to FIs for strengthening their capabilities and expertise in handling biomass project.

The said approach along with enunciation of the technical & financial features is expected to boost the confidence levels of FIs in the biomass sector and will help them in the post project replication phases. FIs are expected to then develop a new mechanism for partial or total funding for such investments in the post project phase or to link them with their existing financing schemes and terms as appropriate.

Criteria for the Selection of MIPs
The broad criteria for short listing MIPs will be as follows:
- Financial viability of the project / financial capability of the promoter
- Innovative character of the project [sub-criteria: a) Technology, b) Institutional Framework, c) Fuel supply chain and d) Waste / Emissions Management]
- Replicability (in the proposed state)
- Social and Environmental Impact
- Past Experience of promoter and manufacturer (track record)

The activities being taken up during the year 2009 - 2010 under the project are as follows:
- Development of technology package, benchmarking and validation for different biomass power technologies
- Biomass resource assessment studies
- Development of ‘Good Practice Documents’/’Generic Documents’ for enhanced capacities and confidence of project promoters, financial institutions, regulators, policy makers, SNAs and other stakeholders through effective information development & dissemination program, along with capacity building initiatives.
- Development of business, commercial and support services networks in different states
- Creation of fund for contingent financing
- Identification of sites and potential investors for establishment of MIPs

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<thead>
<tr>
<th>Particulars</th>
<th>Colour (Rs)</th>
<th>Black and White (Rs)</th>
</tr>
</thead>
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<tr>
<td>Back Cover</td>
<td>20,000.00</td>
<td></td>
</tr>
<tr>
<td>Front and Back Inside Cover</td>
<td>18,000.00</td>
<td>10,000.00</td>
</tr>
<tr>
<td>Inside Full Page</td>
<td>15,000.00</td>
<td>8,000.00</td>
</tr>
<tr>
<td>Inside Half Page</td>
<td>8,000.00</td>
<td>3,000.00</td>
</tr>
</tbody>
</table>
Introduction
Cogeneration facility is defined as one which simultaneously produces two or more forms of useful energy such as electrical power & steam or electrical power and shaft power, etc., by the use of fuel. Use of conventional combustion technology is made for producing steam through burning of bagasse. The sugar mills usually generate power by burning of bagasse. The bagasse produced during the crushing season within a sugar mill is burnt in the boiler to generate high pressure superheated steam (87 ata and 515°C). Steam thus made available is fed into the steam turbine, which in turn is coupled to an alternator to produce power. The outlet steam from the turbine coming at a lower pressure is used for processing sugarcane juice to derive sugar.

It is a common practice with the sugar mills to use bagasse as a fuel during the crushing season and substitute its coal by biomass during the lean season i.e. non-crushing season. To put it in quantitative terms, a sugar mill of 2,500 TCD can produce approximately 12-14 MW of useful power. In the normal course, a sugar mill without cogeneration uses about 50 percent of bagasse for steam generation, while the surplus bagasse was sold to the paper mills for obtaining some additional income. In contrast, sugar mills with cogeneration make use of the entire bagasse and produce some surplus power.

Captive requirements of power are met in this manner and the remaining power is sold to the grid thus enabling a project developer to earn higher income. The key outcome is a definite increase in the profitability of sugar mills. Various state governments, including the state of Tamil Nadu, are successfully running cogeneration programs. To put it in perspective, there are about 18 private sugar mills and 3 cooperatives in Tamil Nadu that have installed cogeneration plants. As of now, the total installed capacity under cogeneration in this state is around 466.10 MW. It is roughly equivalent to around 30 percent of the cumulative capacity of bagasse generation for the entire country. The exportable surplus is 256.11 MW as on March 31, 2009. Tentative cost of a cogeneration plant often varies between Rs. 35-40 million per MW. The Ministry of New and Renewable Energy (MNRE) offers capital subsidy, while loan is available from the Indian Renewable Energy Development Agency Limited (IREDA) and other financial institutions.

Early development of Cogeneration Projects
For India, biomass has always been an important energy source. From the days of the earliest recorded history to the present, biomass has been the mainstay of energy for cooking and heating. If biomass used in the country was to be substituted by petroleum products, we would need to import an additional more than 30 million tons of crude oil every year, costing Rs. 500 billion. It is the power generation potential of biomass, however, which has been attracting greater attention in recent times. High cost of diesel, non-availability of coal for captive power generation, recurrent shortages of power for industrial use and the recent thrust on distributed generation, have all been behind the interest in this option of power generation.

MNRE recognized the potential role of biomass power in the Indian economy quite early, and since then has been the vanguard of its promotion. Over the last two and a half decades, biomass power has become an industry which attracts annual investments of over Rs. 1,000 crore, generates more than 700 crore units of electricity and creates employment opportunities of more than 10 million man days, all in rural areas. As a further outcome of the carefully planned mix of policy and fiscal/financial incentives introduced by the Government, capacity has been built up in the country for absorption of biomass power technologies, their operation & maintenance, management of biomass collection, manufacturing of equipment and for resolving grid interfacing issues. The significant capacity of successful biomass power projects, including cogeneration ones, established by private sector promoters, is a testimony to the effectiveness of the Ministry’s efforts.
Potential Assessment of Bagasse Cogeneration

India is the world’s second biggest producer of sugarcane. Indian sugarcane production during 2006-07 was 320 million tons, which in turn would have generated around 45 million tons of dry bagasse. On calorific value basis, this is equivalent to almost 45 million tons of coal. India’s 550 working sugar mills crush around 200 million tons of cane per year and generate 60 million tons of mill wet bagasse (50 percent moisture), of which they consume around 50 million tons for meeting captive requirements of power and steam. Around 8 million tons of mill bagasse is required for making paper by the paper mills. It was pointed out by a Task Force set up by the Ministry in 1993 that if, all the sugar mills existing at that time, were to modernize and adopt technically and economically optimum levels of cogeneration for extracting power from the bagasse, an additional 3500 MW could be generated. Recent increase in cane milling capacity, developments in cane milling and juice processing technologies, and improvement in steam and power generation devices have now made it viable to generate still higher amounts of additional power. The trends also indicate that in future, mills would crush most of the produced cane, releasing additional power generation potential through cogeneration. Ultimately, if all the cane was crushed in large mills, it may be possible to get 6,000-7,000 MW additional power through cogeneration. Sugarcane cultivation also results in production of trash in fields comprising mainly of dry leaves. It typically constitutes around 7 percent of clean cane, and is disposed off by burning in fields, or is mulched in the soil. There is an inherent potential for generation of around 2,000 MW of power by use of 20 million tons of trash produced every year.

Evolution of Cogeneration Technologies

The most commonly used definition of cogeneration, which is also perhaps conceptually the most accurate, has been given by ASHRAE and states “sequential production of both useful heat and electricity, by use of fuel at only one point in the system.” In simple terms, it implies that the exhaust of a steam turbine instead of being sent to condenser, is utilized in a heating process so that overall usage of heat is improved.

As can be seen from the definition, the concept is independent of fuel type. However, since MNRE is concerned with renewable energy promotion, it was asked to promote biomass-based cogeneration also. In India, the official definition of cogeneration states “a facility which simultaneously produces two or more forms of useful energy such as electric power and steam.” Two types of cogeneration are defined as topping and bottoming cycles and certain qualifying conditions have been laid for each. These definitions and qualifying conditions have been followed by some of the State Electricity Regulatory Commissions also. However, detailed discussion on these is beyond the scope of this paper. It may not be out of place to mention here that the gazette notifications on cogeneration were issued in 1995 by the Ministry of Power, as a spin-off to the impact of MNRE’s Biomass Cogeneration Program.

The Biomass Cogeneration Program is currently divided into two components – bagasse based and non-bagasse based. While bagasse cogeneration is essentially sugar mills oriented, non-bagasse biomass cogeneration can be used by any industry. The Ministry has two separate programs for these.

Bagasse Cogeneration

In India, sugar mills have almost always cogenerated steam and electricity using bagasse produced during crushing. However, the level of cogeneration has improved over the years as brought out in Table 1. Before 1970s, steam generation pressures / temperatures were low, boiler / turbine efficiencies were low, steam requirements for process were high and hence the mills were neither self sufficient in their steam requirements, nor in electricity. Over the years, more efficient boilers / turbines and higher pressure steam generation were adopted and by the 1990s, the mills started to not only become self sufficient in steam and electricity, but they even had some surplus bagasse.

Alternative uses of the surplus bagasse for paper making, etc., were then explored but due to large quantities involved, disposal of surplus bagasse itself became a problem in most cases. Taking note of the potential for additional power generation by improving the efficiency of use of bagasse, the Ministry initiated the program for promotion of ‘optimum cogeneration’ in 1993-94. It involves generation of all the technically and economically viable quantum of electricity from the bagasse produced by a mill, in addition to meeting optimized steam requirements. The Task Force set up by the Ministry in 1993 estimated that by use of optimum
Table 1: Evolution of bagasse cogeneration in India since 1970s

<table>
<thead>
<tr>
<th>Period</th>
<th>Mill Capacity (TCD)</th>
<th>Steam Pressure/Temp. (bar/oC)</th>
<th>Electricity Generation (MW)</th>
<th>Bagasse Self Sufficient (%)</th>
<th>Electrical Self Sufficient (MW)</th>
<th>Boiler Efficiency</th>
<th>Specific Steam Consumption</th>
<th>Steam on Cane (kg/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>&lt;1000</td>
<td>11/200</td>
<td>0.5</td>
<td>-15%</td>
<td>-0.5</td>
<td>&lt;50%</td>
<td>20</td>
<td>65%</td>
</tr>
<tr>
<td>1980</td>
<td>&gt;1250</td>
<td>21/380</td>
<td>1.5</td>
<td>-5%</td>
<td>-0.8</td>
<td>&lt;55%</td>
<td>15</td>
<td>60%</td>
</tr>
<tr>
<td>1990</td>
<td>2500</td>
<td>45/440</td>
<td>3.5</td>
<td>+5%</td>
<td>0</td>
<td>60%</td>
<td>8</td>
<td>55%</td>
</tr>
<tr>
<td>2000</td>
<td>5000</td>
<td>64/485</td>
<td>22-24</td>
<td>-</td>
<td>+18</td>
<td>&gt;70%</td>
<td>5.8</td>
<td>&lt;48%</td>
</tr>
<tr>
<td>Modern</td>
<td>&gt;5000</td>
<td>84/510</td>
<td>25-30</td>
<td>-</td>
<td>+25</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2007</td>
<td>&gt;5000</td>
<td>105/525/110/540</td>
<td>~35</td>
<td>-</td>
<td>~30</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2: Change in marginal utility of bagasse with change in inlet pressure/temperature conditions

<table>
<thead>
<tr>
<th>Inlet Pressure bar (a)</th>
<th>Temp °C</th>
<th>Gross enthalpy (kcal/kg)</th>
<th>Net enthalpy (kcal/kg)</th>
<th>Fuel required (Tons/hour)</th>
<th>Energy generation possible (kWh)</th>
<th>Marginal utility of fuel (kWh/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>250</td>
<td>690</td>
<td>590</td>
<td>20.9</td>
<td>4144</td>
<td>-</td>
</tr>
<tr>
<td>33</td>
<td>330</td>
<td>730</td>
<td>630</td>
<td>22.3</td>
<td>5755</td>
<td>1.151</td>
</tr>
<tr>
<td>33</td>
<td>380</td>
<td>760</td>
<td>660</td>
<td>23.4</td>
<td>6354</td>
<td>0.545</td>
</tr>
<tr>
<td>45</td>
<td>400</td>
<td>765</td>
<td>665</td>
<td>23.5</td>
<td>6406</td>
<td>0.520</td>
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<tr>
<td>45</td>
<td>440</td>
<td>790</td>
<td>690</td>
<td>24.4</td>
<td>7367</td>
<td>1.067</td>
</tr>
<tr>
<td>64</td>
<td>485</td>
<td>810</td>
<td>710</td>
<td>25.2</td>
<td>8196</td>
<td>1.036</td>
</tr>
<tr>
<td>87</td>
<td>510</td>
<td>853</td>
<td>753</td>
<td>26.7</td>
<td>10100</td>
<td>1.27</td>
</tr>
<tr>
<td>105/110</td>
<td>525/540</td>
<td>~850</td>
<td>~750</td>
<td>26.7</td>
<td>10150</td>
<td>-</td>
</tr>
</tbody>
</table>

**Note** – In pure power generation mode, around 2 kg of bagasse is required for generation of 1 kWh. As compared to this, units generated from the additional fuel required to be burnt to enhance the pressure and temperature conditions show much less quantity of fuel requirement. Thus, higher pressure/temperature conditions are desirable.

cogeneration, 9 MW of surplus power could typically be generated from a 2,500 TCD mill. This could be achieved through increase in pressure/temperature conditions of steam generation and also by improving the efficiency of bagasse use. The main justification for increase in pressure and temperature conditions lies in improved marginal utility of fuel. Table-2 brings this out explicitly. It can be seen that for every increase in pressure and temperature, additional fuel consumed has a higher power utility as compared to the case of its use for pure power generation.

