Abellon Receives Ashden Awards 2010: A Green Oscar Award

Abellon has won the Ashden Award 2011 - considered to be the Green Oscars – the top most awards in the green and sustainable energy segment globally. Abellon has successfully established a sustainable biomass pellets manufacturing model using crop waste – a local, clean source of energy that reduces CO₂ by replacing polluting industrial fuels, as well as for driving economic growth, improvement in crop yields and support of farmers through its Poornakumbha initiative.

Eco-Chulha Wins Golden Peacock Eco-Innovation Award 2011

Eco-Chulha, the eco-friendly cookstove, has won the prestigious "Golden Peacock Eco-innovation Award for the year 2011". This award was given to them in recognition of their efforts towards replacing polluting, unhealthy, conventional cooking practices prevailing in India with this cleaner, advanced, efficient and innovative cooking stove. The award was presented to Abellon by Hon’ble K V Thomas, Union Minister of State for Food and Consumer Affairs, at the Awards Presentation Ceremony held in New Delhi on 25 June 2011.
Dear Readers,

Bioenergy India is dedicated in its efforts by bringing to you yet another informative issue. In this 8th Issue of Bioenergy India, we present a broad spectrum of technology options for boosting the sustainable bioenergy development. Sustainable supply of the required quantity of biomass has been one area of concern for up-scaling bioenergy projects, especially biomass based power projects. All stakeholders including Governments, industry, research institutions, and project developers have been working on various options to strengthen this critical link in the overall chain of the bioenergy development.

Facing this scenario, our main focus of the Issue would be energy plantations and the promises it holds to address the supply side concerns. We explore, through case studies and research in this sector, the various innovations being carried out in this area for sustainable biomass development.

Energy Plantation Projects India (EPPI) has initiated the pilot project in 500 acres at Sivagangai, Tamil Nadu that is expected to produce electricity at very reasonable cost. Though the primary focus was to develop energy plantation for its own power stations, it was found that the same techniques and the results can be extremely beneficial for all other power plants. The article “Distributed Power across India through Bioenergy” presents the details and prospects of dedicated energy plantations based bio-energy and power projects, a concept being explored by the Ministry of New and Renewable Energy (MNRE), Government of India for strengthening bioenergy development in the country.

The solution to provide sufficient energy lies in adopting a mix of appropriate technological solutions. The latest developments in attempting fast growing species such as “BEEMA BAMBOO”, “Vanashree” etc. for plantations are presented in this Issue, which shows promise towards availability of low cost biomass from captive energy plantations. Positive and negative externalities of biomass energy systems have been examined with particular reference to Himalayas, which could be a useful tool while encouraging large scale bioenergy projects in that region. Another study contained in this Issue shows the positive impacts of agro-forestry in regenerating alkaline soils for rice and wheat production.

The article on “Self-Power Generating Chula (wood stove)”, a New Alternate Micro-Power Generation Technology” presents a new innovation to replace the kerosene lamps used by the villagers with brighter and safer LEDs energized by bioenergy.

To map the progress of our contemporaries, we bring to you policy perspective and this time we analyze “Thailand’s Biomass Policy from an Indian Perspective”.

Also included are our regular features for your information on What to Read, Attend and Latest News in the sector to keep you abreast with all the happenings.

We look forward to your suggestions and comments.

(K.P. Sukumaran)
BIOENERGY India is a quarterly magazine covering 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 are also included in the publication.

From our Readers

I have gone through the Quarterly Magazine on Biomass Energy wherein I came across a very important information on RE projects registered under CDM. As we are in process of framing RE tariff Regulation-2012 and for evaluation of RE projects cost and other data such list would be very useful to us. If you have track of all RE Projects registered from 09-10 onwards and if you can share the same, CERC would be obliged.

Mr Rakesh Shah, Advisor (RE)
Central Electricity Regulatory Commission

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Distributed Power across India through Bioenergy – Time for Urban Professionals to Take Over

Low Cost Biomass from Captive Energy Plantation

Energy Crop Plantations for Biomass Power Plants and its Future in India

Thailand’s Biomass Policy – A View from Indian Policy Perspective

Economic Feasibility and Socio-economic Impacts of Four Bio-saline Agro-forestry Systems in Haryana, India

Case Study: ‘Sweet Side’ of the Power Sector in Mauritius
Distributed Power across India through Bioenergy – Time for Urban Professionals to Take Over

Distributed Power across India through Bioenergy – is one of the important initiatives launched by Ministry of New and Renewable Energy (MNRE). Their initiative influenced a group of urban professionals in a private power company called Energy Plantation Projects India Limited (EPPI) to such an extent that the company developed an eco-system out of this concept. The eco-system consists of managerial, technical, social and financial wherewithal.

Bioenergy’s importance and the statistics associated with the subject are a common knowledge already. MNRE comes out regularly with various policies, incentives etc. to promote distributed power through bioenergy route. Latest among these initiatives is the “Dedicated Plantations based Biomass Power and Energy”. This initiative is first of its kind in the world where a Central Government makes explicit efforts through policy formulations to convert the much discussed and much researched subject of Energy Plantations for Power into ground level reality and projects. The initiative manifests itself as a very effective combination of the objective and means. What triggered this initiative? Reactive as well as proactive components make up this initiative.

Majority of the Biomass Energized Electrical Power Stations (BEEPS) in India use firewood as feedstock. Lacs of tons of this feedstock (termed often simply as biomass) is required every year for functioning of these power stations. Shortage of feedstock and its effects on functioning of BEEPS is now a well-regretted phenomenon. Only forests can produce such large quantities of firewood. Growing forests is a decade-long effort, which is unattractive practically and financially. Energy Plantations (Forests) is an answer to this. Energy Plantations are Man-Made High-Density Regenerative Forests with fast growing trees specifically for Power Generation. The harvesting cycles are less than four years to start with and less than three years for subsequent harvests. MNRE is encouraging setting up of Power Stations based on Energy Plantations.

In the proactive sphere, MNRE made very attractive the planning and execution of BEEPS with complete fuel security through Energy Plantations. In addition to incentive regime, MNRE is also collecting information from various agencies like EPPI to come out with credible set of policies in various spheres of investment, clearances etc. to encourage all round ease and facilitation.
Role of Urban Professionals

Where do Urban Professionals figure in this scheme of things? Their entry is best facilitated by one of the outstanding aspects of initiative taken by MNRE. It is the scalability. The initiative facilitates setting up Power Stations with capacities of few hundred kW and the associated energy plantation of 15-20 acres for fuel security. The initiative also facilitates setting up Power Stations with capacity of up to 2 MW and the associated energy plantation of a few hundred acres for fuel security. It is this wide range of business possibilities and business prospects that is drawing the attention of urban professionals with disposable incomes.

The “Eco-System” referred to in the very first paragraph of this article is the Cause Célèbre’ developed by EPPI. In the process of developing this Eco-System, the company came across the unique nature and advantages of Urban Professionals taking up the Green Energy Initiative. Following text is a result of years of experience, convictions and proof. It augurs well at this juncture to declare that EPPI consists of professionals none of whom had any exposure or experience in forestry or agriculture. They started with this disadvantage and they found over a period of time that this lack of expertise turned out to be to their advantage in terms of innovation and non-conformity.

Current day urban professionals bring in the planning and work culture not common in the world of forestry and agriculture. Best of their attitudes stems from their quest to make the establishment recursive for performance excellence. Applied R&D, formal management systems like reviews, standard operating procedures, computerization, documentation etc. are some of the elements of the standard building blocks of their recursive approach. In addition to minimizing subjectivity in all aspects of forestry development, they could improve predictability of forest growth tremendously and the downstream predictability of feedstock availability to the power stations. This entailed a very innovative approach of converting the Power Station requirements through a series of backward integration steps involving principles of electrical engineering, management and forestry.

Some of the outstanding advantages urban professionals bring in, in the field of energy plantations leading to Power are enumerated below:

- Reduction of cycle time in almost all activities.
- Elimination of rework to a large extent.
- Seeking and inclusion of new technologies and professional disciplines and making bioenergy a multi-disciplinary approach.
- Lack of fear (comparable) of failure in experimentation.
- Social inclusion as a part of business execution rather than as charity or as CSR.
- Innovation in technologies as well as management practices.
- Out of the Box strategic thinking
- Formalization of the age-old wisdom of rural workers in the form of documentation and Standard Operating Procedures.

The attitudes and approaches of educated urban professionals enumerated here are assets in the field of energy plantations for Power. Some of the achievements of EPPI bear testimony to the results of possessing these assets.

- Cost of Biomass (feedstock) is anywhere between 60 to 70% of the cost of production of one unit of electricity. EPPI is able to bring this cost down to 15 to 20%. One can appreciate the profitability in business in such a case.
- Predictability of the feedstock supply (lack of which haunted the Power Stations for so long) can be achieved with all round benefits.
- In their 300 acres of energy
With such advantages of association in the energy plantations and power production, how attractive is it business-wise, i.e. in terms of investment and returns? A few numbers and other details can validate this aspect. All numbers are tentative and are likely to vary with actual project requirements:

- **IRR of the Power Station and energy plantations together** is of the order of about 25%. This is very high by most industry standards.
- **Break even period** of about seven years in most projects.

**Case – 1:** Setting up a mini 100 kW power plant with about twenty acres of land growing energy plantations for fuel security. A four people project.

<table>
<thead>
<tr>
<th>Project Cost (energy plantations and power station together)</th>
<th>₹130 lacs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment per person (equity component)</td>
<td>₹10 lacs</td>
</tr>
<tr>
<td>Yearly PBT</td>
<td>₹15 lacs</td>
</tr>
<tr>
<td>Break even period</td>
<td>About 7 years</td>
</tr>
</tbody>
</table>

**Case – 2:** Possible to set up a One MW power station with about 120 acres of land for growing energy plantations for fuel security. A 20 people project.

<table>
<thead>
<tr>
<th>Project Cost (energy plantations and power station together)</th>
<th>₹800 lacs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment per person (equity component)</td>
<td>₹20 lacs</td>
</tr>
<tr>
<td>Yearly PBT</td>
<td>₹150 lacs</td>
</tr>
<tr>
<td>Break even period</td>
<td>5 to 7 years</td>
</tr>
</tbody>
</table>

(Note: In both cases, value of the power stations with supporting energy plantations appreciates in a big way with time)

- One need not go to the government for any freebies
- It is possible to procure the lands on lease as they are available in plenty
- One should not go for energy plantations in wet lands. It will have a negative effect on the country’s economy as well as local economy. Instead, it is possible to go for energy plantations in dry and unused lands. EPPI has accomplished the same already.