The figures have been worked out using simplified assumptions (such as the assumption that the exhaust steam conditions remain the same) and hence are broadly indicative in nature. The actual figures could be different, although they would follow a similar trend.

It is interesting to look at how various parameters like pressure, temperature and steam production and power generation are related to one another in Table 3.

Advancements in the steam generation technology and an increased confidence of the sugar industry have now emboldened some mills to adopt even higher pressures for steam generation. Thus, while a typical 2,500 TCD
sugar mill cogenerating for its own needs would generate 3.5-4.5 MW of electricity, in optimum cogeneration mode, this could go to 13.5 MW, of which 9 MW would be sold. In a state-of-the-art case, the surplus could be as high as 10-12 MW. When the Ministry initiated its program on bagasse cogeneration, 45 bar / 440 °C steam pressures were just being introduced. These were then increased to 65 bar / 485 °C, after setting up of the initial demonstration projects with Ministry’s capital subsidy. By 2004, the steam pressures/temperatures had increased to 85 bar / 510 °C. In 2007, mills were adopting 110 bar / 525 °C steam conditions. On the basis of cane, these figures would translate to surplus electricity generation of 80-130 kWh/ton. Optimum bagasse cogeneration benefits not only the sugar mills but also the sugarcane farmers as the value addition to their cane is enhanced and thus they can realize more gains from it.

An important aspect of surplus electricity from bagasse cogeneration is the seasonal nature of its availability. Typical sugarcane crushing periods in India vary from 160-180 days in the North and West to 200-240 days in the South. Some mills have been able to increase crushing to 300 days in a year through planned staggering of plantations. However, the utilities consider bagasse cogenerated electricity as seasonal, unfit for load planning. It is in this context that use of alternative biomass materials during off-season, to ensure year round operation has been proposed and practiced in some mills. Most mills also build in the capability to use alternative biomass materials at the design stage itself. Rice husk, cane trash, coal, cotton stalk, wood, etc., are some of the fuels used by mills to generate electricity during off-season. Some cogenerating mills resort to storage of a part of the generated bagasse for use during the off-season. Some utilities have, however, proposed lower feed-in tariffs for off-season electricity, which reduces the motivation for extra efforts in these directions. Technological innovations, such as building of capability for conversion of boilers to fluidized bed furnace firing for use of rice husk, and to traveling grate for bagasse firing, have also been proposed and installed in a few projects. This would enable highest operating efficiencies in both the modes.

### Evolution of policies/incentives/other measures

The penetration of a new technology is generally a function of:

- Attractive returns on investments
- Conducive regulatory environment
- Assured markets for the products being made
- Technical know-how & equipment availability
- Manageable risks
- Good field references
- Easy financing

The Ministry endeavored to ensure these desirable conditions through measured interventions right from the early years of the biomass power & bagasse cogeneration programs. It will be no exaggeration to claim that the favorable mix of policies, incentives and promotional measures has been crucial for successful commercialization of biomass power. Brief notes on the main interventions and their impacts are given here.

### Field References

There were no significant installations of biomass power or grid connected bagasse cogeneration projects in the field when the Ministry took up these programs in late eighties/early nineties. This was a stumbling block, particularly for the sugar sector, which has traditionally relied on ‘peer references’, or on laid down guidelines for technology selection. In fact, Ministry was repeatedly asked by sugar mills in those years, to get the ‘standard specifications’ changed, so that these covered high-pressure, high temperature and efficient steam generation & optimum cogeneration. Use of high pressure and efficient steam generation to take full advantage of thermodynamic efficiencies was sought to be inducted in the sugar mills by the Ministry with the help of expanded awareness creation and financial incentives.
to partially cover the risks involved in use of the new technologies. A major and bold initiative of the Ministry was announcement of capital subsidies for a few demonstration projects, even if, they were in the private sector. The subsidies were an effort to, *inter alia*, bridge the gap between economic and financial benefits of biomass power projects and thus improve the attractiveness of private investments. A subsidy of around 30 percent of the capital cost was offered to a limited number of ‘demonstration’ cogeneration projects in major sugar producing states provided they used steam conditions of at least 60 bar & 450°C. Reimbursement of cost of DPR preparation was also offered so that a shelf of projects could be built up. Announcement of attractive capital subsidies kindled immediate interest among potential project promoters and a number of projects were initiated during this period. Many of these were commissioned by 1995-96 and thus the problem of references was resolved.

**Risk Management**

The major risks faced by promoters in the initial projects were:

- Difficulty in ensuring year round supplies of biomass.
- Risks due to long term weather changes which could affect sugarcane production
- Risks of unanticipated breakdowns, which could reduce power output
- Irregular payment by SEBs for electricity fed into the grids which could affect revenue streams and thus impact servicing of investments
- Breakdowns in power equipment which could also lead to stoppages in sugar process streams, and which could impact generation of revenue even more

Interventions of the Ministry were designed to tackle the risks to as large an extent as possible. Subsidy on the capital costs reduced the investment risks of promoters. The risk of loss because of stoppage of production was managed by most projects by retaining the existing systems till the new ones stabilized.

**Financing**

The active involvement of leading financial institutions, apart from IREDA, was ensured through extensive dialogues, mechanisms such as chanelization of interest subsidy through them, insistence on project appraisal by one of them before approval of subsidy, etc. The pioneering role played by IREDA in this respect needs a special mention. In those days IREDA acted more like a venture capital fund while backing Ministry’s policies through financing of new and innovative projects. Its liberal financial support to the initial projects also played a key role in opening up of the sector and also for laying down a framework for project appraisal and the structure and conditionalties of loans. Dialogues with specialized sugar mill financing institutions such as NCDC and Sugar Development Fund (SDF) were also established to induce them to change their guidelines, which at that time did not allow support for cogeneration of additional power. These days almost all the banks and financial institutions are willing to finance biomass power and bagasse cogeneration projects.

**Current Incentives**

MNRE has been providing financial incentives to the users of various biomass power technologies. The level of incentives is linked to the configuration of technologies used. This is to promote more efficient and modern technologies. For bagasse cogeneration and grid connected biomass power projects, the incentives are currently in the form of capital subsidies. In addition to financial incentives, a number of fiscal incentives are also available for users of these technologies. These include concessions on income tax through accelerated depreciation, concessional rates of customs and excise duties, exemptions from sales tax, 10 year tax holiday, etc.

**Conclusion**

The Ministry has been fairly instrumental in promoting the use of optimal cogeneration plants in the private sugar mills by adopting progressively higher steam parameters of up to 110 ata and 540°C. The resultant impact is in terms of additional power generation. As such, the bagasse based route of cogeneration is quite a challenging one replete with enough entrepreneurial opportunities.

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**Dr. J.R. Meshram, Director, MNRE**
E-mail: jrmeshram@nic.in

**Sh. Sudhir Mohan, Adviser, MNRE**
E-mail: sudhirmohan@nic.in

Ministry of New and Renewable Energy
Block No. 14, CGO Complex,
Lodi Road, New Delhi 110 003
‘SuryaChambal Power Ltd.’ – A Green Powerhouse at Kota

Kota is a city with various types of power plants – starting from thermal, hydel, nuclear and now this Green Power Plant named SuryaChambal Power Ltd. based on biomass (Mustard Husk).

There are four biomass based power plants (IPP) in Rajasthan which are supplying power to the Rajasthan Power Grid. SuryaChambal is second in line, the first being at Sri Ganganagar, commissioned in the year 2004. Two more plants were commissioned in the latter half of 2006 in Uniyara and Kothputli. Thus it can be said that the operating experience of biomass – mustard husk – based power plants in Rajasthan is about 5 to 6 years only. In fact there are reportedly only four power plants (IPP) in the country, which were designed and are operating to date solely on mustard husk as their main fuel.

Green Power

It is said that power generated by the combustion of biomass is green power, which is right because it does not increase CO₂ pollution in the atmosphere. Whenever something is burnt, CO₂ is produced; however plants, in this case mustard, during their life cycle compensate for this by having already absorbed large quantities of CO₂ from the atmosphere and releasing O₂ into the atmosphere, for our benefit.

Apart from this, biomass based power plants in their own small way also contribute towards saving conventional fuels like coal, lignite, oil, etc., which are traditionally used for generation of power.

Mustard Husk

In our country more than 50 percent of mustard is grown in Rajasthan. Mustard plants are cut manually at a height of 1.5’ to 2’ from the ground level and are left in the field for a few days for drying. Thereafter they are fed into a machine called the thresher for separating the seeds from the plant. In the thresher, the plant is shredded into very small pieces, and thus mustard husk is produced.

![Combine machine](image)

This mustard husk, which is considered a total waste and not even used as fodder for cattle, is very light with a density of about 105 Kg/m³. Till a couple of years back, before the commissioning of these four Biomass based power plants, more than 90 percent of the mustard husk used to be burnt by the farmers in their fields and mixed with the soil to prepare the fields for the next crop. Sometimes the farmers had to pay money to get their fields cleaned of this waste. Even now 1.5’ to 2’ long stems, left in the field while manually cutting the plant, are either ploughed or burnt and mixed with the soil and thus are not being used for better purposes like converting it into energy or making proper manure for agricultural purposes. There is another method of harvesting of mustard crop and that is by using a combine machine instead of cutting it manually and then using...
the thresher for separating the seeds. This combine machine separates and collects the seeds effectively but it does not shred the plant into husk. It just cuts and leaves the plant lying in the field.

The problem with the entire process lies in the fact that collecting these plants and converting them into husk separately puts additional costs thus making it unviable for use in biomass based power plants. In fact, in remote areas, farmers continue to burn the ready mustard husk in their fields either due to lack of information or poor transportation facilities.

SuryaChambal Power Ltd.

SuryaChambal Power Ltd., formally known as Chambal Power Ltd., is a 7.5 MW capacity biomass (mustard husk) based power plant, located at Rangpur Village of District Kota, about 8 kms. from Kota railway station on the banks of the Chambal river. The project was started in April 2004 and the plant was commissioned and synchronized with the Rajasthan Power Grid at 33 kV on 31st March, 2006, thus starting the supply of power through its Gopal Mill GSS situated near Kota railway station. The company has its headquarter in Mumbai. The promoter of the company, Mr. Sanjay Bagrodia is supported by a strong team of professionals like Mr. V.K. Aundhe, Chief Advisor, Mr. S.R. Wagle, Chief Technical Officer and Mr. J. C. Dargar, Chief Finance Officer at the Head Office.

The company, while carrying out the feasibility study in the year 2002, for putting up this 7.5 MW biomass based power plant, had chosen its present location at Rangpur village in Kota district due to the following reasons—

- Water was available from the nearby Chambal River.
- 132/33 kV GSS was located at a reasonable distance of about 8 kms.
- Government was planning to build a bridge over the Chambal river near the site, connecting Keshoraipatan (Bundi District) to Rangpur village, which would facilitate the procurement of biomass from Bundi in a big way.

However this bridge has still not been constructed and the company is facing difficulty in procuring biomass at viable rates. The cost of biomass envisaged was Rs. 800/MT but now the actual cost has gone up to about Rs. 1,400/MT.

The actual cost of the project was about Rs. 40 crore. The company has about 55 persons on its rolls and about 90-100 persons on contract for biomass feeding, security and other facilities. Apart from this, it generates about 1,00,000 man days/annum of employment indirectly for loading, unloading and transportation of biomass. Also, farmers have started getting extra income for their waste products. The company has never used fossil fuel to support biomass and purchases Rs. 10–12 crore of biomass annually and thereby generates income for farmers and others in a region of 50 km. radius from the plant. This has improved the quality of life of villagers who are now using cooking gas, buying television sets, motor cycles and even sending their children to the school.

The company faced initial teething troubles. However, after carrying out certain technical modifications, it started yielding satisfactory results. In the last two years, it has achieved more than 80 percent PLF annually. Not
only this, it has achieved even 100 percent PLF monthly on various occasions. The company is also engaged in continuous improvement programs for operating the plant at optimum efficiency and projects for energy saving etc. The company is fully conscious of its social responsibilities and carries out various activities to raise the quality of life of the villagers of Rangpur, like repairing of roads, providing water and lighting facilities, development of village school, encouragement to children by providing them with scholarships, conducting various sports & games, awarding prizes at functions and competitions, conducting blood donation camps, joining and participating in religious functions/festivals, etc.

Having gained confidence by successfully running the plant at Rangpur, the company is now expanding and putting up another unit of 10 MW at Khatoli village in Kota, about 100 kms. from Rangpur. Its sister concerns, Sathyam Power Pvt. Ltd. is putting up a 10 MW plant at Merta Road in Nagaur district and Prakriti Power Pvt. Ltd. is putting up a 12 MW Power Plant at Gangapur city in Sawai Madhopur district.

Barriers
There are several barriers that require attention such as–

- Construction of a bridge over Chambal River (as proposed), connecting Rangpur with Keshoraiapatan.
- Payment of energy bills by purchasing discoms within seven days of submission of bills, specially during the months of February to June when mustard husk has to be purchased and stored for the full year (actual availability is between March to May without any discount)
- Annual average GCV should be considered 3,000 Kcal/Kg for the purpose of fixing tariff.

- Due to excessive increase in biomass price, present tariff should be Rs. 5.50 per unit.
- Free wheeling of power should be allowed for IPP also on similar lines as for CPP.
- Reserve area between two biomass based power plants should be 100 kms. without any overlap.

Areas for Development
The company is putting its best efforts for the development in the following areas :

- Technology development to convert mustard plant into husk while using Combine machine for separating seeds.
- Cutting of mustard plants from the ground level so that 1.5’ to 2’ of plant stem is not wasted.
- Technology development to prevent self ignition of biomass during the storage period.
- Development of economically viable collection system of alternate biomass husk like Maize, Cotton, Soybean, etc., during the months of October to January.
- Development of technology so that its ash is used in the cement industry.
- Technological development with regard to furnace size, heating surface area and biomass conveying system, to avoid choking of the system.

To conclude, SuryaChambal Power Ltd. has not only adopted the Green Technology to generate Power but it also maintains a neat, clean and lush green healthy environment, having 30 percent of its campus covered by green trees and flowers.

Jyoti Ranjan, CEO
SuryaChambal Power Ltd., Rangpur, Kota (Rajasthan)
Email: cplkota@rediffmail.com; Tel: 0744-2867328
Mob: 9982219150

Request for Articles

Bioenergy India is intended to meet the updated information requirements of a diverse cross-section of stakeholders from various end-use considerations, be it biomass combustion, gasification or cogeneration. To meet such an objective in a timely manner, the editorial team of the magazine invites articles, features, case studies and news items, etc., from academicians, researchers & industry professionals.

The contributions should be of about 2000-2500 words (maximum of 3-4 pages, which would include relevant graphs, charts, figures and tables). Please send in your inputs along with your photograph to:

Dr. Suneel Deambi (suneel@winrockindia.org); Ashirbad S Raha (ashirbad@winrockindia.org)
Winrock International India; 788, Udyog Vihar, Phase V, Gurgaon-122001; Phone: 0124 430 3868
Large Capacity Producer Gas Engines - Experience of GE

Abstract
Increased ecological consciousness and the knowledge of limited reserves of primary energy in the form of fossil fuels make it necessary to utilize the available energy sources economically. Biomass, the originator of fossil carbon sources can therefore produce similar energy with the distinction that the carbon in biomass is sourced from the atmosphere and therefore, is a part of an intrinsically balanced carbon cycle. India’s increasing energy needs have put great pressure on the existing natural resources. Globally, India is in the fourth position in generating power through biomass and with a huge potential is poised to become a world leader in the area of biomass energy production.

There are three generic major biomass processing technologies based on direct combustion, pyrolysis and gasification. Gas engines are presently powered primarily with natural gas, biogas or propane. The use of “special gases” like producer gases, pyrolysis gas or gas from gasification processes, gas with low calorific values or changing gas compositions with respect to emission limits of common air quality requirements is a new challenge for gas engine development. Highly sophisticated gas engines with intelligent engine management systems now allow the utilization of gases, which could not be burnt till a few years ago. Jenbacher AG has already installed pyrolysis gas from domestic waste gasification (35 percent H₂ content), gas from wood chip gasifier, and producer gas from the chemical industry with an extremely low heating value (0.5 kWh/m³). These experiences have shown that the gases from gasifier or pyrolysis from waste can be used in gas engines, as long as the gases fulfill certain requirements.

Biomass Resource Potential
As per MNRE’s recent annual report, the availability of biomass in India is estimated at about 540 million tonnes per year, covering residues from agriculture, forestry, and plantations. Principal agricultural residues include rice husk, rice straw, bagasse, sugar cane tops, leaves, trash, groundnut shells, cotton stalks and mustard stalks, etc. It has been estimated that about 70-75 percent of these wastes are used as fodder, as fuel for domestic cooking and for other economic purposes, leaving behind 120–150 million tonnes of usable agro industrial and agricultural residues per year which could be made available for power generation. By using these surplus agricultural residues, more than 16,000 MW of grid quality power can be generated with the presently available technologies.

Biomass Processing Technologies

Direct Combustion
Biomass combustion can produce heat or steam. Dry biomass has an energy content of approximately 10-20 Giga Joules per tonne (GJ/t). This is comparable to the lower ranked coal, making biomass suitable for electricity generation. Lower grade waste heat from biomass combustion can also be used in combined heat and power (CHP) applications. The direct combustion of woody biomass for power production is currently the highest volume bioenergy market worldwide. Biomass may be used as the sole fuel for heat and power generation or may be blended with coal, in a process known as co-firing. This technology is generally used for bagasse biomass, which is considered good biomass in India. However, with other biomasses which have high alkali content, there are some disadvantages in terms of fouling of heating surfaces, corrosion of super heater coils, agglomeration, secondary combustion and high unburnt carry over, etc.

Pyrolysis
Pyrolysis is thermal decomposition of organic material with no or limited oxygen. The pyrolysis of biomass for bioenergy is a relatively undeveloped technology. Pyrolysis technologies using a wider range of low cost biomass feeds, including woody crops, wastes and residues are under active development with several operating commercially. Reducing the capital intensity and improving the energy efficiency of pyrolysis is important in facilitating the uptake of the technology.
Gasification

Gasification is a process in which oxygen-deficient thermal decomposition of organic matter (coal, oil or biomass) produces non-condensable fuel or synthetic gases. Gasification combines pyrolysis with partial combustion to provide heat for the endothermic decomposition reactions. Gasification technologies offer an opportunity to use biomass more efficiently, especially when used in the CHP mode. The heating value of this gas varies between 4.0–6.0 MJ/Nm³, which is about 10-15 percent of the heating value of natural gas, unless the gas is combusted directly for power, it is cooled, filtered and scrubbed to remove any condensable and carry-over particles. The synthetic gas produced can then be used in a variety of energy conversion devices (for example, internal combustion engines, gas turbines and fuel cells) or converted to high value fuels and chemicals. For power generation applications, gasification technology has been gaining prominence in recent years as an alternative to direct combustion for various reasons, such as low emissions, high efficiency and less fresh water usage, etc.

Gas-characteristic Values and Requirements Regarding the Quality, for use in Gas Engines

Gas engines are presently powered mainly with natural gas. But the use of renewable energy sources like landfill gas or sewage gas with lower thermal heat values, represents a growing market for gas engines all over the world. Gases and their respective constituents have different properties, which can be assessed through their characteristic values such as methane number, heat value

<table>
<thead>
<tr>
<th>Gas</th>
<th>Composition</th>
<th>Density [kg/Nm³]</th>
<th>LHV [kWh/Nm³]</th>
<th>Methane number</th>
<th>Laminar flame speed [cm/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td>H₂</td>
<td>0.0899</td>
<td>2.996</td>
<td>0</td>
<td>302</td>
</tr>
<tr>
<td>Methane</td>
<td>CH₄</td>
<td>0.717</td>
<td>9.971</td>
<td>100</td>
<td>41</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>CO</td>
<td>1.25</td>
<td>3.51</td>
<td>75</td>
<td>24</td>
</tr>
<tr>
<td>Natural gas</td>
<td>CH₄ = 88.5%, C₂H₆ = 4.7%, C₂H₈ = 1.6%, C₄H₁₀ = 0.2%, N₂ = 5%</td>
<td>0.798</td>
<td>10.14</td>
<td>80</td>
<td>41</td>
</tr>
<tr>
<td>Biogas</td>
<td>CH₄ = 65%, CO₂ = 35%</td>
<td>1.158</td>
<td>6.5</td>
<td>135</td>
<td>27</td>
</tr>
<tr>
<td>Wood gas</td>
<td>H₂ = 7%; CO = 7%; C₃H₅ = 5%; N₂ = 56%, CO₂ = 15%</td>
<td>1.258</td>
<td>1.38</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>
Physical properties
The methane number and the heating value are the determining physical values for standard gases like natural gas, LNG, LPG or biogas. For low concentrated gases, like wood gas, the laminar flame speed is the decisive criterion indicating whether it is possible for the air-gas mixture to be completely burnt in the engine. The methane number is crucial physical value for assessing the knock resistance of a combustible gas. The methane number requirement and the knock resistance of the engine are influenced by constructional and operational factors, respectively. In order to be able to guarantee fault free engine operation, it is necessary to keep the pollutant concentrations in the fuel gas within the prescribed limits.

Measures for Reducing Emissions
Due to increasingly stringent governmental regulations regarding delimitation of emissions, Jenbacher is working intensively on methods to reduce further pollutants in the engine exhaust gas. There are fundamentally two options (illustration 4) to reduce the emission of pollutants from internal combustion engines, namely secondary treatment of exhaust gas and measures implemented inside the engine.

Today, a majority of gas engines are operated as lean burn engines, depending on the required emission limits, with or without catalytic exhaust gas after treatment. In particular, applications with special gases are exceptionally lean burn engines.

Lean-burn concept for reduction of NOx
Through operating with a large amount of excess air (lean mixture), the combustion temperature is reduced and hence NOx formation in the combustion chamber is strongly reduced. The “German TA-Luft” limit of NOx (< 500 mg/Nm³) can be complied with reliably and economically by the Jenbacher lean-burn engines. NOx emissions can be reduced by making the mixture even leaner. This means, however, putting up with a loss of efficiency, a reduction in output (and increased maintenance) to 250 mg/Nm³. A greater reduction of the emission is not possible at this time without secondary treatment of the exhaust gas for natural gas. The lean-
burn concept was pursued in Jenbacher and the LEANOX lean-burn (illustration 5) combustion process developed a process guaranteeing constant compliance with the prescribed NOx emission limits throughout the operating time of the engine.

**LEANOX-control system**

The air ratio Lambda ($\lambda$) is linked with the thermodynamic engine and gas-specific parameters. Both constant and variable values are contained in this relationship. Lambda can therefore be represented as a function of:
- engine output,
- mixture pressure (equal to boost pressure) and,
- mixture temperature after the intercooler.

These three values are measured and transmitted to the LEANOX control system. The signal output by the LEANOX controller moves the adjusting cone of the air/gas mixer into the desired position, so that the required air ratio is achieved (see illustration 5).

The main advantage of the patented LEANOX system is the secure and reliable measurement of the input signals for fuel-air mixture control. There are no sensors in hot zones like the combustion chamber or the exhaust. The mixture pressure and temperature sensors are working in low stress and stable environment conditions and are free of deposits and aging. This allows a secure and reliable mixture control. The exact mixture control guarantees not only an accurate emission control, but it also controls the whole combustion process and thus protects the engine against high thermal or mechanical stress.

**Reduction of CO by measures inside the engine**

The most common way to achieve the “TA-Luft” limit for CO (< 650 mg/Nm³) with biogas is the implementation of internal measures. For example, reducing the compression ratio, adjusting a later ignition point (closer to the top dead centre - TDC) and water cooled exhaust gas manifolds will help to reduce the CO emissions without exhaust gas after treatment.