**Conclusion**

One can count a number of positive factors when urban professionals take up the Green Power Route. There are many positive aspects of the energy plantation scenario in the country like the bank funding (up to 70% of the project cost), MNRE’s help etc. Setting up the power stations through the Green Route was never more attractive, never more doable and never more welcome than now.

It is time that urban professionals with disposable incomes plunge into the Green Route to produce Power. They will create huge employment opportunities in the villages. They will create an atmosphere of progress and development in the country. They will serve the cause of ecology. With their resources and capabilities, they will make a positive impact on the industrial and social map of the country while earning for themselves as well as entrepreneurs.

When urban professionals come in to set up small to medium power stations backed up with fuel security (in the form of energy plantations) they will play a very big role in the much desired decentralized power production and distribution. In addition to alleviating the stress on the national grid, they will be creators of a large number of industrial centers based on power available locally.

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**The company established fuel security for its own power stations before setting up power stations. They achieved this by growing Man-Made High Density Forests with fast growing trees in their 300 acre energy plantations. S. Venkatesam was previously a Director of Motorola and a former Wing Commander of I A F.**

---

**Courtesy: S. Venkatesam, Chairman and Managing Director, Energy Plantation Projects India Limited Email: sam@eppi.co.in**
Low Cost Biomass from Captive Energy Plantation

The demand for renewable energy through biomass is increasing, but the utilizable biomass is not available sufficiently. The present agricultural waste available in cotton field as stalk, maize field as stalk and corn, paddy field as straw and husk, sunflower field as stalk & head are suitable for biomass, but the collection becomes very laborious. To generate 1 MW of electricity, the requirement of biomass varies from 8,000 to 10,000 tons every year, which is available from 6,000 to 8,000 acres of agricultural waste. The cultivated biomass such as Eucalyptus, Casuarina and wild *Prosophiis juliflora* are better substitute for agricultural waste since the annual quantity of biomass required for 1 MW is available from 1,000 to 1,200 acres. The latest development in bamboo based energy plantation has resulted in high biomass, reducing the area required for 1MW to 200 acres of cultivated high-yielding clone of bamboo.

**BEEMA Bamboo**

Biomass from bamboo is considered best among other known biomass resources due to its good calorific value (4,000 kcal/Kg), low ash content of 0.5% and sustainable harvest. The usage of bamboo is known for construction work, furniture, fiber and paper but for energy as biomass remains untapped. The new bamboo variety called “BEEMA” has got huge potential to bring revolution as bioenergy resources and it is not popular among many since it is something naturally existing with very low annual yield. The bamboo is the tallest grass and a non-woody plant, but still is called a tree. Beema bamboo is improved clone selected from naturally occurring wild population of *Bambusa balcooa* with specific emphasis on higher biomass production, better carbon sequestration, low ash content and superior fuel quality. It is 100% homogenous and highly suitable for high density plantation and responds well to agronomic practices.

Beema bamboo is a high density bamboo which is sterile, fast growing, thorn less, thick walled and high yielding. The wall thickness of Beema bamboo is 3 to 4 times better than other bamboo species available in wild. The total dry matter production of Beema bamboo under optimum condition ranges from 40 to 50 ton per acre per year worked with 12% moisture condition. Beema bamboo has got calorific value of 4,000 kcal per Kg and very low ash content of < 1% and is best suited for energy plantation.

At the same time the total carbon accumulation every year is from 20 to 24 tons per acre per year which is equivalent to 73 to 88 ton of CO₂. Beema bamboo generates 70 to 80 Certified Emission Reduction (CER) per acre per year, which is equivalent to 175 to 200 CER per hectare per year. Carbon credit can also be obtained by generating electricity from the renewable biomass of bamboo. Apart from providing carbon credit directly from power generation, the process of Pyrolysis generates carbon as byproduct. When this is applied to soil as soil amendments, it is also eligible for carbon credit.

As bioenergy resources, bamboo can meet both thermal as well as electrical energy requirement and thereby bamboo can give energy security in the most efficient way possible. Energy plantation based on bamboo could be raised in many parts of India...
and highly suitable for degraded forest lands, non-agricultural lands, degraded lands with water facility, and river banks.

India is one of the important developing countries with deep interest in renewable energy. MNRE is working with an aim to achieve at least 10,000 MW of energy through biomass in the next few years. The biomass required to achieve this target of 10,000 MW can easily be achieved, if 2 million hectare can be planted with hi-yielding biomass bamboo as “Energy Plantation” in an intensive manner adopting scientific agricultural practices.

The advantage of energy plantation based on the new bamboo clone is that it starts providing biomass in two years time and does so continuously for over next 100 years, at a low cost of less than ₹800/- a ton with energy value of 4,000 K.Cal./kg and ash content of 0.5%. The biomass of bamboo is highly suitable for gasifier and the by-product of gasifier called “biochar” is very attractive agriculture input to increase the productivity of agricultural land as well as degraded lands.

Rising cost of biomass over a period is increasing the cost of production of biomass based power making biomass projects unviable. In the days to come, the firewood prices are likely to increase further and in order to make the biomass power industry viable in future Growmore Biotech Ltd. has been exploring the possibility of generating quality biomass at a lower price. Though in the past many types of biomass and fire wood has been explored and utilized, the recent development of fastest growing clone of Beema bamboo can effectively provide a solution to the present crisis of biomass as firewood.

During the last ten years, Growmore Biotech Ltd. has conducted several trials with different species of plant with an objective to increase the biomass yield in a unit area. This has resulted in the development of new bamboo clone Beema, which has the following desirable characteristics:

- Calorific value of 4,000 kcal/Kg
- Low ash content of less than 1%
- Increased wall thickness compared to normal bamboo resulted in higher density, resemble as natural briquette with no adulteration
- Thorn less bamboo as against the natural thorny bamboo
- Sterile bamboo and hence no death of plant for several decades
- Responds very well to better agronomical practices and yielding as much as 40 to 50 tons of biomass per acre every year
- Under well managed condition, the biomass would be available at a cost lesser than ₹750/- per ton as against the market price of above ₹3,000/- for firewood and above ₹4,000/- for briquettes.

The clone of Beema bamboo was developed from an Indian species called Bambusa balcooa which is common in North Eastern India. The plantlets of Beema bamboo is being made available by propagating through tissue culture in large number. The Beema clone has been planted for energy plantation by several companies generating electricity through biomass.

Planting of Beema bamboo can be taken up either with regular planting density of 200 plants per acre where the biomass can be harvested after 4 years. The Beema bamboo can also be planted in intensive method having 1,000 plants per acre where the harvest begins two years after planting.

Well drained soil having a depth of 2 to 2 ½ feet is sufficient for cultivating Beema bamboo. Being a tropical variety the best growth is achieved between 10 to 45°C. However, it can tolerate temperature as low as 2°C. Most of the tea, coffee and rubber plantation areas are most suitable for cultivating Beema bamboo for biomass purpose. The water requirement for Beema bamboo, for the best
yield to obtain is 2,000 mm per year, however it can grow in the regions having average rain fall from 1000 mm onwards. Best growth of Beema bamboo is achieved under high humid condition with well spread rain or irrigation along with regular application of adequate fertilizer as per the soil condition. This bamboo reaches a growth speed of 1 to 1 ½ feet a day after it attains the age of 2 years. The fertilizer requirement for Beema bamboo is 160:40:200 NPK per acre, which should be altered based on the soil tested at 6 inches depth and 2 feet depth.

**Harvesting of Bamboo**

Bamboo can be harvested throughout the year except during monsoon. At the time of harvest the bamboo pole will have 40% moisture and it should be dried to 10 to 15% before using as fire wood. The drying of bamboo is faster and quicker after it is being split in to two or made into chips as per the requirement of the boiler.

The expected yield on a dry basis (10 to 15% moisture content) under well managed condition is as given below:

<table>
<thead>
<tr>
<th>Period</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>End of 2nd year</td>
<td>30 to 40 tons</td>
</tr>
<tr>
<td>End of 3rd year</td>
<td>40 to 50 tons</td>
</tr>
<tr>
<td>End of 4th year</td>
<td>50 to 60 tons</td>
</tr>
<tr>
<td>End of 5th year</td>
<td>60 tons and above</td>
</tr>
</tbody>
</table>

Bamboo has wide range of climate adaptability. It can tolerate temperature of 2°C to 45°C. and can be cultivated in any type of soil. Unlike other trees it does not deplete ground water (bamboo has got shallow - adventurous root system). It has got higher water use efficiency of 3.8 to 8.1 g/lit. It rejuvenates faster than any other tree species. It usually sheds its leaves during dry months and when there is supply of water or rain it starts to grow, it will not die unlike most of the tree species.

Bamboo sequesters carbon faster and higher than many other biomass trees. The root and rhizome portion of bamboo also plays a role in sequestering carbon. It acts as a carbon sink as it absorbs excess CO$_2$ in the air with three to four times more efficiency than any other tree. Which means, the more bamboos we plant, the more CO$_2$ is absorbed and thus we can stop neutralizing the global warming effect.

Though there are many entrepreneurs interested in investing in biomass based power generation, shortage of biomass remains a major obstacle in establishing renewable energy projects. Establishment of bamboo based energy plantation would permanently solve the raw material requirement (biomass) for renewable energy projects.

**Request for Articles**

Bioenergy India offers a useful platform for experts, investors and other stakeholders to exchange their experiences, expertise and to discuss issues related to harnessing biomass energy in an efficient and cost effective manner. The magazine encompasses the full spectrum of biomass energy sector related information, which will help creating awareness about the same amongst the relevant audiences.

The magazine tries to bring an overall perspective by bringing out the experiences, information related to this key sector for a wider benefit of the Renewable Energy community. Bioenergy India therefore, 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 and industry professionals.