**Examples of Utilization of Special Gases**

Jenbacher has been working, since the mid eighties, on the utilization of special gases like pyrolysis gas or wood gas in gas engines. With the target of sufficient performance output and an appropriate cost benefit relation, a turbo-charged gas-otto-lean burn engine has to be used. This requires a certain maximum gas temperature with low humidity and a low content of heavy hydrocarbon compounds (e.g. tars). Besides the problems of fluctuating gas qualities and contamination of the gas, it is a challenge to fulfil the international emission standards (e.g. TA-Luft Standard) at these applications. To increase the basic know-how and understanding of the utilization of these kind of gases, Jenbacher participated on several Joule research projects, as well some demonstration projects, and also joined some other European and national projects. Next to these activities, commercial gas engine applications for H$_2$-gases (e.g.: coke gas, H$_2$ containing weak gas, etc.) have been available since 1995 and are in successful operation. All experiences of utilization of these special gases with H$_2$ will be directly used for the approach of solutions for problems with utilization of woodgas and pyrolysis gas in gas engines. The following examples give a short overview of some pilot plants operating with wood gas.

**Woodgas plant: “Harboøre – Vølund updraft gasifier” - 2 x J320GS**

In 1988, ”Babcock & Wilcox Vølund Aps“ decided to take an active part in the development of gasifiers in order to create a gasification principle with the possibility of:
- achieving stable and continuous gas production
- gasifying fuel with a moisture content of up to 50 percent
- producing gas for use in gas engines
- achieving a high degree of automation for the total plant
To achieve these goals the updraft gasification principle was chosen, because of the built-in drying zone. The major advantages of an updraft gasifier are its simplicity, an ability to gasify very wet fuels, high charcoal conversion and internal heat exchange leading to low gas exit temperature and high gasification efficiency. A disadvantage is the large amount of tar produced. Therefore gas cleaning is required to make the gas usable for gas engines. After several years of development work, the first gasification plant was put into commercial operation in 1993 at the district heating plant Harboøre in Denmark, which currently supplies heat to approximately 560 heat consumers and to the municipal buildings of the town.

The gasifier has an output of 4 MW (thermal) and the gas has been burnt over the last years in a Low-NOx gas burner built onto a 4 MW hot water boiler. The primary fuel is wood chips but successful tests have been made at the plant with other types of fuel, e.g. chunk-wood, bark and waste wood. The producer gas consists of approx. 15–18% hydrogen, 25–28% carbon monoxide, 7–10% carbon dioxide, 3–5% methane and the rest being nitrogen and water.

During the summer of 1996, a program to optimize and develop the gasifier was successfully completed. Subsequent research and development activities have concentrated on gas cleaning. Today the gas is cleaned through a complex system of gas scrubbers, heat exchangers and electrostatic filters, before it is fed into the gas engines. In the beginning of the year 2000, two Jenbacher gas engine modules JMS 320 GS-S.L were installed and the district heating plant was converted into a CHP plant. A significant part of the work has been related to the conditioning of the gasifier product gas, for use in gas engines, a reliable solution based on gas cooling and wet electrostatic precipitation. A novel technology for cleaning the resulting tar contaminated water has been demonstrated. The produced gas is cooled– using the district heating grid – to about 45 °C, during which a considerable amount of water/tar condensate and also aerosols (microscopic water/tar droplets) are released. The aerosols are subsequently removed from the gas stream by means of a wet electrostatic precipitator. After this treatment, the gas is clean and applicable for the gas-engines (both tar and dust contents are below 25 mg/Nm³). The gas is boosted to a slightly higher pressure to accomplish an engine inlet pressure regulation – by means of a traditional “gas train” – to slightly below atmospheric pressure.
Each unit has an electrical output of 648 kW and a thermal output of 883 kW. With these high efficient gas engines, the woodgas can be converted, with an overall efficiency of up to 90 percent, into electricity and heat, depending on the heating water temperature level. The engines are operated as lean burn LEANOX-controlled gas engines with an air access ratio of approximately 1.6. Therefore, low NOx emissions can be obtained. A total of approximately 60,000 operating hours of the 2 engines was successfully achieved by the end of 2008. Frequently performed internal inspections of the vital parts of the engines show no sign of tar deposits or other abnormalities up to now.

**Woodgas plant: “Güssing – Fluidized Bed Steam Gasification” - 1 x J620GS**

In order to make the generation of electricity from biomass possible, in the small, decentralised power stations as well, another new type of power station was realized for the first time in Güssing/Austria. The biomass power station at Güssing supplies 4500 kW heat for district heating and up to 2000 kW electricity originates from 1760 kg of wood per hour. In order to realize this project from the idea to the finished product, the partners, i.e. Austrian Energy as design engineer, scientists from the Technical University, Vienna, the EVN and the District Heating Company, Güssing formed the authority network RENET and developed this new, well planned system of cogeneration on the basis of biomass gasification.

The heart of the power station is the fluidized bed steam gasifier. During gasification, the biomass is gasified with approximately 85 °C under supply of steam. Using steam instead of air, as a medium of gasification, results in a nitrogen free, tar-poor producer gas, with a high heating value. A part of the remaining coke is transported to the combustion chamber via a circulating bed material (sand), which acts as a heat transfer medium as well. The heat dissipating to the bed material is then used for the gasification process. The flue gas is carried off separately, and the contained heat is recovered for the district heating system.

**Fluidized bed steam gasifier Güssing**

For the operation of a gas engine, the producer gas must be cooled and cleaned. The heat of the gas cooling is used again for the district heating. The dust is removed in a woven filter. After this procedure a scrubber reduces the concentrations of tar, ammonia and sour gas components. Due to this special procedure, it is possible to feed back all the residual substances into the process. As a consequence neither wastes nor waste water result during the process of gas cleaning.

The gas engine converts the chemical energy of the producer gas into electrical energy. Beyond that, the waste heat of the engine is used for the supply of district heating system. The overall electrical efficiency is 25-28 percent and the total plant efficiency (electricity and heat) is even more than 85 percent.

The commissioning of the gasifier started in September 2001 and the commissioning of the Jenbacher gas engine J620GS matured in February 2002. Jenbacher’s aim with...
this pilot phase was the optimization of the gas engine for this gas with a relative high H₂ content (30-40 percent), by a new type of gas mixing system, the gas supply to the engine and special test applications for the reduction of the CO-emissions by an oxidation catalyst. During the first test run, the engine achieved the expected output and the preliminary results of the catalyst test were positive. Meanwhile, the plant is in commercial operation and has already achieved 40,000 operating hours by the end of 2008.

Summary

The main criteria for the utilization of pyrolysis gas or wood gas are the contamination of the gas and the content of condensing hydrocarbons like tars. The common NOx emissions (e.g. TA-Luft: NOx <500 mg/Nm) can be achieved by the lean burn combustion concept without any exhaust gas after treatment. A further challenge for the utilization of these kind of gases is the often-required limits in terms of CO-emission, which cannot be achieved without exhaust gas after treatment due to the typical high CO content of the wood gas itself.

In the area of utilization of biomass renewable energy sources, the gas engine, with the use of modern control and monitoring systems, presently represents the commercially available technology.

Martin Schneider
Product Management GE Energy
Jenbacher Gas Engines
Achenseestr. 1-3; A 6200-Jenbach/Austria
Email: martin.schneider@ge.com

For more details please contact: Ravi Kumar Dhulipala
Email: ravikumar.dhulipala@ge.com

Call for Proposals

Call for Proposal(s) for Organizing of Seminar / Workshop / Business Meet on Generation of Energy / Power from Biomass under UNDP / GEF Biomass Power Project

Communication and Advocacy on Biomass Power including Bagasse cogeneration, among various stakeholders and Project Promoters, is one of the key activities to be undertaken under this Project.

Proposals are invited from interested organizations / institutions for organization of Business Meet / Seminar / Workshop / Conference on areas related to biomass management and its utilization for the generation of energy/ power.

Funding Pattern

<table>
<thead>
<tr>
<th>Category-Event Level</th>
<th>Exclusive Event for Biomass Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Meet</td>
<td>Rs. 50,000/-</td>
</tr>
<tr>
<td>State Seminar / Workshop</td>
<td>Rs. 1,00,000/-</td>
</tr>
<tr>
<td>National Seminar / Workshop</td>
<td>Rs. 2,00,000/-</td>
</tr>
</tbody>
</table>

The proposal should be submitted three months in advance in the prescribed format, through the Head of the organization or the Registrar in case of universities, to Shri V.K.Jain, Director and NPC, Biomass Power Project, Ministry of New and Renewable Energy, Block No. 14, CGO Complex, Lodi Road, New Delhi – 110003, Telefax: 011-24369788, Email: jainvk@nic.in.

The format and other details can be obtained from the Ministry or downloaded from MNRE’s website www.mnre.gov.in
Biomass Based Cogeneration Power Plant
At Claris Lifesciences (Clarion Campus), Ahmedabad, Gujarat

Power cuts, blackouts and shortages in power supply are a critical situation being faced by a majority of the Indian states. While the demand for power has increased by 3.5 percent as compared to last year, total power deficit is at about 12-15 percent, thus creating significant mismatches in the power supply situation. The industrial sector is one of the largest consumers of electrical energy in India, and suffers from many problems including shortage of electricity supply, power fluctuation, high tariffs, load shedding and staggering. All of these lead to heavy production losses besides reduction in efficiency and productivity. Using standby DG sets is also a costly option.

Cogeneration Power: An Effective Solution
As industry struggles to balance the demands of growth and progress, with the crippling power situation, Cogeneration plants are emerging as a highly promising alternative to mitigate the risks faced by organizations, and also to scale up their output and productivity.

Claris Lifesciences: Leading the Way
For most people around the globe, a factory is synonymous with black smoke billowing out of towering chimneys, foul stench filling the air, untreated water and waste being funneled out, and many such grim pictures.

“Clarion” – a state-of-the-art manufacturing facility, set up by Claris Lifesciences at Ahmedabad, in Gujarat tells a different story altogether. Located in the midst of picturesque environs, in a sprawling 80 acre area, the factory embodies the classic yet rare convergence of nature in all its beauty, and the practical world of business. Run on green energy, Clarion is a clear reflection of the endless possibilities that can exist for an organization which has imbibed the true spirit of “green”.

A 70 percent Carbon Neutral campus, Clarion owes its verdant, pollution free environs to the fact that it has successfully set up a biomass based cogeneration power plant, which satisfies 100 percent steam load and 40 percent electrical load of the manufacturing facility. This captive 2 MW Co-Generation Power Plant generates 16 TPH (tonnes per hour) process steam to meet a part of the electrical load within the manufacturing facility of the campus.

The boiler for steam generation was supplied and commissioned by Thermax Ltd. It is a Fluidized Bed Combustion (FBC) boiler, where in Claris uses various types of biomass as fuel. This boiler was designed and initially commissioned on Lignite. Considering the environmental degradation, Claris took the decision to change the fuel from fossil fuel to a renewable biomass fuel. The primary fuel for the co-generation power plant is a Castor De Oiled Cake (DOC) supported by saw dust and other agro residues like cotton stalk, which accounts for no carbon emissions.
For better dust management, at the Agro-residue cogeneration power plant, Claris has installed a unique indoor ESP (Electro Static Precipitator), within the campus premises. The company also produces fly ash bricks from the ash available from the plant, which is later sold off to the cement industries. This process helps bring down air pollution within the factory vicinity.

**Technology - Process**
The project has been initiated in 2 phases. The first phase is under operation since August 2006. The technical description of the first phase is as below:

Phase I - The biomass residues are combusted directly to generate 16 TPH of high pressure (HP) steam at boiler outlet with operating conditions of 44 kg/cm² and 430 ± 50 °C. Around 12 TPH of this HP steam is generated in the boiler. This HP steam is injected into the steam turbine and at lower pressure i.e. at 9kg/cm² around 12 TPH steam is extracted and the balance goes to the condenser after a full expansion in the turbine. The total configuration is made in such a way that priority is given to steam for process and the left over steam is directed towards the condenser for more electricity generation with a higher efficiency.

The said project was registered under UNFCCC on 21st February 2009 for the purpose of availing CDM related benefits.

**Process Flow**

**Financial**
The total cost of the project was Rs. 10 crores during 2005-2006. From 2006 to 2009, even when the project was not registered, Claris voluntarily opted to use the biomass fuels without any CDM benefits. Hence, Claris got certification for Voluntary Emission Reduction (VERs) under the latest Voluntary Carbon Standards version 2.0 (VCS 2007.1) prevailing at that time. Over the entire crediting period, Claris has generated about 90,000 VERs for sale.

The overall efficiency of cogeneration plant varies from 60–75 percent depending upon the demand of process steam as a first priority.

The efficiency goes up with more steam becoming available for electricity generation.

**Benefits**
- Government of India’s fiscal benefit i.e. accelerated depreciation
- Duty exemption on self generation. In case of using fossil fuels in Gujarat, the generator needs to pay an additional 40 paise per unit towards duty charges
- Our entire installation is in-house, which does not create noise pollution in the campus and the surrounding villages as well
- Latest pollution control equipment (ESP – Electro Static Precipitator) is installed, which protects the dust emission, thereby ensuring that it is almost negligible
- In order to minimize internal dust emission, an inlet air section of the boiler is positioned in such a way that the smallest particles of fuel, if any, goes into the boiler, while sucking the air for combustion
- Ash generated from the plant is used in making ash bricks, which are then used as eco bricks for the routine needs of the campus
- In order to increase sustainability, more energy crops are harvested and grown on the campus for utilisation in the boilers
- Claris has grown bamboos all around the campus, and all activities are diligently taken care of, right from trimming, to maintaining and collecting biomass, which is fed into the boiler
- While running this facility, the company successfully portrays itself as a green and eco friendly company in India and outside
- Our business associates have been emotionally attracted by our initiatives and respect our efforts
towards green initiation as we are also in the domain of saving lives

- Energy efficient measures like setting up of sky domes for natural lighting and HVAC and VFD systems have been installed that bring down the campus specific carbon footprint
- Well designed rainwater harvesting systems attempt to reduce fresh water extraction quantities and treated water from the effluent treatment plant is used for watering of the campus lawn
- Attractive landscapes have been designed by soil excavation during construction of the campus, while taking due care that the ecological aspects of the soil stay undisturbed
- Moreover, use of glass, metal panels and RCC structure have enhanced an overall aesthetic beauty of the campus

Claris has been successfully driving the philosophy of going green and making sustainability the order of the day. Further as an extension of its initiatives, it has forayed into a new business venture of clean energy generation and sustainable development, with a special emphasis on Bio-Energy in the name of Abellon Clean Energy Limited. With its expertise in microbiology, biotechnology and running a state-of-the-art biomass based co gen plant; Abellon is poised to be the leader in all the domains of Bio-Energy in India and outside

The visible success of this project sets an example for other enterprises in the sector to invest in such innovative measures. These may possibly lead to further reductions in the GHG emissions - a win win situation for every one.

Nirav Shah
Manager - Business Development
Abellon Clean Energy Limited
Email: nirav.shah@abelloncleanenergy.com

Major Events

- **Bio Energy Engineering**
  October 11-14, 2009
  Washington, USA
  Contact: mcknight@asabe.org

- **Biomass Summit**
  October 19-20, 2009
  Washington, USA
  Contact: mail@infocastinc.com

- **Bio Energy Markets West Africa**
  October 27-29, 2009
  Accra, Ghana
  Contact: nigel-veales@greenpowemrconferences.com

- **Biomass Power Technical Seminar**
  October 28-30, 2009
  Ruska, Louisiana, USA
  Contact: t4hunt@hga-llc.com

- **Energy from Biomass and Waste**
  January 26-27, 2010
  London, UK
  Contact: info@ebw-uk.com

- **International Biomass Conference & Expo**
  May 4-6, 2010
  Minneapolis, Minnesota, USA
  Contact: service@bbinternational.com

- **ISES Solar World Congress 2009**
  October 11-14, 2009
  Johannesburg, South Africa
  Contact: hq@ises.org

- **International Congress on Renewable Energy (ICORE 2009)**
  October 6-7, 2009
  India Habitat Centre, New Delhi, India
  Contact: info@sesi.in

- **National Conference on Renewable Energy 2009**
  November 5-7, 2009
  Jodhpur, Rajasthan, India
  Contact: usmirdha@gmail.com

- **Third Renewable Energy Finance Forum**
  November 20-21, 2009
  Mumbai, India
  Contact: mferreiro@euromoneypic.com
Technological Challenges in Development of Biomass Power

Various estimates have been made about availability of surplus biomass at national, state and taluka level. The overall resource availability has been assessed at 500 MNMT, out of which 120-150 MNMT can be used for power generation. At an average specific consumption of 1.5 Kg/kWh and 100 percent biomass collection efficiency at 100 percent PLF, potential would be 10,000 to 12,000 MW. The overall potential could be lot more if some of the forestry residues like pine needles, etc., are also factored in. Currently, only about 2,000 MW is operating including very large contributions from sugar cogeneration. The issue therefore, is really not what the overall potential is, but how quickly can the potential be converted into projects. In the last decade or so, there have been few encouraging developments in different areas like regulatory and technology environment and better financing ability of such projects due to availability of carbon finance. These have helped in faster capacity addition particularly in the sugar cogen segment. Consequently more interest has been generated in the market and many investors, both from India and abroad, have entered the field. All of the recently bid projects by some of the States like Punjab, Haryana, Rajasthan, etc., have been successfully concluded. However, the conversion rate of bid projects has not been as encouraging.

DSCL Energy Services (DSCLES) has been involved in developing biomass power globally besides its recent involvement in some exciting projects like:

- High pressure (105 bar, 540 °C) high capacity (30 MW, 170 TPH single boiler) bagasse cogeneration projects - four such projects in India
- World’s largest single facility bagasse cogen project-105 MW at White Nile sugar complex at Sudan
- India’s first commercial paddy straw based project-12 MW at Punjab
- Project consulting for development of 16 MW MSW based project
- Feasibility report preparation for over two dozen projects in Punjab, Haryana, Rajasthan, Madhya Pradesh, Chhattisgarh, Maharashtra, Gujarat, Bihar and Tamil Nadu
- Grid connected distributed power and cooking gas project based on gasification of corn stalk in rural area in China (200 KW and cooking gas supply to 330 households)
- 20 KW R&D power generation project based on gasification of leafy biomass
- MNRE sponsored project on evaluation of performance of biomass based power projects in the states of Punjab, Rajasthan, Chhattisgarh and Maharashtra

This article captures some of the learnings from these projects, particularly in the areas of:

- Biomass characterization and
- Power generation technologies

Biomass characterization

From the perspective of development of commercial power plants, biomass can be classified under the following different categories:

- Sources of biomass
- Physical characteristics
- Combustion properties
- Ash characteristics

Source of biomass – Different sources include agro-residue, agro-industrial residue, forest residue and municipal solid waste. The market for agro-industrial residues like bagasse, rice husk, etc., is now established and it is possible to make a reasonable forecast on price and availability. For the other biomasses, uncertainty would remain. Financial and risk analysis must always be carried out to take care of these uncertainties.

Physical characteristics – Biomass can be either in woody/granular form like chips, shells, husks or leafy form like straw, stalks, trash, etc. These characteristics play a very important role in the design of:

- Biomass harvesting and collection strategy
- Transportation and storage system
- Fuel feeding system for the boiler and
- Combustion system

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1 MNRE website-biomass atlas
2 DSCLES estimate
The bulk density of woody biomass on ‘as received’ basis usually ranges from 200 to 400 Kg/M$^3$, whereas that of leafy biomass is around 20 to 30 Kg/M$^3$. Thus, without densification, a truck of about 30 M$^3$ carrying capacity would be able to transport 12 MT of woody biomass as against only about 1 MT of leafy biomass. Similarly, for storage too, enormous space would be required.

Some densification can be carried out simply by sizing and binding, as is the age old practice by farmers. Densification technology like pressure baling is widely practiced in the sugar industry. Pelletization is also quite a common practice in the west. However, the energy cost of pelletization is too high to make it economical for the power plant.

Presently, integrated reaper cum field baling system is the most commonly used method for harvesting and simultaneous densification of agro-residues like straw and stalks.

Table 1: Bulk density of different types of biomasses$^4$

<table>
<thead>
<tr>
<th>Type of fuel</th>
<th>Moisture content (%)</th>
<th>Bulk density Kg/M$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log</td>
<td>50-20 (Air dried)</td>
<td>450-700</td>
</tr>
<tr>
<td>Chips</td>
<td>50-20</td>
<td>175-350</td>
</tr>
<tr>
<td>Pellets</td>
<td>10</td>
<td>600</td>
</tr>
<tr>
<td>Grain</td>
<td>15</td>
<td>750</td>
</tr>
<tr>
<td>Straw</td>
<td>15</td>
<td>30-130 (Baled)</td>
</tr>
<tr>
<td>Coal-loose slack</td>
<td>5-7</td>
<td>900-1100</td>
</tr>
</tbody>
</table>

In Europe, most of the straw based power plants feed bales directly into the boiler thereby reducing the need for additional fuel preparatory system in the power plant.

In the first demonstration, a straw fired plant was set up at Jalkheri in Punjab, India, with support from the Danish Government and MNRE, where a similar system was used. However, the system was found too complex and costly to maintain. Eight conveyors were used, four from either side of the boiler; from the main bale conveyors, diverters were used to load the individual conveyors. These diverters tend to malfunction with the slightest irregularity in the bale geometry/solidity, causing jamming of the conveyors. The binding threads used for the bales are supposed to melt immediately as the bale enters the furnace, so that the bale gets dislodged and loosened fibers catch fire. Developing a nylon thread with such fine characteristics became quite a challenging task. This plant had to be modified with traditional fuel feeding arrangement for better reliability. The fluidized bed system used also created problems due to the ash

$^3$ Maize, Soyabean stalk and alfalfa densification-Timothy J Van Pelt et al, Iowa State University

characteristics creating difficulty in draining ash through the holes provided in the bed deck.

In the 12 MW project being constructed in Punjab, the system has been designed keeping in mind learning from the European projects, the Jalkheri project and a few mustard residue based projects in Rajasthan. A large number of reaper baler machines have been procured for harvesting and baling of the available straw in the shortest possible time, so as to free the farmers’ land for the next crop. Bale shredding and belt conveying systems are being installed so that loose straw is fed and fired in the boiler. Travelling grate stoker system has been used instead of the fluidized bed system.

Combustion properties – Moisture, ash and net calorific values are the important parameters; the moisture content usually varies from 15-50 percent, depending on the type of biomass and impact of natural drying. Most of the biomass, on a bone dry basis, has heat content of about 4,000 kCal/Kg and about 3,200 kCal/Kg on air dry basis. The moisture content in bagasse is about 50 percent. For the purpose of project design, the calorific value may be taken at 2,000 kCal/Kg for bagasse and 3,000 kCal/Kg for other biomasses.

MSW is different from naturally available biomass depending upon the characteristics of the city garbage. It is therefore, very important to carry out a detailed investigation, over an extended period, during all the seasons and covering all the zones for characterization. Technology choice (Incineration of as received biomass vs preparation of residue derived fuel, RDF, for conventional combustion) would be dependent upon the characteristics.

Ash characteristics – Ash content in most of the biomasses is quite low ranging from 2-6 percent except in husks and some woods, wherein it could be upto 18 percent. More importantly, it is the chemistry of ash, which plays a key role in deciding the steam parameters and design of the boiler furnace. Ash content in MSW is more a function of external impurities like inerts.

For certain biofuels, the ash melting temperature is a relevant driving force for combustion process, since a
high process temperature initiates ash melting and slag expansion, resulting in plant breakdown and high maintenance. Low ash melting temperatures are characteristic for most of the leafy biomasses and energy grain, while woody biomass has less ash melting problems.

Ash fusion temperature and the ratio of basic and acidic salts are the two important factors influencing clinker formation. On the other hand, presence of alkali salts, particularly oxides of sodium and potassium causes fouling in the convection zones.

MSW ash may contain heavy metals and other toxins. This may require incorporation of special treatment facilities for conformance with environmental regulations.

Most of the leafy biomass as well as MSW contains significant amounts of chlorides and sulphates. The presence of chlorides promotes corrosion in the high temperature zones like superheaters, whereas sulphates have an adverse impact in the low temperature zones like economizers, air preheaters, etc.