The contributions should be of about 2,000-2,500 words (approximately 5-6 pages, which would include relevant graphs, charts, figures and tables). The two lead articles would be given an honorarium of ₹ 1,500 each. Please send in your inputs along with relevant photographs to:

**Sasi M (sasi@winrockindia.org)**
Winrock International India: 788, Udyog Vihar, Phase V, Gurgaon-122 001; Phone: 0124-4303868

**Courtesy:** Dr N Barathi  
Director, Growmore Biotech Ltd.  
Email: growmore@vsnl.com
Energy Plantations Projects: A New Step towards Sustainable Development

Energy plantations provide almost inexhaustible renewable sources of energy which are essentially local and independent of unreliable and finite sources of fuel. The attractive features of energy plantations are: (a) heat content of wood similar to that of coal, (b) wood is low in sulphur and not likely to pollute the atmosphere, (c) ash from burnt wood is a valuable fertilizer, (d) utilization of erosion prone land for raising these plantations help reduce soil erosion by wind and water, thereby minimizing hazards from floods, siltation, and loss of nitrogen and minerals from soil and (e) help in rural employment generation - it is estimated that an hectare of energy plantation is estimated to provide employment for at least seven persons regularly.

The feedstock (firewood as biomass in this case) for power stations is supplied from home grown plantations. A combination of fast growing, high calorific wood yielding, and easily reproducible species are designed for this purpose.

The pilot project in 500 acres initiated by Energy Plantation Projects India (EPPI) is under implementation at Sivagangai, Tamil Nadu that is expected to produce cheapest electricity by far. Though the primary focus was to develop energy plantation for its own power stations, it was found that the same techniques and the results can be extremely beneficial for all other power plants.

High Density Energy Plantations

Since generation of heat energy using biomass is an age old concept, it need not be detailed here. It concentrates on the idea of using ‘home grown feedstock’ for generation of heat energy. ‘Home grown’ pertains to cultivation of forests of fast growing trees on hundreds of acres of unused land. The need for a captive plantation by the power producing company is essential because:

- It substitutes the use of electrical energy for withering and drying process
- It provides the much needed biomass availability and security
- Social benefits for the company
- Reduction in the raw material cost
- Reduction in logistics cost when the energy plantation is within the vicinity of the tea factory
- Optimization of the design brings in economies of manufacture and resultant reduction in the cost of the equipment
- Based on the ideal parameters of operation the plants can be run at maximum load factor.

Heat production using natural renewable sources qualifies as one of the most desirable methods by energy plantations. Energy plantation forests are grown specifically for the purpose of producing electricity / heat production. Hence, they are to be designed, implemented and maintained for producing firewood required for power plants in a ‘predictable’ manner. This aspect of predictability has three elements as given below:

- **Suitability**: The species involved in the energy plantations will be of the variety that can produce biomass of right density, right thermal characteristics like the calorific value, ash content and right physical characteristics according to growth parameters (height, girth etc.), coppicing (regenerative) qualities and right adaptability to local environment, etc.

- **Repeatability**: The species involved in the energy plantations will be qualified for repeatability. This means that the species are to be amenable for reproduction in large quantities with all the characteristics of healthy growth built in. Techniques for the regeneration (like seed farming, vegetable propagation, EMI techniques etc.) may be man-made, but the species themselves should be those that can adapt to the regeneration techniques.

- **Scalability**: As large quantities of biomass is expected to be acquired from the energy plantations every year, the plantations should have the ability to produce a large number of saplings for this purpose. This involves development of suitable techniques for organized and orderly reproduction techniques, supervision and placement at the right time and in the right quantity.
**Technical Description of the Energy Plantation**

The company has for the past seven years conducted experiments, compiled data and statistics to identify many species which are suitable for firewood purpose. Below is the technical list of species which have been tried at our own fields and have also been recommended by many more research organizations for the purpose of firewood. The table (above) also gives the technical parameters of the species selected.

The basis of selecting the above mentioned species are:

- **Rate of growth**: The minimum growth rate of the plants is 5 m in a year. The expected growth parameters of all the species selected are almost in the same range. These trees are expected to grow to a height of 15 m by 5 years with a trunk diameter of 1 m at breast level.

- **Calorific value**: The calorific values of all the species are around 4,500 kcal/Kg. This is the optimum range of calorific value that can be attained with the combination of good growth characteristics.

- **Coppicing quality**: The regenerating nature of these species is the most important aspect of commercial viability. All the species are very good coppices and can regrow very well on cutting.

- **Weight density**: The species are chosen after studying more than 60 different species. The species selected all have a weight density ranging between 45 Kgs/cft to 60 Kgs/cft.

The expected yield from a well maintained biomass plantation using these species can give 500 Mt/Hectare.

**Value Addition**

Most of the power plants are suffering from raw material supply / sourcing problem. The biomass plantations are a one window solution for complete biomass security of the raw material requirement of a power plant. This ensures the smooth functioning and maximum efficiency of the power plant. The size of plantation can be planned in line with the production needs. The cost of firewood as we all know, in the open market, has shot up more than 300% in the last 3 years.

Captive biomass plantations not only secure the power plants from non availability of biomass, but also from the increase in market price. Other than the initial capital investment for the project establishment, there shall be no further huge capital investments made on biomass plantation. Therefore the owner is insured from the upward movement of the market prices of firewood.

The cost of biomass (firewood) which is harvested from a home grown plantation is more economical compared to purchasing it from open market. The quality and specifications of the raw material has a direct impact on the maintenance of the boilers. Whereas in the case of captive biomass plantations the raw material fed to the power station is predetermined, this reduces the frequency of boiler maintenance. By developing captive power stations, there is total control on the supply of raw material. The harvesting, drying and cutting cycle can be exactly matched to the power production needs, since the raw material is available in home grown plantation. This results in optimum utilization of raw material available without giving scope for loss of weight due to early procurement and parking of raw material. As a result, there will be a huge reduction of cost due to availability of biomass near power station. Since the biomass is permanently available, logistics involved in biomass transportation can be well planned and managed.

Since this is the age of global warming and green energy projects, the project shall surely earn laurels from all corners of society including governments and bankers. This is in reality a true contribution to Mother Earth.

The plantation will also provide employment opportunity to local habitats. The setting up of energy plantations will lead to generating employment opportunities in dry areas that are focus areas for government development projects. Private companies can contribute by fulfilling their corporate social responsibility by being a part of setting up of such energy plantations.

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**Technical details of Selected Species**

<table>
<thead>
<tr>
<th>Technical details of Selected Species</th>
<th>Calorific value</th>
<th>Weight density</th>
<th>Yield in tons per hectare</th>
<th>Harvest cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4,000 Cal/g to 5,000 Cal/g</td>
<td>0.335 gm/cm³ to 0.616 gm/cm³</td>
<td>250 MT</td>
<td>Harvest ready from the 4th year and then coppicing process starts</td>
</tr>
</tbody>
</table>

**Courtesy:** Avin Nanjappa
Senior Manager
EPPi (Energy Plantation Projects India Limited), Mob: 096552 39896
Email: avin@eppi.co.in

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Most of the power plants are suffering from raw material supply / sourcing problem. The biomass plantations are a one window solution for complete biomass security of the raw material requirement of a power plant. This ensures the smooth functioning and maximum efficiency of the power plant. The size of plantation can be planned in line with the production needs. The cost of firewood as we all know, in the open market, has shot up more than 300% in the last 3 years.

Captive biomass plantations not only secure the power plants from non availability of biomass, but also from the increase in market price. Other than the initial capital investment for the project establishment, there shall be no further huge capital investments made on biomass plantation. Therefore the owner is insured from the upward movement of the market prices of firewood.

The cost of biomass (firewood) which is harvested from a home grown plantation is more economical compared to purchasing it from open market. The quality and specifications of the raw material has a direct impact on the maintenance of the boilers. Whereas in the case of captive biomass plantations the raw material fed to the power station is predetermined, this reduces the frequency of boiler maintenance. By developing captive power stations, there is total control on the supply of raw material. The harvesting, drying and cutting cycle can be exactly matched to the power production needs, since the raw material is available in home grown plantation. This results in optimum utilization of raw material available without giving scope for loss of weight due to early procurement and parking of raw material. As a result, there will be a huge reduction of cost due to availability of biomass near power station. Since the biomass is permanently available, logistics involved in biomass transportation can be well planned and managed.

Since this is the age of global warming and green energy projects, the project shall surely earn laurels from all corners of society including governments and bankers. This is in reality a true contribution to Mother Earth.

The plantation will also provide employment opportunity to local habitats. The setting up of energy plantations will lead to generating employment opportunities in dry areas that are focus areas for government development projects. Private companies can contribute by fulfilling their corporate social responsibility by being a part of setting up of such energy plantations.

**Technical Description of the Energy Plantation**

The company has for the past seven years conducted experiments, compiled data and statistics to identify many species which are suitable for firewood purpose. Below is the technical list of species which have been tried at our own fields and have also been recommended by many more research organizations for the purpose of firewood. The table (above) also gives the technical parameters of the species selected.

The basis of selecting the above mentioned species are:

- **Rate of growth**: The minimum growth rate of the plants is 5 m in a year. The expected growth parameters of all the species selected are almost in the same range. These trees are expected to grow to a height of 15 m by 5 years with a trunk diameter of 1 m at breast level.

- **Calorific value**: The calorific values of all the species are around 4,500 kcal/Kg. This is the optimum range of calorific value that can be attained with the combination of good growth characteristics.

- **Coppicing quality**: The regenerating nature of these species is the most important aspect of commercial viability. All the species are very good coppices and can regrow very well on cutting.

- **Weight density**: The species are chosen after studying more than 60 different species. The species selected all have a weight density ranging between 45 Kgs/cft to 60 Kgs/cft.

The expected yield from a well maintained biomass plantation using these species can give 500 Mt/Hectare.

**Value Addition**

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The plantation will also provide employment opportunity to local habitats. The setting up of energy plantations will lead to generating employment opportunities in dry areas that are focus areas for government development projects. Private companies can contribute by fulfilling their corporate social responsibility by being a part of setting up of such energy plantations.
Human development is inextricably linked to access to energy. A developed country is one that has been able to provide access to modern forms of energy to all its citizens at their doorsteps. Often the single most important step in the direction of poverty alleviation is a significant increase in the provision of both household and commercial energy to the poor communities at affordable prices. Providing this access is difficult enough for developing countries on account of lack of human and financial resources and the technology deficit they usually face but the problem can become insurmountable in the face of geographical features of a mountainous terrain. Poverty alleviation over large parts of the isolated habitations over almost the entire Himalayan ranges spread across Afghanistan, Pakistan, China, India, Nepal, Bhutian and Myanmar has been slow as many isolated communities living in these hills are still effectively beyond the reach of electricity. Mountain villages tend to be small on account of low availability of arable lands. High cost of carriage, high transmission losses and severe difficulties in maintenance limit the extension of energy grids to remotely located communities.