The design and engineering has to be done for maintaining the desirable temperatures at various zones. Adequate on-line cleaning arrangement should also be provided in the various zones, which are prone to fouling.

Steam parameters
From thermodynamic consideration, higher the temperature, higher would be the cycle efficiency. To maintain the desired level of entropy at higher temperature, pressure also has to be correspondingly raised.

The practically attainable limits of temperature are influenced by fuel and ash characteristics. Superheater temperature is selected such that there should not be any ash fouling in the superheater zone and corrosion of super heater tubes. The furnace temperature and combustion system is influenced by the ash fusion characteristics. The presence of alkali matters reduces the ash fusion temperature, which can cause clinker formation. Grate material of construction and type of cooling are also governed by this factor.

The gain from higher efficiency has to be examined considering cost and extra revenue generation. From the table below (for an MSW based project), it can be seen that almost 10 percent additional power can be generated from the same amount of fuel by upgrading the parameters.

For bagasse and rice husk fuels, it is possible to aim for the highest level of prevalent pressure and temperature on the basis of techno-economic analysis. Configurations of 110 bar and 540°C have been established, but for other biomasses, we are on a learning curve. For difficult fuels like straw and mustard residue, the comfort zones are still around 430°C and 65 bar pressure. However, in a recent survey carried out by DSCLES, at least one plant has been observed to operate a mustard residue fired boiler at 68 bar and 450°C temperature with manageable fouling problems.

Table 2: Gain from higher parameters5 (MSW Project)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Case-1</th>
<th>Case-2</th>
<th>Case-3</th>
<th>Case-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiler outlet steam pressure</td>
<td>kg/cm²(a)</td>
<td>40</td>
<td>40</td>
<td>47</td>
<td>67</td>
</tr>
<tr>
<td>Boiler outlet steam temperature</td>
<td>°C</td>
<td>400</td>
<td>425</td>
<td>425</td>
<td>425</td>
</tr>
<tr>
<td>Boiler net outlet steam flow</td>
<td>TPH</td>
<td>80.9</td>
<td>78.4</td>
<td>77</td>
<td>74.7</td>
</tr>
<tr>
<td>Gross power generation</td>
<td>MW</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Boiler efficiency</td>
<td>%</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>64</td>
</tr>
<tr>
<td>GCV of fuel</td>
<td>kcal/kg</td>
<td>1300</td>
<td>1300</td>
<td>1300</td>
<td>1300</td>
</tr>
<tr>
<td>Fuel consumption</td>
<td>TPH</td>
<td>61.9</td>
<td>61.3</td>
<td>60</td>
<td>57.5</td>
</tr>
<tr>
<td>Fuel consumption per day</td>
<td>TPD</td>
<td>1486</td>
<td>1471</td>
<td>1440</td>
<td>1380</td>
</tr>
<tr>
<td>Specific fuel consumption</td>
<td>kg/kwh</td>
<td>3.87</td>
<td>3.83</td>
<td>3.75</td>
<td>3.59</td>
</tr>
<tr>
<td>Additional power generation</td>
<td>kW</td>
<td>-</td>
<td>155</td>
<td>510</td>
<td>1225</td>
</tr>
</tbody>
</table>

5 DSCLES analysis
Some plants have been built in Europe (Fig 4 above) on straw fuel at much higher levels of pressure and temperature parameters with different technological interventions like:
- Pre-washing to reduce alkali content
- High alloys for superheater
- Low fouling flue pass design

However, the capital cost of such plants is very high and it is unlikely that such plants would be viable in India without financial/policy support.

Considering the present level, following parameters are likely to become standards for different types of fuels:
- Bagasse & rice husk >20 MW - 110 bar, 540°C
- Bagasse & rice husk <20 MW - 87 bar, 510°C
- Cotton sticks/other woody biomass - 67 bar, 465°C
- Mustard residue/paddy straw - 67 bar, 440°C
- Municipal solid waste - 40 bar, 400°C

**Boiler design considerations**

The boiler design consideration has to factor in all the different characteristics described above. Some of the critical parameters influencing design considerations are shown in Table 3.

For good quality woody biomass of uniform size distribution, fluidized bed boiler is a preferred option. In fact, rice husk is probably the best suited fuel for fluidized bed technology. For most of the other biomasses, travelling grate stoker is the best option. Though water cooled grate is a preferred option, but due to higher cost and lack of design and manufacturing experience in the country, air cooled grates are being used.

The grate design is a function of the heat and moisture content in the fuel and the pre-heat temperature of FD air. However, at higher air temperatures, there may be problems with maintenance of the grate and also clinker formation.

The optimization exercise needs to be carried out considering the ash chemistry and operational efficiency. As the grate area increases, complex mechanical and thermal problems are faced. This puts a limitation on the maximum size of travelling grate biomass fired boiler.

In India, to the best of the knowledge of the author, the single biggest size of 170 TPH was installed in the year 2006\(^7\) and has been operating successfully since then.

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\(^6\) DSCLES analysis

\(^7\) DSM Sugar, Dhampur and Asmoli and Chaddha Sugar, Dhanaura

\(^8\) Characterizing fuels for biomass, Thermal Energy Systems
### Table 3: Boiler design consideration

<table>
<thead>
<tr>
<th>Area/property</th>
<th>Issue</th>
<th>Design consideration</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low bulk density</td>
<td>Feeding the required quantity in the boiler</td>
<td>Densification, Bale feed</td>
<td>In most of the European plants, bales are directly fed. Pellets are also used</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High capacity feeders and spreaders</td>
<td>High capacity screw feeders have been successfully developed and used in the operating mustard residue fired boilers in India</td>
</tr>
<tr>
<td>Bridging and choking</td>
<td>Obstruction free chutes and feeders</td>
<td>Providing access for poking/cleaning on line</td>
<td>Divergent chutes with ground internal finish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Furnace area</td>
<td>Water cooled travelling grate is the best solution followed by air cooled travelling grate</td>
</tr>
<tr>
<td>Non-uniform fuel size</td>
<td>Combustion efficiency</td>
<td>Type of combustion equipments</td>
<td>Travelling grate stoker seems to be the best solution</td>
</tr>
<tr>
<td>Clinkering characteristics</td>
<td>Operation of the combustion equipments</td>
<td>Managing temperature, Ease of breaking and removal</td>
<td>Fluidized bed helps in maintaining lower temperature, but is ill suited as far as extraction is concerned</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Furnace area</td>
<td>Water cooled travelling grate</td>
</tr>
<tr>
<td>Fouling characteristics-</td>
<td>Fouling of heat transfer area/choking of</td>
<td>Managing the temperature at the furnace exit, Adequate provision of furnace height and volume</td>
<td>Managing the temperature bandwidth between the volatilization and condensation points</td>
</tr>
<tr>
<td>presence of oxides of sodium and potassium</td>
<td>passages</td>
<td>generous soot blowing arrangement</td>
<td></td>
</tr>
<tr>
<td>Corrosion characteristics-</td>
<td>High temperature corrosion of super heaters</td>
<td>Steam temperature parameter</td>
<td>Usually kept below 430°C. However, with use of higher alloy, it is possible to raise the temperature. Superheater should be preferably located in the convection zone, though this can increase the cost.</td>
</tr>
</tbody>
</table>

Working on developing a system of monitoring of the pressure and temperature profiles of such boilers on a real time basis and integrating the soot blowing control system for automatically managing the boiler cleanliness.

**Conclusion**

Some of the technological features discussed above have been successfully deployed in the mustard residue fired projects in Rajasthan. Most of these projects have logged in over 80 percent PLF on 100 percent biomass. The fuel feeding and soot blowing systems have been modified in stages and it is hoped that reliability of these projects would be comparable to coal fired plants. The straw based project in Punjab is expected to be commissioned in a few weeks’ time. This project would be the first one to use all the technological features as discussed above. The successful operation of this project is expected to open new vistas for development of biomass based projects in the country.

**G. C. Datta Roy**  
*Chief Executive*  
*DSCL Energy Services Co Ltd*  
*Email: gdr@dscl.com*
Supporting Biomass Power Development through Programmatic CDM

India is an agriculture dominated country and plenty of biomass is generated here every year. The availability of biomass in India is estimated at about 540 million tonnes every year, out of which 120-150 million tonnes can be made available for power generation. It is estimated that the potential of biomass power generation is nearly 21,000 MW in the country. The renewable biomass used for power and heat generation is a GHG neutral source, therefore, biomass based energy can significantly reduce GHG emissions if, substituted for conventional grid power. It is estimated that this can help mitigate around 100 million tonnes of CO₂ every year.

As biomass based energy generation has great potential for meeting the energy requirements in an environment friendly way, the Ministry of New and Renewable Energy (MNRE) has been providing many incentives for biomass based power systems. In addition, biomass based power plants result in GHG emission reduction and thus are eligible for availing carbon credits under the Clean Development Mechanism. This additional carbon revenue helps these projects in increasing their IRR by 2-4% depending upon the technical features.

In India, there is a huge power shortage for industries located in remote areas. Incidentally, in these regions the potential of decentralized biomass based power plants is vast because of biomass availability. However, such decentralized units are generally smaller in size and the potential for Certified Emission Reductions (CERs) earnings is also less. Therefore, such projects do not consider CDM benefits in their business model, apprehending the complexity in the process and the accompanying huge transaction cost, which does not vary significantly with the project size. The risks associated with the registration and the amount of transaction cost paid before the registration is so high that the projects with potential of earning below 5000 CERs are not generally advised to enter the CDM cycle. Because of these reasons, despite being a major source of finance, many biomass power projects do not enter the CDM pipeline to earn the CERs. The “Programmatic CDM” approach is a promising way of providing these projects with carbon credits that they deserve.

Programmatic CDM

This approach is mainly characterized by a Program of Activity (PoA) and many CDM Project Activities under the PoA. This mechanism is a relatively new concept in an international climate change regime. As an extension of the conventional CDM, it allows bundling and registration of similar kind of GHG emission reduction (or removal) projects having different implementation schedules over a period of time.

According to the CDM Executive Board, a CDM program of activities (PoA) is a voluntary coordinated action by a private or public entity, which coordinates and implements any policy/measure or stated goal (i.e. incentive schemes and voluntary programs). It leads to anthropogenic GHG emission reductions at source or net anthropogenic greenhouse gas removals by sinks, which are additional to any that would occur in the absence of the PoA, via an unlimited number of CDM Program Activities (CPAs).

A CPA, basically, is a single, or a set of interrelated measure(s), to reduce GHG emissions or result in net anthropogenic greenhouse gas removals by sinks, applied within a designated area as defined in the baseline methodology.

Therefore, PoA is an umbrella program with a number of similar activities called CPAs. The PoA is implemented at three levels i.e. the program level or PoA, activity level or CPA and end user level. The PoA is governed by a managing or coordinating entity, which takes care of CDM registration and issuance of CERs. The CPAs are implemented by many implementing agencies or CPA operators, which take care of the implementation and monitoring of the activity.

Programmatic CDM and Biomass Project
The programmatic CDM is an innovative mechanism to support projects, which are decentralized in nature,
small/medium in size and having relatively low potential of earning carbon credits. Most of the biomass projects are characterized by these indicators. Typically, there are three major categories of biomass projects. The appropriateness of PoA for biomass projects is illustrated in Table 1.

The power generated by biomass has the potential of meeting the demand of many industries in the surrounding region. A program designed for biomass application for industries can be taken up in a programmatic CDM cycle. The important players involved in the Program of Activity would be:
- Managing or coordinating agency at the PoA level
- Implementing agency at the CPA level
- Industries (Large or SMEs)/users

SMEs generally do not have sufficient capital to invest in power plants that can help them meet their power requirements. Even if they set up a biomass power plant, they would not take the risk of entering the CDM registration process, as it would not yield sufficient number of CERs. If a PoA is launched by a coordinating entity, then it can provide the initial financial support in terms of capital and CDM registration costs for individual power developers implementing the CPAs. As the PoA is normally big in size, sufficient number of CERs will be generated. Depending upon the financial model and CER sharing agreement, the coordinating agency will benefit from the power generated and the carbon credits earned from the project. The coordinating entities may be technology suppliers, industry associations or any group with a huge network and penetration in the rural areas. The agencies implementing the CDM project activities could be state nodal agencies, NGOs, microfinance institutions, private players, etc.