Stand alone renewable energy production and supply system, where the resource is locally available, communities are both the producer and the consumer of energy and are capable of routine maintenance tasks, is more suited to these remote parts of the Himalayas. In the case of the Himalayas these renewable energy systems could be based on wind, solar, micro-hydreel and biomass all of which have site specific advantages and limitations. Wind energy based systems work best during windy seasons that do not last for longer than four months in most parts of Himalayas except along the ridges which tend to be windier. But, precisely for this reason, such places are the least preferred sites for habitations since continuous high winds drains the lands of moisture leaving them desiccated. Besides, wind based systems demand relatively high expertise even for routine maintenance which is rarely available in such low population remote localities. Solar energy so far has limited use for heating water since electricity generation using solar cells has the
problem of storage costs on account of the fact that it is produced during day while the demand for household energy peaks at night. Water flow based micro-hydel systems offer good opportunities in many places but has obvious limitations during the prolonged dry periods when the amount of water gets reduced sharply over most of the Himalayas.

Thus wind, solar, and micro-hydel stand-alone energy systems all have seasonal, locational, maintenance expertise and maintenance cost limitations that might not permit high levels of dependence on these systems in the Himalayas. In contrast, biomass based energy systems may prove better option since their primary requirement is land which is often available in remote areas at relatively low opportunity costs. There is plentiful human expertise available in remotest parts in tree rearing and harvesting and most small sized modern biomass gasification based electricity generation systems require a level of routine maintenance that can be undertaken by most villagers with only a few hours of training under minimal supervision by higher levels of technical expertise.

**Objective**

Biomass based energy systems, however, also have a number of limiting factors, and positive and negative externalities that are site specific. Large quantities of sustainable production of woody biomass would be required for meeting the growing demand of energy in these localities which can not be supplied using wastelands alone as has often been proposed in national wood energy policies and considerable extents of new lands, not hitherto used for wood production, would have to be utilized for this purpose. The production of woody biomass for this energy system has a number of associated externalities, both positive and negative. Generally, positive externalities are soil and moisture conservation on hill slopes, landslide control and energy security. Food security, water availability, biodiversity conservation and conservation of wildlife can, however, be negatively impacted by intensive cultivation of large quantities of woody biomass for energy production. For a meaningful economic development of these hill regions it is imperative that the positive externalities far outweigh the negative ones in these biomass for energy production sites. This paper suggests ways to balance supporting and limiting factors and positive and negative externalities for selecting suitable sites for biomass energy systems and thus develops a theoretical basis for optimizing site selection for stand-alone biomass based energy systems for remote isolated communities in the Himalayas.

**A Key Element of Low Carbon Path of Development**

Biomass based modern form of energy is a key element of the low carbon path of development that is considered crucial for limiting the climate change to a level above which it can have dangerous consequences for the earth. In the G20 summit held at Italy in July 2009 it was decided that all countries, developed and developing, take steps to limit the temperature rise to 2 degree Celsius by the year 2100. Such a step would require an emission cut as high as 80% below the 1990 levels for the larger developed economies and similar departures from the business-as-usual scenarios for the big developing economies of China, India, Brazil, Indonesia and others. Such deep changes can not be achieved based on energy efficiency and other technological innovations while continuing to grow economically relying on fossil energy. The biomass based energy, even at its current stage of technological development, has a high potential to permit a significant shift from fossil energy of the past to the energy that reaches the earth today and is available to us through photosynthesis. It is for this reason that biomass based energy is a key element in the low carbon path of development that is so crucial to prevent dangerous consequences to the earth from the warming climate.

**Understanding Risks and Uncertainties for Encouraging Investments**

New developments in the energy sector on a scale large enough to make a significant contribution to the energy supply become possible through the willingness of the investors, developers and suppliers to enter the market which is, in turn, dependent upon the risk and reward environment of such ventures (Elghali et al, 2007). To the investors, who can not rely on ecological benefits for making gains on their investments except to the extent
translated into carbon credits, the risks emanate from the complex matrix of ecological, social and economic factors that impinge on each other, sometimes compensating each other and, as often, enhancing others both in their negative and positive aspects. The complexity of a biomass based system is enhanced by the very large number of stakeholders involved not only as consumers but as producers of the biomass and as the owners of (or having stakes over) lands where the biomass is to be raised. Besides them the significant others are biomass intermediaries, plant owners and operators, regulatory authorities and the general public residing in the neighborhood and downstream all of whom can stall project consent leading to risks associated with time and cost overruns (Elghali et al, 2007).

As discussed above a large biomass based energy system in the Himalayas would attract investments if the risks and rewards are clear to the stakeholders and the uncertainties are reduced and brought within manageable limits. Since this energy system is heavily influenced by the site selection it stands to reason that the choice of sites should contain within itself a measure of risks and rewards. There are three core components of bioenergy, namely, the feed stock supply, conversion to energy and distribution of energy. All these three fundamental components are, in turn, affected by social, economic and ecological factors. These factors are almost independent of each other at their core but have large overlaps on their flanks and for best results a cohesive integration of these factors is essential. Arriving at a consensus is difficult when faced with concerns that such an array of stakeholders can bring to the negotiating table.

While the national governments would be concerned about meeting their GHG reduction targets through the development of biomass based energy system the local concerns are more likely to be cheap uninterrupted energy supplies, income from their lands and employment generation and local environmental issues like the landslides and the soil and moisture conservation (Domac et al 2005, Elghalli et al 2007). These issues have been classified in three broad categories as economic viability, environmental performance and social acceptability (Elghali et al, 2007, Mitchell et al, 2004).

**Multi-criteria Decision Analysis**

In bioenergy system of the type that is under discussion here, which covers a very large area across a multitude of geographic, economic and social features constantly interacting with and influencing each other, can not be analyzed by using the normal scientific approach of reductionism. A central feature of a system approach is that a whole is greater than the sum of its part where as reductionism is examining small parts of a system and then summing them up to get a complete picture. A systems approach allows simplification of complex systems by identifying key indicators and common known principles that capture the interplay of its constituents, and thus its dynamism, without losing a holistic view. This methodology involves identification of a host of such key indicators relevant to the purpose and then using a suitable multi-criteria analysis for arriving at the desired objective.

A number of multi-criteria approaches have been developed over the past few years that seek to integrate a host of varying indicators with different dimensions, as well as uncertainties and ignorance, using explicit value judgement by a trained body of peers and stakeholding communities (Elghalli et al, 2007). For this analysis eleven attributes including extent of isolation, population, land availability, soil, moisture, biodiversity and wildlife conservation, landslide control, energy security, food security, and NTFP production were selected as suitability attributes and attribute parameters were identified. These attributes were made dimensionless dividing them in very low, low, moderate, high and very high categories on 1 to 5 scale on the basis of their impact on the desirability of establishing biomass based energy systems. Negative externalities are awarded negative weight. Detailed explanation is given below:

The extent of isolation of the site is measured in terms of distance from an all weather road. The more remote the site more is its utility as a site for stand-alone biomass based energy since those near the roads are easily served by the grid based energy systems that can not only supply their higher requirements, since commercial activities requiring higher amount of energy are more likely to be located along roadside, but can also be maintained properly on account of ease of access.

The population is another attribute taken in consideration and the number of households is considered a suitable parameter because it is a more reliable indicator of energy consumption than the number of people and also because this data is generally available all through the Himalayan region cutting across the nations, with the possible exception of Afghanistan. The smaller
the size the greater would be the utility for a stand alone system. Tiny hamlets are also more likely to be remote thus according defacto additional weight to the remoteness.

Third attribute is the land availability and the attribute parameter chosen is the sufficiency of the available land for meeting the biomass demand for energy production. If the land available at a site is much more than required for meeting the biomass demand then it is most suitable. This would mean that no land fit for agriculture would be put under bioenergy production thus reinforcing the food security requirement which is also dealt separately. Further a site with much higher extent of land availability is also likely to be remote and thus this requirement is also further likely to strengthen the remoteness requirement.

Next attribute is the landslide control with severity of the landslides taken as the attribute parameter. With an appropriate harvesting mechanism undertaken in a sustainable manner tree growing for energy would play a positive role in landslide control and hence the most landslide prone lands are considered the best choices for biomass growing for energy.

Next attribute is the moisture conservation and the amount of rainfall and number of rainy days are taken as twin parameters. The sites with the least rainfall occurring over the shortest span are considered most suitable as the trees raised for biomass generation on such lands would provide the highest positive externality in so far as moisture conservation is concerned.

Another attribute is the energy security with the amount of energy available from other sources in terms of fulfilling the requirement as the attribute parameter. The site that has the least availability of energy from other sources would score the highest on this scale since the objective is to enhance the energy security of the communities.

Yet another attribute is the food security where the attribute parameter is the extent of agriculture land that is used for raising trees for biomass generation and carries negative weight. Food security concerns have been given high weight and sites, where more than a quarter of the available agriculture lands would have to be used for meeting the tree bioenergy needs, are awarded the highest negative weight. The most preferred are the sites where no agriculture lands are diverted for raising biomass for energy.

Another attribute is the wildlife conservation having one negative and one positive attribute parameter. The negative attribute parameter operates in sites where the keystone wildlife species requires a grassland habitat as is the case in many high altitude Himalayan areas which are suitable habitats for the rare Tibetan antelope. This is because tree raising for biomass could lead to reduction of grassland habitats. Highest negative ranking is accorded to sites where raising trees for biomass would reduce more than a quarter of the community landscape suitable for such a keystone species. The positive attribute parameter becomes operational if tree raising for biomass increases the habitat of a keystone species for wildlife conservation and the highest ranking is awarded where the increase in habitat is more than 75% within the community landscape.

Yet another attribute with negative dimensions is the economic security of the local resource poor people dependent upon the NTFP for livelihood requirements. Tree planting for biomass has the potential of reducing the income of these people significantly. Just like in the case of the other two negative externalities in this case also high weight has been accorded to the loss of income from NTFP to the poor community and a 25% decrease in such income would result in the maximum negative valuation.

Soil conservation is another positive externality of tree planting for biomass. For the sake of ease only one attribute, namely, steepness of slope has been taken as attribute parameter and the higher the slope the higher is expected to be the benefits from tree planting and slope in excess of 75% is awarded the highest ranking. It is, ofcourse, presumed that bio-energy harvesting would be sustainable.

Biodiversity conservation is also an important attribute with the extent of restoration of the original habitat taken as attribute parameter. Highest rank is accorded when the biomass generation is expected to lead to restoration of more than 75% of the native fauna.

**Discussion and Conclusions**

All the possible sites are than ranked against each attribute parameter by a well trained peer group along with well informed local stakeholders. The total of all attribute parameters for each site would give its score and those with higher scores would constitute priority that would help optimize economic, ecological and social benefits through appropriate site locations.
### Scoring Plan for Different Attributes

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Attribute Parameter</th>
<th>Positive Externalities/Supporting Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Very Low</td>
</tr>
<tr>
<td>Extent of isolation</td>
<td>Distance from road</td>
<td>Upto 5 Km</td>
</tr>
<tr>
<td>Population</td>
<td>No. of households</td>
<td>&gt; 100</td>
</tr>
<tr>
<td>Landslide control</td>
<td>Severity</td>
<td>Very rare</td>
</tr>
<tr>
<td>Moisture Conservation</td>
<td>Amount of rainfall</td>
<td>&gt;200 cm</td>
</tr>
<tr>
<td></td>
<td>No. of rainy days</td>
<td>&gt;200</td>
</tr>
<tr>
<td>Energy security</td>
<td>Energy from other sources</td>
<td>Much more than required supply available from other sources</td>
</tr>
<tr>
<td>Food security</td>
<td>Land used for dedicated plantation</td>
<td>–</td>
</tr>
<tr>
<td>Wild life conservation</td>
<td>If the keystone species requires high altitude meadows</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Increase in habitat of Keystone species</td>
<td>Slight increase habitat area</td>
</tr>
<tr>
<td>Economic security</td>
<td>Reduction in the income from NTFP</td>
<td>–</td>
</tr>
<tr>
<td>Land availability</td>
<td>Land availability for biomass generation</td>
<td>Meets only a part of the requirement</td>
</tr>
<tr>
<td>Soil conservation</td>
<td>Steepness</td>
<td>Gentle</td>
</tr>
<tr>
<td>Biodiversity</td>
<td>Likely positive impact in bringing the native floral species back</td>
<td>Slight impact</td>
</tr>
</tbody>
</table>

Now we turn our attention to the question of sustainability. Any energy system has to be sustainable in order to attract investments of the scale required and this sustainability has to be achieved in a very dynamic moving frame of rapid advancements in technology and the equally rapid changes in the physical environment and the societal understanding of these changes and expectations of dealing with them. At this stage it is important to clarify what is meant by sustainability which has been variously defined. In natural resource management an acceptable definition would be that a sustainably managed renewable natural resource like forests enables maintenance of its ecological integrity permitting the continuance of evolutionary processes with least hindrance and leaves its capital stock of economic value intact across generations.

But this definition cannot be applied satisfactorily to all components of an economic production system spread over a large area like provision of bioenergy. One interesting definition of sustainability that it is the capacity to create and maintain adaptive capabilities of a system meaning thereby that a system is sustainable when it possess now, and through its life, the necessary infrastructure and material wealth to enable adaptation.
A sustainable system should thus be able to create, or at least access, technological advancements and finances in order to deal with the changes that are necessitated by the changing environment and the altered societal expectations of dealing with them both in quantitative and qualitative terms.

The balancing of attributes through multi criteria analysis should help enhance the overall sustainability of the biomass production system. But it may not able to ensure the economic sustainability of the system over any significant length of time since technological advancements, and consequential increase in financial requirements, have not been integrated in the analysis. For example, the probable technological advancement of shift to lingo-cellulosic fuels in the coming decades would render a system of bioenergy based on the current technology redundant and threaten its economic sustainability.

The model accords high importance to food security, conservation of wild life and economic security of poor people depending upon NTFP. The most suitable site for biomass based power plant selected by using this model are those with least negative externalities and high values of positive externalities.

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**References**

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Even after 63 years of Indian Independence, 44% of Indian villagers are still living in dark without electricity. Rural areas of India are characterized by very low per capita energy consumption and in most places commercial energy like electricity is not available. Majority of rural households in India use only kerosene for lighting. Most of the lamps are hurricane-type, which produce very poor light intensity of about 60-70 lumens. Similarly, rural areas in India use about 180 million tons of biomass fuel for cooking through inefficient and smoky stoves.

Records show 18,000 rural villages in India lack electricity. This automatically puts much of rural India at a disadvantage in comparison to urban India.

Presently available sources of power generation are:
- Thermal power plant
- Hydro power plant
- Nuclear power plant
- Wind mill based power plant
- Biogas based power plant
- Solar power plant

But even with these many power generation options, it is not enough to light each and every house in the remote areas of the country.

Bringing electricity to these villages through grid system is not an easy task as some being located in very remote areas and these sources depend on different input materials, seasons and climatic conditions.

The answer will be “YES” if you consider and generate power through our new concept “Thermoelectric Power Generation System” – another source of energy unheard in India which generates electricity in micro level sufficient for lightings.

Our aim is to introduce a New Alternate Micro-Power Generation Technology and to participate in government efforts in electrifying 18,000 odd villages. Bharadwaj E-technologies worked in that line to bring an alternate source of generating power to bring at least a minimum number of lighting systems to the villages through Thermoelectric Power Generation Technology. The idea is to replace the kerosene lamps used by villagers with brighter and safer LED's.

The concept behind this idea is to produce power from waste heat of:
- Woodstoves (chulas)
- LPG stoves
- Kerosene stoves
- Woodstoves with chimneys

Thermo Electric Local Power Station
According to American researchers working in this field, thermoelectric technology has been in widespread
commercial and industrial use for over 50 years, yet the true value of thermoelectric has been seriously underestimated resulting in almost no advancements in technology. Although this state of affairs is not all that surprising considering the energy costs, which have been very low over the same time frame. Cheap energy means there is no incentive to use, improve or develop alternative methods of using or producing energy. However, as we all know circumstances have changed and the days of cheap and abundant energy are over and the race to invest in the development of new alternative energy sources and improving energy efficiency of the devices we use is on, it becomes imperative to find solutions and advance this technology.

Another factor that has slowed the emergence of thermoelectric generators as a viable alternative for the production of electricity, is the relatively low energy conversion efficiency, this is only about 5% to 7%, whereas photovoltaic (solar panels) are now in excess of 20%. Unfortunately, this low efficiency rating also had a negative impact on further research and development of thermoelectric generators. However comparing TEGs to PV panels by the watt rating is a grossly inaccurate comparison and makes it appear that TEGs are simply too expensive of an option. To be accurate and fair in the comparison one should look at the kWh produced per day by each of the two technologies.

When the costs of solar and thermoelectric generators are compared based on the amount of energy they actually produce per day, it is found that TEGs cost far less per kWh than solar. The PV (photovoltaic) equivalent of 50 watt TEG operating on a wood stove is 330 watt of solar or 1.2 kWh per day. This means using just 3 of 50 watt TEGs can produce the same amount of electricity in a day as 990 watts of solar PV panels. This claim is not to undermine the importance of PV as it is one of the greatest technological developments of the last century and in time will probably provide for 50% or more of the world’s energy needs. The only point to be made is that a fair and accurate output rating should be used when comparing costs between the two systems, because people will automatically make the comparison on their own and falsely assume that TEGs are more expensive than PV based on wattage and that is the reason to term it as “photovoltaic equivalent”.

This assessment is based on the indisputable fact that TEGs are capable of producing electricity at full power 24 hours a day and PV panels are not. In addition, in making this assessment we assume that the source of heat that TEG uses comes from a system that is already producing heat as a by-product for another purpose. In these types of applications the TEG is simply recovering a percentage of wasted heat energy. There is no added fuel cost that can be assessed to the operation of the TEG because these systems will be consuming this fuel whether a TEG is employed or not.

It should also be noted that solar panels are almost useless in far northern or southern latitudes due to shorter days and the sun being low on the horizon. In these situations, TEGs are often the first pick for electrical power because they thrive in colder environments and can run continuously without maintenance for extended periods of time. Whereas a gasoline or diesel generator would break down if it was not periodically shut down for maintenance.

Thus, thermoelectric generators do have their limitations and are only practical in certain applications, but those applications are numerous and presently many of them are virtually untapped. The market potential is in the billions of dollars and still wide open.

**Wood Stove Market Overview**

The value of thermoelectric generators have long been recognized hence time and money have been invested into developing the market and
advancing the technology. The cost per watt reduction which is obviously a big factor in advancing the market for thermoelectric power has been attempted to be achieved.

It has been a very successful attempt, which is evident in the scope of market statistics. As the initiators to recognize the market potential for TEGs designed to be used on wood stoves and the first to market them it has been a promising project for future investment. The greatest marketing potential for thermoelectric power is linked to wood or other bio-fuel stove industries. Each wood stove in use in the world is a potential home power plant capable of providing a home owner with electrical power ranging from 50 watts to 5,000 watts depending on size of the stove.

According to ATSDR there are 13 million wood stoves in USA. [1] There are more than 2 billion people in the world who use wood burning stoves for both heat and cooking [2]. This figure only includes people living in developing nations where wood is their primary source of domestic fuel. It does not include people in developed countries who use wood stoves as a primary (by choice) or secondary heating system. None of the above data includes the booming pellet stove market. [3] It is also important to note that outdoor wood furnace is becoming increasingly popular for both heating and hot water due to rising fuel costs.