A typical CDM PoA implementation framework, involving Technology Supplier as coordinating agency at the PoA level, MFIs at the CPA level and SMEs as end users, is illustrated in Figure 1:

**Table 1: Appropriateness of Biomass Power Projects for Programmatic CDM**

<table>
<thead>
<tr>
<th>Elements</th>
<th>Biomass based power</th>
<th>Biomass based heat</th>
<th>Biomass based cogeneration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sites</td>
<td>Multiple, clustered</td>
<td>Multiple, clustered</td>
<td>Multiple, clustered</td>
</tr>
<tr>
<td>Possibility of adding new devices over time</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>CER potential per unit device per year</td>
<td>Medium</td>
<td>Medium/High</td>
<td>Medium/High</td>
</tr>
<tr>
<td>Size of device</td>
<td>Medium/Large</td>
<td>Medium/Large</td>
<td>Medium/Large</td>
</tr>
<tr>
<td>Ex-ante identification of project sites</td>
<td>Less difficult</td>
<td>Less difficult</td>
<td>Less difficult</td>
</tr>
<tr>
<td>Project developers/promoters</td>
<td>Many</td>
<td>Many</td>
<td>Many</td>
</tr>
<tr>
<td>Degree of Replicability of projects</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

**Fig 1: CDM PoA implementation framework for Biomass application in Industry**

A business entity/technology supplier launches a program. MFI is interested in clean energy technology and buys it from the supplier. MFIs give this technology to an end user, on loan, which is repaid back in installments. The end user enjoys the benefit without paying huge capital costs initially. The MFI also provides necessary training to end users for operation and maintenance (O&M) and also bears the expenses of a
A group formed to carry out the necessary monitoring and verification. The technology supplier further invests in R&D and MFI provides vocational training to locals for their development. The CDM revenue is shared by the technology supplier and the MFI. However, this may vary depending upon the financial model involved in the PoA and CPAs. Normally, the sharing of CERs is based on a CER sharing agreement.

Alternatively, a program can be launched by a cluster of SMEs, where the cluster will invest in one biomass power plant to fulfill their demand of power. Many such clusters could be formed and a program can be launched to support all such clusters. MNRE or any government agency can play the role of the coordinating agency in this case and they can provide necessary support to any financial institution or a group of financial institutions, which can then invest in the CPAs. Depending upon the financial structure, the CER revenue may be realized fully by these financial institutions or may be shared between the FIs and the end users.

**Advantages of Programmatic CDM for Biomass Power projects**

The above frameworks show that the Programmatic CDM approach can be helpful in removing certain inherent barriers normally associated with smaller and decentralized projects. It can prove advantageous for such projects in the following ways:

- Availing carbon credits will become economical as the entire program including small project units will be registered as one project. Therefore, the transaction cost per project will be significantly reduced
- Additional benefits though CERs will attract private investors and other interested parties to participate in the program
- CER benefits availed under programmatic CDM will increase the penetration of the latest modern biomass power technologies in the remote areas. The existing practices are well below the baseline standard in these areas.
- Since programmatic CDM will be launched as a program with effective implementation, monitoring, verification and maintenance framework, the smooth functioning of power plants and generation of power will be ensured.
- As multiple stakeholders will be involved in the entire program, it will lead to significant employment generation in the region.

**Challenges in Programmatic CDM**

Although the programmatic CDM approach could be a useful way of supporting the decentralized and small scale biomass projects in remote areas, the concept has yet not been fully adopted. In India, not a single project has been registered till date. There is scope for many improvements in terms of the guidelines and rules of this approach. The concept, in particular, faces strong resistance from validators, who perceive many disincentives for them in the existing framework. Also, the methodologies for registering PoAs are not robust and there are still many issues, which have made the process very complex. Various stakeholder workshops and meetings have taken place recently to address these problems and some reforms have been made. However, more aggressive efforts are needed from the CDM Executive Board, Designated National Agency, Validators and consultants, to speed up the entire process.

**Conclusion**

To conclude, it can be said that Programmatic CDM is an effective way of implementing small scale and decentralized biomass power projects in remote areas of India. The approach has good potential to make carbon credits available for these projects and thus create a proper institutional framework of stakeholders essential for the sustainable operation of the projects. The need of the hour is to remove the procedural barriers in the existing approach so that a larger number of projects and players can take advantage of this concept. The role of central government agencies and state nodal agencies is particularly critical in this context. In the line of programs like the Bachat Lamp Yojana of BEE, which is also a Programmatic CDM approach for achieving energy efficiency, some programs can be launched to facilitate this process. It is likely that once programs enter the process, the reforms required will become more evident. Subsequently, intensive efforts can be made to bring about these reforms, which will not only help the proposed program but also forthcoming programs.

Anjan Katna & Alok Barnwal

Consultants at Emergent Ventures India Pvt. Ltd.  
Email: aloke@emergent-ventures.com

The article is based on the report prepared by Emergent Ventures India Pvt. Ltd for MNRE titled “Framework for Programmatic CDM in Renewable Energy”.
Central Electricity Regulatory Commission (CERC) has notified the tariff regulations for electricity generated from renewable energy sources. These regulations have been finalized keeping in view the statutory mandate to Electricity Regulatory Commissions for promoting cogeneration and generation of electricity from renewable sources of energy. The Tariff Policy had also mandated CERC to lay down guidelines for pricing non-firm power, especially from non-conventional sources, to be followed in cases, where such procurement is not through competitive bidding.

These regulations assume special importance in view of the National Action Plan on Climate Change, which stipulates that minimum renewable purchase standards may be set at 5 percent of the total power purchases in year 2010, and thereafter should increase by 1 percent each year for ten years. The new tariff regulations are expected to promote new investments so that renewable electricity supply can expand to meet the goals stipulated in the National Action Plan.

Specifying capital cost norms and fixing tariff upfront for the whole tariff period are the two main features of the new regulations. The regulations provide normative capital costs for projects based on different renewable technologies. These capital costs are to be revised every year for incorporating the relevant escalations. The norms themselves would be reviewed in the next control period, which will start after a period of three years. However, the regulations have enabling provisions to review the capital cost norms for solar power projects every year, in view of the fact that the costs for these technologies are expected to decline more rapidly.

Also, the tariff permitted to a project under these regulations would apply for the whole tariff period, which is 13 years. The tariff period for solar power has been kept as 25 years and for small hydro below 5 MW, it has been kept as 35 years in view of the special considerations required for these technologies. This feature of upfront tariff for the whole tariff period is a major initiative to ensure regulatory certainty.

The tariff philosophy in these regulations is to give preferential tariff to the projects based on renewable technologies during the period of debt repayment. Preference has been given mainly in respect of return on equity, shorter loan repayment period and higher normative interest on loan. Thereafter, these projects are expected to sell power through competitive route.

The tariff model adopted is levelized tariff in order to avoid front loading of tariff while, at the same time, ensuring adequate project IRR.

These regulations also provide that in case of solar power, which is comparatively an evolving technology, as well as for other new technologies, such as municipal waste based generation, the project developer can also approach the Commission for a project specific tariff.

The Forum of Regulators has also agreed to implement Renewable Energy Certificate (REC) mechanism, which will be an alternative route for fulfilling renewable purchase obligations. This mechanism is mainly aimed at addressing the mismatch between renewable resources availability in the local region and the renewable purchase obligations. CERC would play a supportive role for designing and regulating national level REC registry and REC market.

Further, in order to address the technical problems relating to absorption of large volumes of non-firm power, such as wind, in the grid, CERC has constituted an expert task force which has representation from Central Electricity Authority, States, System Operator and C-WET. The Task Force has been mandated to give recommendations in respect of forecasting of the power generation from these technologies, ensuring grid reliability and equitable sharing of costs involved in ensuring reliable operations. The Task Force will also recommend appropriate grid connectivity standards for renewable sources based generating stations.

Table 1 shows the policies introduced by State Electricity Regulatory Commission for purchase of electricity from biomass and bagasse based cogen power projects.
Table 1: Policies introduced by State Electricity Regulatory Commission for purchase of electricity from biomass & bagasse cogen power projects

<table>
<thead>
<tr>
<th>State</th>
<th>Participation</th>
<th>Wheeling</th>
<th>Banking</th>
<th>Buy Back</th>
<th>Third Party Sale</th>
<th>Other Incentives</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.P*</td>
<td>Pvt.</td>
<td>28.4% +</td>
<td>Allowed</td>
<td>@Rs.4.05/kWh, (09-10) (BM)</td>
<td>Not Allowed</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rs.0.5/kwh</td>
<td>2% for 8-12 months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chhattisgarh*</td>
<td>Pvt.</td>
<td>6%</td>
<td>Not allowed</td>
<td>@Rs.3.21/kWh, (09-10) (BM)</td>
<td>Allowed</td>
<td>As to other industry; Electricity Duty Exempted for 1st five years</td>
</tr>
<tr>
<td>Gujarat*</td>
<td>Pvt.</td>
<td>4% of energy</td>
<td>Allowed</td>
<td>@ Rs. 3.08/unit, (BM)</td>
<td>Allowed</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12 months</td>
<td>No escalation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haryana* (RPO-3%-07-08)</td>
<td>Pvt.</td>
<td>2% of energy</td>
<td>Allowed</td>
<td>@ BM -Rs. 4.00/unit, -Rs. 3.74/unit (Cogen) 2% escalation (base year 07-08)</td>
<td>Allowed</td>
<td>—</td>
</tr>
<tr>
<td>Karnataka*</td>
<td>Pvt.</td>
<td>5% surcharge Rs.1.13/unit</td>
<td>Allowed</td>
<td>@ Rs. 2.74/unit, (Cogen) @Rs. 2.85 per unit (04-05) 2% on base tariff (BM)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Kerala</td>
<td>Pvt.</td>
<td>5% of energy</td>
<td>Allowed</td>
<td>@ Rs. 2.80/unit, (BM) escalated at 5% for five years (2000-01)</td>
<td>Not allowed</td>
<td>50% cost of power evacuation line to be borne by KSEB</td>
</tr>
<tr>
<td>Maharashtra*</td>
<td>Pvt./Coop.</td>
<td>7% of energy</td>
<td>Allowed</td>
<td>@Rs. 3.05/unit (Comm yr.) (Cogen) @ Rs. 4.28 (09-10) (BM)</td>
<td>Allowed</td>
<td>50% cost of power evacuation line to be borne by MSEB</td>
</tr>
<tr>
<td>M.P</td>
<td>Pvt.</td>
<td>Yet to be decided</td>
<td>Allowed</td>
<td>@ Rs. 3.33 to 5.14/unit paise for 20 yrs. With escl of 3- 8 paise</td>
<td>Allowed</td>
<td>—</td>
</tr>
<tr>
<td>Punjab</td>
<td>Pvt.</td>
<td>2% of energy</td>
<td>Allowed</td>
<td>@Rs. 3.49/unit, (06-07) escalated at 3% -cogen, &amp; 5%-BM</td>
<td>Allowed</td>
<td>As to other industry</td>
</tr>
<tr>
<td>Rajasthan*</td>
<td>Pvt.</td>
<td>10% of energy</td>
<td>Allowed</td>
<td>@ Rs. 4.47 / unit, (09-10)-water cooled and Rs. 4.96- air cooled condensers</td>
<td>Allowed</td>
<td>—</td>
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</table>

(contd...)
* Policy announced by State Electricity Regulatory Commission in respective State.