The technology used in energy production converts waste heat to generate power which can be utilized for lighting LED’s to replace conventional kerosene lamps. This works on well known phenomena called “the Seebeck Effect” depending on temperature differential between the two sides of a thermoelectric module, heat energy converts into electricity. This technology is very useful in remote locations where power is required. Though solar power is available but due to its limitations, it is unreliable or insufficient. The advantages of this effect are as follows:

- Off-grid small/micro power generation, no transmission losses
- This technology works in any location, any time in a day, irrespective of climatic conditions unlike solar energy
- Generation of power with no extra cost- Almost FREE POWER
- Power generation and cooking facility at the same time
- Power can be produced at any time in all climatic conditions unlike solar power generators
- Non-conventional energy
- Green Technology, Eco-friendly
- A power of minimum of 27 W and above is always available

The Alternative Micro-Power Generating Product

The effectively designed self-power generating chula, which uses wood as fuel and helps in almost complete burning of fuel with less smoke, enabling cooking of a whole meal with it, keeping the air cleaner with fewer hydrocarbons as compared to conventional wood stoves. The in-built power generating unit generates power while cooking the food by using the waste heat and stores the generated power by charging the battery which is placed in a charge control unit supplied along with the unit. The stored energy can be used to light the LED’s:

- To provide electricity for basic daily needs
- This new renewable energy can provide power to remote villages in rural India

- Almost free power to tribal areas
- Almost free power to small business vendors

The wood stove works on fuel efficient natural plant based fuel with the following advantages:

- Clean cooking with very little smoke
- Light weight and easy to carry
- High thermal efficiency due to fan circulated air
- Burns any combustible material like wood dust, sticks and pieces of branches
- Wood fire smell completely eliminated
- Cooks food quickly
- Clean cooking with very little smoke
- Burns almost any natural plant based fuel

Conclusion

This Micro Power Generation will be a revolution in Indian village history by eliminating darkness from houses. As our late Prime Minister Rajiv Gandhi said: ”No house should remain unelectrified” for which he laid emphasis on promoting alternate source of energy. 40 W power can be produced with one system per 10 hours. If 10 lakh such systems are installed, 4MW power can be generated in 10 hours. No distribution losses will be there as individual houses will generate power required to light their own house.

Courtesy: Mr. Narasimhan
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Email: info@bharadwaj-e.com
Energy Crop Plantations for Biomass Power Plants and its Future in India

Cultivation of fast-growing trees such as Vanashree (a clonal selection of *Melia dubia*), bamboo and Paulownia that can serve as biomass fuel for establishing a national network of decentralized rural power plants. These power plants, ranging in size from 1-2 MWh, can generate thousands of megawatts of power from renewable fuel sources in a cost-effective manner. This would reduce India’s dependence on imported fuel oils, stimulate private investment in the power sector, and generate massive income and employment opportunities for the rural poor.

In order to meet pent up demand, India needs to create an additional 100,000 MW of power generation capacity. Establishment of 4 million hectares of energy plantation will be sufficient and would provide year-round employment for 4 million people.

The viable, employment-oriented program for production of biomass fuels for electric power on India’s huge extent of degraded wastelands is an established fact today. In combination, these programs can generate additional rural employment opportunities, while creating additional rural income, reducing India’s dependence on imported fuel, establishing a national network of rural power plants, and reducing environmental pollution.

### Wasteland Development Programs

India has approximately 50 million hectares of degraded wasteland that lie outside the areas demarcated as national forests. Development of these wastelands offers enormous potential both for economic development and sustainable employment generation. Some of the challenges of wasteland development are:

- Low soil fertility
- Little irrigation potential
- Not suitable for cash crops that require fertile soil and continuous water supply
- High cost of investment in soil and irrigation development (cost per acre) beyond the reach of most rural families
- Improved technology required to make lands productive is beyond the skill levels of poor families
- Complex organization required for land development, cultivation, production and marketing.

A large part of India’s population, mostly in rural areas, does not have access to energy services. The enhanced use of renewable energy in rural areas is closely linked to poverty reduction because greater access to energy services can:

- Improve access to pumped drinking water. Potable water can reduce hunger by allowing for cooked food (95 percent of food needs cooking).
- Reduce the time spent by women and children on basic survival activities (gathering firewood, fetching water, cooking, etc.).
- Allow lighting which increases security and enables the night time use of educational media and communication at school and home.
- Reduce indoor pollution caused by firewood use, together with a reduction in deforestation.

Lack of access to affordable energy services among the rural poor seriously affects their chances of benefiting from economic development and improved living standards. Women, older people and children suffer disproportionately because of their relative dependence on traditional fuels and their exposure to smoke from cooking, the main cause of respiratory diseases. Electricity through transmission lines to many rural areas is unlikely to happen in India ranks sixth in the world in terms of energy demand, accounting for 3.5 percent of the world commercial energy demand. But at 479 kg of oil equivalent, the per capita energy consumption is still very low, and the energy demand is expected to grow at the rate of 4.8 percent per annum.

Viable Programs

These wastelands can be developed in a variety of ways designed to meet the needs of a growing Indian economy:

- Biomass energy plantations for fast-growing tree crops to generate electricity on marginal waste land.

- Wasteland Development Programs

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the near future, so access to modern decentralized small-scale energy technologies, particularly renewable energy, are an important element for effective poverty alleviation policies. A program that develops energy from raw material grown in rural areas will go a long way in providing energy security to the rural people. Increase in nutrients to soil, decrease in soil erosion and land degradation.

In ethanol production from sugarcane, the by-products like vinasse (solid residue left after distillation) and filter cake contain valuable nutrients. Using these organic fertilizers instead of chemical fertilizers reduces the need for chemicals, which could be hazardous and avoids pollution of ground water and rivers. The International Crop Research Institute for Semi-Arid Tropics (ICRISAT) compares the nutrient content of filter cake obtained from various oilseeds in renewable energy manufacture with that of commonly used fertilizers like Di-Ammonium Phosphate (DAP) and Urea and demonstrates that the filter cake is an effective fertilizer. Also the cultivation of land for biomass, and oilseed-bearing crops contributes to a decrease in soil erosion and land degradation.

**Energy Security**

India ranks sixth in the world in terms of energy demand, accounting for 3.5 percent of the world commercial energy demand. But at 479 kg of oil equivalent, the per capita energy consumption is still very low, and the energy demand is expected to grow at the rate of 4.8 percent per annum. India's domestic production of crude oil currently satisfies only about 25 percent of this consumption. Dependence on imported fuels leaves many countries vulnerable to possible disruptions in supplies which may result in physical hardships and economic burdens. The volatility of oil prices poses great risks for the world’s economic and political stability, with unusually dramatic effects on energy-importing developing nations. Including renewable energy in the energy basket can help diversify energy supply increase energy security and improved social well-being.

**Biomass Plantations**

Clean energy generation at economic levels, to a large extent, depends on availability of sustainable fuel supplies on an uninterrupted basis at reasonable prices. Clenergen Corporation has been able to develop a workable model in this regard. Following are some of the energy crops that can provide biomass fuel:

**Melia Dubia**

Melia dubia originates from the Meliaceae family and is an indigenous species of tree to India, South East Asia and Australia, where it has been cultivated as a source of firewood. The tree can be cultivated in all types of soil and requiring a low supply of water on a daily basis. Melia dubia has the unique feature of growing to 40 feet within 2 years from planting and can be mechanically pruned and harvested. As an energy crop, Melia dubia has the potential of yielding in excess 40 tons of biomass on average per acre per annum over a 10 year period (before replanting is required). Its high calorific value makes it a viable source of feedstock for biomass power plants.

**Vanashree (A Clonal Selection of Melia dubia)**

1. Forest tree originated from Southern Asia
2. Widely cultivated in China, Malaysia, East Southern Africa, Middle East, Bermuda, Brazil, Argentina, Australia, SE Asia pacific Island, and Southern Europe
3. Grows well in dry areas with less than 900 mm annual rainfall
4. In India, it grows in places up to 1,800 m above MSL (Mean Sea Level)
5. Used for construction, panel, ply board, veneer industry, ornament, packing cases, cigar and tea boxes, match boxes, ceiling planks, agricultural implements, pencil, splints, etc
6. In Sri Lanka, timber is used for the outriggers of the boats
7. In Java and Sumatra used for the interiors of houses
8. Planted as a fuel wood species
9. Calorific value of wood is 5,043-5,176 kcal/kg and hence very suitable for energy plantation

Though the potential of Vanashree as a source of green energy has been well known, it has not been exploited fully.
Considering the world-wide awareness of the urgent need to develop power with least harm to atmosphere by way of green house gases production, this forest tree has come to the limelight as a viable alternative. It is propagated by self sown seedlings in nature. For converting it into a cultivated crop to supply feedstock of high yield and desired quality to the power plant, it is necessary to develop suitable agro techniques. For making the cultivation of this forest tree profitable to farmers and industry, BM2BP GPI has conducted research work on:

- Germplasm collection and evaluation
- Production of Polyploids and tissue culture plants
- Agro techniques for maximum biomass production with high calorific value

Experiments have been conducted by a team of agricultural experts both in the laboratory as well as field in scientifically laid out trials for the first time in India. These trials have given agro techniques easy for field adaptation. The agro techniques include seed germination method, rooting of stem cuttings, spacing in field, irrigation, pruning technique, biofertilizers, biocontrol of diseases etc for large scale cultivation of this forest tree.

**Bamboo**

The species of bamboo selected for energy crops is from the Bambusa Balcooa family of grasses. After 10 years of breeding and fertilization programs, this species of bamboo is now cultivated from tissue culture and then micro propagated. As a result, each tissue culture sapling is identical, asexual, non evasive, non flowering and has a density of 5 times greater than any other species of bamboo. It can be cultivated in all types of soil where there is sufficient water availability or where climatic conditions such as in the equatorial regions offer a natural environment for cultivation. Bamboo has the potential as an energy crop of yielding 20 tons per acre in a year and 35 tons per acre in three years. By fourth year the bamboo can be mechanically harvested and produce on average, up to 65 tons per acre per annum, with a lifespan of up to 50 years.

**Marjestica**

Marjestica is a species of tree that has resulted from applying the Tree Adaption Process (polyploidisation) from the mother stock of Paulownia, thus increasing its annual growth rate by up to 28-40%. Clenergen has signed an exclusive license to the polyploidy technology for the cultivation of the species in India and Sri Lanka. The tree will grow to 28 feet high within the first year from planting and can be mechanically pruned and harvested on an annual basis. Marjestica has a low water requirement and is ideally suited as an energy crop as it develops multiple stems after the first harvest. Marjestica has the potential of yielding in excess of 40 tons on average per acre per annum over an 8 year period before replanting. Its low moisture
content results in a highly efficient renewable biomass feedstock for gasification power plants.

Increased Employment
A combination of these programs can be simultaneously launched in virtually all parts of the country. All of the programs would create large numbers of jobs for landless rural families. It is estimated that two hectares of cultivated waste land can generate year-round employment for 2 persons.

At the beginning of the new millennium, 260 million people in India did not have access to a consumption basket which defines the poverty line. India is home to 22 percent of the world’s poor. A program that generates employment is therefore particularly welcome.

The renewable energy sector has the potential to serve as a source of substantial employment. The investment in the ethanol industry per job created is US$ 11,000, which is significantly lesser than the US$ 220,000 per job in the petroleum field. In India, the sugar industry, which is the backbone of ethanol production, is the biggest agro-industry in the country. The sugar industry is the source of the livelihood of 45 million farmers and their dependants, comprising 7.5 percent of the rural population. Another half a million people are employed as skilled or semi-skilled labour in sugarcane cultivation.

The first phase of the National Renewable Energy Mission demonstration project will generate employment of 167.6 million person days in plantation by 2012. On a sustained basis, the program will create 36.8 million person days in seed collection and 3,680 person years for running the seed collection planting, harvesting and handling of biomass and oil-extraction centers.

Clean Energy Generation
The model suggested a loss for production of electricity by using gasification and steam combustion technologies wherein the biomass in the form of wood pallets is used in power plant.

Financing of Plantations and Setting up of Small (1-2 MWh Power Plants)
The current policy of Government of India (Defence offset) does not permit utilizing the obligation of Defence suppliers in fulfilling their requirement through investments in any sector other than the Defence related products for exports. The policy also requires the obligor to more or less concurrently complete their obligation along the supply period. The policy could be suitably amended to include investments in biomass based power generation eligible to get credits under the program. This would help the Defence in following way:

- Utilization of surplus land with Ministry of Defence (MOD)
- No encroachment
- Smaller units to be set up in far flung areas
- Ensuring uninterrupted power to Defense establishments
- Supply of power to production units either directly or through grid
- Offset obligations could be utilized for putting up large number of units in a short time which will make up for the delay in funds from the budget
- If offset banking is allowed and suppliers give credits on capital investments and power generated there on, obligor would be keen to do such investments even before any contracts are signed under DOFA.

Cultivation of fast-growing trees such as Vanashree, bamboo and Paulownia can serve as biomass fuel for establishing a national network of decentralized rural power plants. Biomass energy and agriculture demand an ecological architecture with its regenerative potential as an energy source. Hence, the prudent usage of the crop would get an adequate amount of plants growing again providing sustenance and energy.

Courtesy: Dr. Arvind Pandalai
Honorary Chairman
Clenergen India Pvt. Ltd.
Email: apandalai@gmail.com
Biomass is one of the most important sources of renewable energy in India and Thailand. Energy from biomass in rural areas through direct combustion has been the most important process in converting biomass to other useful forms of energy. In Thailand, the industries that rely on biomass as an energy source are brick production, tobacco, and lime production, smoking of rubber sheet and fish mill production. Wood fuels, including charcoal, are the most prominent biomass energy sources. Substantial uses of biomass energy in developing countries continue to be in rural and traditional sectors of the economy. Most biomass is not traded, but is homegrown or collected by households.

Rice farming is the largest sector of agriculture in Thailand. Rice husk is a by-product of paddy mill. In Thailand, rice husk contributes about 4.6 million tons a year, 23% of the total rice production. Instead of being dumped as waste, rice husk has been used as fertilizer, chicken and duck farm’s litter, fuel source for manufacturing processes such as brick and charcoal making. The main problem for rice mill owners is to decide on how to utilize the full potential of total amount of rice husk available to them.

Biomass is a principle energy source and contributes a third of India’s energy. Technologies like biogas and improved cook-stoves exist in India since half a century. Policy makers perceived biomass as an energy alternative that could alleviate energy crisis. The biomass strategy focused on improving efficiency of traditional technologies, enhancing supply of biomass by introducing modern biomass technologies to provide reliable energy services at competitive prices and establishing institutional support. The DNES, established in 1982, implemented the improved cook stoves program with moderate success. Programs such as fuel wood plantation and biomass based electricity generation have begun recently. There is a growing experience of managing biomass projects. In 1992, up gradation of DNES to MNES has accorded a higher status to renewable energy technology programs. Ministry of Non-Conventional Energy Sources (MNES) was renamed as Ministry of New and Renewable Energy (MNRE) in 2006. The role of new and renewable energy has been assuming increasing significance in recent times with the growing concern for the country’s energy security. New policies aim to promote modernization and commercialization of biomass production, combustion, densification, and electricity generation. A long term techno-economic analysis using the MARKAL model shows that biomass electricity technologies have significant potential to penetrate Indian market under a fair competition with fossil technologies. Under an optimal greenhouse gas mitigation regime, biomass electricity penetration can reach 35 gigawatt in 2035.

Evolution and Growth of Biomass Policy in Thailand

The Thai government has enforced an energy policy to promote use of biomass as fuel for generating electricity through SPPs (Small Power Producers) and VSPPs (Very Small Power Producers) program. Under which rice husk and rice husk mixed with other biomass-based power generation plants increased to 35 plants in 2006 with total capacity of about 574 MW [3]. The amount of rice husk which is used as fuel for generating electricity is approximately 6 million tons per year (9,800 tons per MW per year). At the beginning of policy enforcement, rice husk was among the first choices due to its low price, small size, and low moisture, compared to palm oil residue. Moreover, rice-husk ash has good quality and it can be sold to material industries if its combustion is well controlled. Effect of this policy appeared in rice-husk collection process. In the past, price of rice husk was reported to be in the range of 50 - 150 baht per ton (US$1.25-3.75 per ton) but nowadays, price in some areas have jumped suddenly and has reached around 1,000 baht per ton (US$25 per ton). The high price of rice husk occurred in some areas due to limitation of amount of rice husk. Investigation of economic viability shows that current price is maximum value at which rice-husk-based power generation plant can get profit by selling electric power to the grid. On the other hand rice husk in some area is not used effectively has low price and is often disposed. The price of rice husk depends on its location of production.

Since the Thai government has a policy that encourages private sector
to an even stronger role in electricity supply industry, SPPs and VSPPs programs were proposed by 1992 and 2000 respectively. In July 2006, 74 SPPs which use biomass energy as fuel to generate electricity have received notification of acceptance with total capacity of about 1,295 MW and 44 SPPs have connected to the grid with total capacity of about 839 MW and total sale of about 352 MW. Rice husk and rice husk mixed with other biomass based power generation plant, 33 SPPs have received notification of acceptance with total capacity of about 571 MW and 12 SPPs have connected to the grid with total capacity about 229 MW and total sale of about 163 MW [3]. For VSPPs [6], two VSPPs have connected to the grid with total capacity of 2.1 MW and total sale 1.85 MW.

According to the residue potential in 2001 from 10 main agriculture products assessment, 22 million tons out of 66 million tons of agricultural residues were used as fuel and small amount for other purposes. In 1999 the Energy Conservation Promotion Fund Committee (ENCON Fund Committee) authorized the National Energy Policy Office (NEPO) to manage an amount of 2,060 million baht to subsidize SPPs using renewable energy. To increase renewable energy ratio from 0.5 - 8% new power plant must generate power from renewable energy 3 - 5% of total capacity. This should lead to expand opportunities and markets for biomass power production in Thailand.

**Specific Policy Interventions in India**

India has a long history of energy planning and policy interventions. The programs for promoting biogas and improved cook-stoves began in 1940s. National biomass policy originated later, in 1970s, as a part of rural energy policies. To meet increasing oil import burden and to meet the challenge posed by deepening rural energy crisis, programs for renewable energy technologies (RETs) were developed in 1970s. Biomass, being a local, widely accessible and renewable resource, was potentially the most suitable to alleviate both macro and micro concerns. Biomass policies followed a multi-pronged strategy: i) improving efficiency of traditional biomass use (e.g. improved cook-stove program), ii) improving supply of biomass (e.g. social forestry, wasteland development), iii) technologies for improving quality of biomass use (e.g. biogas, improved cook-stoves), iv) introduction of biomass based technologies (wood gasifiers for irrigation, biomass electricity generation) to deliver services provided by conventional energy sources, and v) establishing institutional support for program formulation and implementation [10].

Since early 1990s, there has been a noticeable policy shift. Under market oriented economic reform policies pursued by the Government of India, market forces are now allowed a greater role. The shift in policy approach is characterized by: i) higher emphasis on market instruments compared to regulatory controls, ii) reorientation from technology push to market pull, and iii) enhanced role of private sector. The new policies signify a shift in policy perspective towards biomass. The old perspective viewed biomass as a non-commercial rural resource which has to be pushed by the government programs. The new perspective considers biomass as a clean competitive energy resource which will be pulled commercially by energy users if the government policies help to internalize its multiple social benefits and social costs of conventional fuels. The new policy perspective has resulted in enhanced support to the sugarcane bagasse based co-generation, improved biomass combustion technologies, biomass densification, charcoal making and decentralized electricity generation.

**Future Challenges**

Development of biomass technologies in India and Thailand are classic reflections of a developing country. Thailand and India are agricultural countries with an abundance of biomass production; hence the price of biomass is still low. There exist an emerging pool of technological knowledge, experience and commercial acceptance of modern biomass technologies in the niche markets such as in wood and agro-processing industries where biomass materials are cheaply and readily available as byproducts. Whereas the vast traditional sector in India indicates the potential for improved use of biomass energy, emerging commercial technologies demonstrate the promise to tap this potential. To make this happen there are many support programs from government and other international funds, to ease the difficulty to access financing.

As developing country drawbacks, many barriers hinder technological change in vast traditional sectors. Predominant use of biomass still continues to be in rural household and traditional industry sectors. It was increasingly realized that failures of biomass programs resulted from deficiencies in policy perspective. First, biomass was viewed solely as a traditional fuel for meeting rural energy needs. Second, biomass policies
primarily focused on supply-side push. On supply side, since most biomass are home grown or gathered by households for own needs, the market for biomass energy needs to be developed, both in ensuring economic and sustainable production as well as in promoting efficient use. Under the circumstance, organized technological intervention in biomass production is also required.

The most vital issue for biomass energy in India and Thailand is the development of market for energy services. Two possible ways of doing this would be: i) providing reliable and enhanced biomass supply, and ii) reliable energy services with biomass technologies at competitive cost. The main objectives of the policy of Thailand on power purchase from SPPs are to promote the use of indigenous by-product energy sources and non-conventional energy for power generation, e.g. wind, solar, geothermal, waste and waste agriculture, and economical and efficient use of energy, to encourage participation of private sectors in power generation by allowing them to generate and sell electricity to the power utilities, and to promote competition in the power-generation sector by authorizing private power producers to supply electricity directly to industries and nearby residential customers. Consumers are, therefore, given more options on which electricity is traded.