+ The Uttar Pradesh Electricity Regulatory Commission (UPERC) has just announced tariffs for Biomass power & Bagasse based Cogeneration as per Tables 2 & 3 below:

**Table 2: Effective Tariff for Biomass Power Plants**

<table>
<thead>
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</thead>
<tbody>
<tr>
<td>FY 2008-2009</td>
<td>4.29</td>
<td>4.41</td>
<td>4.55</td>
<td>4.69</td>
<td>4.84</td>
</tr>
<tr>
<td>FY 2009-2010</td>
<td>4.38</td>
<td>4.50</td>
<td>4.63</td>
<td>4.77</td>
<td>4.92</td>
</tr>
<tr>
<td>FY 2010-2011</td>
<td>4.58</td>
<td>4.71</td>
<td>4.85</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>FY 2011-2012</td>
<td>4.80</td>
<td>4.93</td>
<td>5.02</td>
<td>5.17</td>
<td></td>
</tr>
<tr>
<td>FY 2012-2013</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FY 2013-2014</td>
<td></td>
<td></td>
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</table>

**Table 3: Effective Tariff for Bagasse Plants-New Projects**

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>FY 2009-2010</td>
<td>4.21</td>
<td>4.24</td>
<td>4.29</td>
<td>4.34</td>
<td>4.40</td>
</tr>
<tr>
<td>FY 2010-2011</td>
<td>4.39</td>
<td>4.43</td>
<td>4.47</td>
<td>4.53</td>
<td></td>
</tr>
<tr>
<td>FY 2011-2012</td>
<td></td>
<td>4.57</td>
<td>4.61</td>
<td>4.67</td>
<td></td>
</tr>
<tr>
<td>FY 2012-2013</td>
<td></td>
<td></td>
<td>4.76</td>
<td>4.81</td>
<td></td>
</tr>
<tr>
<td>FY 2013-2014</td>
<td></td>
<td></td>
<td></td>
<td>4.96</td>
<td></td>
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</tbody>
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*aSource: www.uperc.org*
News Snippets on Biomass Power

$24 Million in Biomass Research and Development Grants
The U.S. Departments of Agriculture and Energy have announced projects selected for more than $24 million in grants to research and develop technologies to produce biofuels, bioenergy and high-value biobased products. Of the $24.4 million announced, DOE plans to invest up to $4.9 million with USDA contributing up to $19.5 million. Advanced biofuels produced through this funding are expected to reduce greenhouse gas emissions by at least 50 percent. “The selected projects will help make bioenergy production from renewable resources more efficient, cost-effective and sustainable,” said Energy Secretary Steven Chu. “These advancements will benefit rural economies through creation of new processing plants and profitable crops for U.S. farmers and foresters.” “Innovation is crucial to the advancement of alternative, renewable energy sources, and these awards will spur the research needed to make significant progress in bioenergy development,” said Agriculture Secretary Tom Vilsack.

Biomass Power Plant investments receiving a boost
Shriram EPC has a significant presence in the wind energy area. It is now making forays into biomass power generation by committing investments of Rs. 7,300 million through its group company Oriental Green Power. The intention is to serve both the national and international markets. As per the company plan, the investment would be directed towards setting up of 146 MW capacity plants. Each MW thus installed would cost around Rs. 50 million. Most of these plants are expected to be operational by 2010. As of now, the company operates biomass plants with a total production capacity of 22 MW.

Reinforcing the R&D efforts at IISc
MNRE has recently sanctioned a project on “Advanced Biomass Research Centre” to the prestigious Indian Institute of Science (IISc), Bangalore, at a total outlay of Rs. 90.84 million. The far sighted objective is to further strengthen the research cum design capabilities of the group at Combustion, Gasification and Propulsion Laboratory (CGPL). It is equally significant to mention here that biomass gasifier specific technical know-how has already been transferred by IISc to a selective few industrial units presently in commercial production.

Mega Joint Venture for Biomass Power Generation
A strategic partnership between the energy giant AREVA and Astonfield Renewable Resources Limited, for large scale biomass power production, is going to begin soon. The idea behind the venture is to set up biomass based power plants across India with an aggregated capacity of 100 MW at an estimated investment of around 100 million. As per the information available, AREVA’s Bio-Energy unit in Chennai will be fully responsible for designing, constructing and commissioning biomass plants across India. The work on the first of these plants is about to be taken up in the state of West Bengal. Presently, AREVA is managing about 100 bio energy plants spread throughout the world, which have either been commissioned or are under various stages of construction.

Cogeneration Projects in Maharashtra aimed for an early start
The government of Maharashtra has just initiated a scheme to offer 5 percent equity in respect of cogeneration projects sanctioned by the high level committee with a clear cut objective to enable their early commissioning. Under this specific initiative, around 55 sugar mills in the state have been shortlisted for the purpose. This committee has so far released sanctions for 18 projects and accordingly orders for procurement of major equipment like boiler and turbines have been placed with the reputed names in the industry. It is planned that a cumulative capacity of 265 MW be installed under this major initiative. On the technical front, the minimum pressure and temperature configuration has been kept at 87 ata and 515°C for these projects. Expectedly, a few sugar mills may use the even higher pressure and temperature configurations of 110 ata and 540°C.

Poultry Litter based 3.36 MW Biomass Power Plant
A 3.36 MW biomass power plant using poultry litter was commissioned at Duppalapudi village in East Godavari district of Andhra Pradesh some time back. The project...
may generate around 256 lakh units per year out of which about 223 lakh units are to be exported to the grid after meeting the captive power requirements of the plant. The raw material in this case-poultry litter is being collected from the poultry farms located within a 25 km radius from the site of the power plant. As per the available estimates, the total availability of poultry litter in East Godavari district is around 800 MT/day and the plant needs around 165 MT/day. A storage capacity for keeping the raw feedstock for around ten days has also been constructed. The litter is fed to the boiler on a continuous basis and the supplementary fuel i.e. rice husk is stored elsewhere. The mixing proportion of the poultry litter and rice husk is 75 percent and 25 percent respectively. An electrostatic precipitator has been installed to control the particulate emissions into the atmosphere. The gaseous emissions of poultry litter combustion have a very low content of sulphur, chlorine and heavy metals. The steam turbine installed in the power plant is a condensing turbine, which is designed to drive the generator directly to generate power at 50 Hz.

### Books

<table>
<thead>
<tr>
<th>Title:</th>
<th>The Handbook of Biomass Combustion and Co-firing</th>
</tr>
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<tbody>
<tr>
<td>Publisher:</td>
<td>Earth Scan Publications*</td>
</tr>
<tr>
<td>Editors:</td>
<td>Sjaak van Loo and Jaap Koppejan</td>
</tr>
<tr>
<td>No. of Pages:</td>
<td>464</td>
</tr>
<tr>
<td>Price:</td>
<td>£75</td>
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This unique handbook presents both the theory as well as applications of biomass combustion and co-firing. From basic principles to industrial combustion and environmental impact, it manages to touch every topic in a clear and comprehensive manner. It offers a solid grounding on biomass combustion, and also throws light on how to improve combustion systems. Written by leading international academicians and industrial experts, and prepared under the auspices of the International Energy Agency (IEA) Bioenergy Implementing Agreement, the handbook is an essential resource for anyone interested in biomass combustion and co-firing technologies; the activities of which may vary from domestic woodstoves to utility-scale power generation. The book covers subjects including biomass fuel pre-treatment and logistics, modeling of the combustion process and ash-related issues and also features an overview of the current R&D needs with regard to biomass combustion.

<table>
<thead>
<tr>
<th>Title:</th>
<th>The Biomass Assessment Handbook</th>
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<tr>
<td>Publisher:</td>
<td>Earth Scan Publications*</td>
</tr>
<tr>
<td>Author:</td>
<td>Frank Rosillo Calle, Sarah Hemstock, Peter De Groot</td>
</tr>
<tr>
<td>No. of Pages:</td>
<td>269</td>
</tr>
<tr>
<td>Price:</td>
<td>Rs. 6557</td>
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Responding to the need for reliable and detailed information on biomass consumption and supply and overcoming the lack of standardized measurement and accounting procedures, this handbook provides the skills to understand the biomass resource base and the tools to assess the resource as well as the pros and cons of exploitation. The topics covered include assessment methods for woody and herbaceous biomass, biomass supply and consumption and remote sensing techniques. International case studies, ranging from techniques for measuring tree volume to transporting biomass help to illustrate the step-by-step methods and are based on fieldwork experience. A set of technical appendices offer a glossary of terms, energy units, and other valuable reference data. The Handbook provides invaluable reading for energy consultants, agronomists, foresters, project developers, natural and social scientists, environmental policy analysts and students interested in bioenergy and environmental studies.

*Earth Scan, Dunstan House, 14a St. Cross Street, London EC1N 8XA, UK
Tel: +44 (0) 20 7841 1930; Fax: +44 (0) 20 7242 1474; Email: earthinfo@earthscan.co.uk
MANUFACTURER:-

ASHOK PODDAR
GANESH ENGINEERING WORKS
PODDAR HOUSE, JYOTI CHOWK, BUXAR - 802101 (INDIA)
PH.: 06183-224571, FAX : 227503, Mob.: 9431420171
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- Our Biomass Gasifiers are tested & approved by Indian Institute of Technology, New Delhi.
- Our Down Draft Gasifiers are supplied under technical collaboration of “The Energy and Resources Institute” (TERI), New Delhi
- We are manufacturing all types of Gasifiers like Down-Draft, Up-Draft and Coal Gasifiers.
- We have our own full fledged Manufacturing facilities. We have supplied our Gasifier systems to various industries for power generation and for thermal applications.

OUR OTHER PRODUCTS:
Cement Plants, Fertilizer Plants, Lime Plants, Mineral Processing Plants, Material Handling Equipment, etc.

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MNRE Program on Biomass and Bagasse Cogeneration based Power Generation

Biomass is an important energy source for power generation in developing countries, including India. Biomass power has assumed the shape of an industry in the last 15 years and is attracting an annual investment of over Rs. 1,000 crore, generating more than 9 billion units of electricity per year and creating employment opportunities in the rural areas. Megawatt scale electricity generation, through the combustion and cogeneration routes, is employed under the Biomass/Cogeneration program. The government has introduced a host of measures to create awareness amongst stakeholders, demonstrate commercial viability and attract investments in this sector. This has resulted in significant capacity addition of biomass and bagasse cogeneration projects in sugar mills through the private sector. The Ministry has been promoting optimal cogeneration plants in private sugar mills by adopting progressively higher steam parameters of up to 110 ata and 540°C, which provides for additional power generation.

Pattern of Central Financial Assistance (CFA) for Biomass Power and Bagasse Cogeneration Projects
The Ministry offers assistance for biomass power and bagasse cogeneration projects undertaken in the special category states and other states as per Tables 1 & 2 below:

### Table 1: Financial Assistance

<table>
<thead>
<tr>
<th>Program</th>
<th>Special Category States</th>
<th>Other States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass Power Projects</td>
<td>Rs. 25 lakh X (Capacity in MW) ^ 0.646</td>
<td>Rs. 20 lakh X (Capacity in MW) ^ 0.646</td>
</tr>
<tr>
<td>Biomass Cogeneration (private sugar mills)</td>
<td>Rs. 18 lakh X (Capacity in MW) ^ 0.646</td>
<td>Rs. 15 lakh X (Capacity in MW) ^ 0.646</td>
</tr>
<tr>
<td>Bagasse Cogeneration projects by Cooperative/Public/Joint Sector</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 bar &amp; above</td>
<td>Rs. 40 lakh*</td>
<td>Rs. 40 lakh*</td>
</tr>
<tr>
<td>60 bar &amp; above</td>
<td>Rs. 50 lakh</td>
<td>Rs. 50 lakh</td>
</tr>
<tr>
<td>80 bar &amp; above</td>
<td>Rs. 60 lakh</td>
<td>Rs. 60 lakh</td>
</tr>
<tr>
<td>Per MW (maximum support Rs. 8.0 crore per project)</td>
<td>Per MW (maximum support Rs. 8.0 crore per project)</td>
<td></td>
</tr>
</tbody>
</table>

* for new sugar mills (which are yet to start production and sugar mills employing back pressure route/seasonal/incidental cogeneration) subsidies shall be one-half of the level mentioned above.

### Table 2: Fiscal Incentives

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accelerated Depreciation</strong></td>
<td>80 percent depreciation in the first year can be claimed for the following equipments required for cogeneration systems: 1. Back pressure, pass out, controlled extraction, extraction cum condensing turbine for cogeneration with pressure boilers 2. Vapour absorption refrigeration systems 3. Organic rankine cycle power systems 4. Low inlet pressure steam inlet systems</td>
</tr>
<tr>
<td><strong>Income Tax Holidays</strong></td>
<td>10 years income tax holiday</td>
</tr>
<tr>
<td><strong>Customs Duty</strong></td>
<td>Concessional customs and excise duty exemption for machinery and components for initial setting up of the projects</td>
</tr>
<tr>
<td><strong>General Sales Tax</strong></td>
<td>Exemption is available in certain states</td>
</tr>
</tbody>
</table>

*UNDP is the UN’s global network to help people meet their development needs and build a better life. We are on the ground in 166 countries, working as a trusted partner with governments, civil society and the people to help them build their own solutions to global and national development challenges.*