However, there are certain challenges that need to be focused upon like high investment cost for modern biomass technologies. Due to inconvenience caused by power plant set-up people don’t want any new power plant in their area. There is a high requirement of research personnel in the area of thermal conversion. The conversion efficiency in utilizing biomass as an energy source is generally low. At present, technologies that utilized biomass are ranked from local made to imported technology and many biomass technologies especially in rural use and some factories are classified to be quite an old technology with low efficiency. So there are enormous rooms for promoting an efficient and most promising biomass technology, especially biomass gasification technology to replace the old one.

The future prospects of biomass technologies depend considerably on removing existing barriers. The key issue before the Indian policy makers is to develop the market for biomass energy services by ensuring reliable and enhanced biomass supply, removing tariff distortions favoring fossil fuels and producing energy services reliably with modern biomass technologies at competitive cost. Biomass power is a major contributor to domestic and international energy needs while providing substantial environmental benefits. It is one essential source of energy for production particularly for saving the environment.

References
Economic Feasibility and Socio-economic Impacts of Four Bio-saline Agro-forestry Systems in Haryana, India

The worldwide demand of energy is expected to rise dramatically in the near future. Emerging nations such as India and China require more and more energy, while the demand in developed nations is still on the rise. In inverse proportion, the supply and price of traditional forms of energy (coal, oil and natural gas) is expected to decline as a result of steady depletion. Environmental factors also have an increasingly important role in shaping our future energy demands. The world requires cleaner and more sustainable energy sources to avoid pollution, depletion, over exploitation and climate change. Many alternative sources of energy are being proposed and evaluated, e.g., solar power, wind energy, tidal energy and energy from biomass sources.

Biomass for energy production can be produced in the form of dedicated ‘energy’ plantations or waste biomass (from maintaining forest, roadsides, parks and agricultural waste). This article focuses on the use of plantations to produce biomass energy products. This integration of trees, with intercropping, in the agricultural system is called agro-forestry. However, if the demand for renewable energy from biomass sources is to be met, large plots of agricultural land will have to be converted to agro-forestry systems. This can potentially create a food...
for fuel dilemma, since less land is available for agricultural food production.

One potential solution to avoid this problem is the establishment of agro-forestry systems on land that is unsuitable for agricultural production, such as salt-affected soils. Worldwide, 933 million hectares of land are badly degraded by salts and cannot be productively used for traditional agriculture. More than 8 million hectares of previously productive land in India is now salt affected. These huge tracts of land can potentially be used to grow fast-growing salt-tolerant tree species that can be used for a variety of energy and other products.

This study reviewed in this article has focused on the economic feasibility and socio-economic effects of working bio-saline agro-forestry systems in Haryana, India. The socio-economic effects constitute of potential benefits to the farmers and other actors that may come from the use of agro-forestry systems. These benefits include, for example, extra income, higher yields, higher employment and more divers products from the land (fuel wood, fodder etc.). In line with this stands the economic feasibility of these systems, if the system is not viable it will not have any benefit to the farmers and users and implementation of the system will not be successful.

The aim of the study was to construct and analyze three value chains that are derived from the bio-saline agro-forestry plantations. Every value chain begins with the biomass production phase and has three different output products. These are fuelwood, timber, and charcoal. The analysis includes all inputs (costs, labour, transportation, energy and processing) to produce a unit of output product (ton or kWh). These data are used for the calculation of the Net Present Value (NPV) and cost of production (COP) of the produced products.

The plantations were established as part of the Haryana Social Forestry Project. Through this program, the state government is encouraging the establishment of agro-forestry plantations on salt-affected Panchayat lands. The initial cost of plantation establishment and maintenance in the first three years is financed by the government. The benefits of selling the trees or using the trees in the community are allocated entirely to the Panchayat. This can potentially make agro-forestry very lucrative for the local communities. The case studies plantations were all established under this project. In Haryana, a survey was conducted in four villages (Figure 1) to determine the inputs needed to maintain and harvest the agro-forestry system present, as well as the annual and total biomass yields. Prior to plantations, all land was highly alkaline in nature and no traditional agriculture could be performed (Figure 2 on next page). The land was essentially a wasteland and only scarce vegetation such as grasses and some Acacia nilotica were present. The land was used for fuelwood collection and grazing of livestock. Table 1 (next page) gives a quick overview of the specifics of each plantation that was established in each individual village. Figure 3 (next page) shows an example of a bio-saline plantation at the Central Soil Salinity Institute (CSSRI) in Karnal.

Each output product requires a different amount of processing before the finished product can be used or sold to the market. In addition to surveying the villages for the biomass production phase, several processing facilities were visited with the aim to establish the inputs and outputs to get
a complete picture of all the costs and other inputs required to manufacture an unit of finished product. Figure 4 shows an example of a charcoal manufacturer.

When looking at the final results of this study, it can be concluded that the overall economic feasibility of the five product chains is very positive. Figure 5 (next page) shows a cost/benefit breakdown of the plantations and clearly shows higher benefits compared to the costs.

The results show that the NPV ranges from 318 to 1,441 €/ha. In most cases the NPVs of subsidized plantations are well above the NPVs of the baseline land use. However, without subsidies only the NPV of the (agro-)forestry

The results show that the NPV ranges from 318 to 1,441 €/ha. In most cases the NPVs of subsidized plantations are well above the NPVs of the baseline land use. However, without subsidies only the NPV of the (agro-)forestry plantation in Gudha is higher than of the baseline land use.

Table 1. Overview of case study plantations (source: Stille et al, 2011)

<table>
<thead>
<tr>
<th></th>
<th>Gudha</th>
<th>Kohand</th>
<th>Nain</th>
<th>Sutana</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree species</td>
<td>Acacia nilotica (50%) and Eucalyptus tereticornis (50%),</td>
<td>Acacia nilotica</td>
<td>Prosopis juliflora</td>
<td>Prosopis juliflora</td>
</tr>
<tr>
<td>Plantation period (yr)</td>
<td>16</td>
<td>14</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Intercrop species</td>
<td>Leptochloa fusca</td>
<td>Native grasses</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Plantation size (ha)</td>
<td>8</td>
<td>14</td>
<td>56</td>
<td>60</td>
</tr>
<tr>
<td>Tree density (number/ha)</td>
<td>400</td>
<td>200</td>
<td>1,100</td>
<td>1,100</td>
</tr>
</tbody>
</table>
F i e l d  E x p e r i e n c e

The cost of production is calculated and compared to the market prices of fuelwood, timber, and charcoal. Despite the low market value of *Prosopis juliflora* the COP of the fuelwood and charcoal chains of Nain and Sutana are well below current market prices. The production of fuelwood and charcoal is especially attractive in the case of Gudha and Kohand, mainly because of the low feedstock costs.

The COP of timber in Kohand, Nain and Sutana are higher than the market prices, but lower in Gudha. It is important to note that the costs of timber would be much lower (and well below market prices), when the COP would be based on the total costs of the plantation, minus the profits from the sale of fodder and fuelwood.

Furthermore, the study found that (agro-)forestry plantations can help regenerate alkaline soils for conventional rice and wheat production. Soil regeneration can increase the NPV strongly but the actual increase depends on the method used to quantify the value of soil regeneration.

The results also indicate that the production of fuelwood, timber, and charcoal from wood from (agro-)forestry plantations on salt-affected soils is competitive with existing production chains. The results of this study show the need and benefits of optimizing the economic performance of (agro-)forestry plantations as part of current and future policies by, for example, subsidizing (parts of the) establishment costs and creating a mechanism by which soil regeneration is rewarded.

Further details about this study can be found at the following source:


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**Figure 5. Cost/benefit breakdown of the four case study plantations (source: Stille et al, 2011)**

Plantation in Gudha is higher than of the baseline land use. The highest NPV is observed in Gudha, which is due to the high economic value of the tree species *Acacia nilotica* and *Eucalyptus tereticornis* and the fodder crop *Leptochloa fusca*. In Nain and Sutana *Prosopis juliflora* trees were planted at a higher density compared to Gudha and Kohand, which resulted in a higher productivity, but also higher establishment and maintenance costs. The net result in these cases is a NPV lower than at Gudha.
Case Study: ‘Sweet Side’ of the Power Sector in Mauritius

For the uninitiated – the Republic of Mauritius is an island nation off the southeast coast of the African continent in the southwest Indian Ocean, about 900 kilometres (560 mi) east of Madagascar. In addition to the island of Mauritius, the Republic includes the islands of Cargados Carajos, Rodrigues and the Agalega Islands.

The country provides a good example of commercially sustainable energy generation from sugarcane bagasse which is the fibrous residue obtained after the extraction of juice from sugarcane. Table 1 shows the increase in the contribution of electricity generated using bagasse.

Mauritius has no known fossil fuel reserves and till some decades ago it was almost entirely reliant on fossil fuel imports for its energy requirements from other countries. Even though production of electricity on a large scale from biomass (bagasse) started in the late 1950’s, the increase in energy demand was substantial over successive decades.

The Evolution of the Sugar Industry in Mauritius

Sugarcane plantations were introduced on the island as early as the 17th century by the Dutch. The 1950s was the time when sugar factories began utilizing bagasse to produce high pressure steam to generate electricity, instead of just low pressure steam for the sugar extraction process. After producing electricity, the resulting low pressure steam was used as process heat for the sugar crystallization process. This was an added benefit for the sugar plantations because they enjoyed preferential markets in Europe where sugar was sold at a regulated price.

However, production of sugar did not remain a ‘sweet’ success story for the island nation due to the fluctuation of sugar export prices between the 1970s and 1980s along with the increasing size and output of sugar plantations which severely threatened the profitability of operations.

To counter the effects of decreasing share in preferential markets, increasing export duties and cyclones and droughts on production, the Sugar Action Plan of 1985 was implemented. The plan focused on export duty relief, improving technology and practices, restructuring and pertinent to this discussion, utilizing sugar plantations for producing energy. This was followed by a Sugar Industry Efficiency Act of 1988 that aimed to make the sugar industry more efficient and promote agricultural diversity along with diversification within sugar.

The implementation of these acts opened avenues for investment in electricity generation using bagasse, the biomass residue from sugar plantations. The option to use bagasse to generate and sell electricity to the national grid made independent power production a potentially viable business operation in Mauritius.

Power generation trends in Mauritius

In the first few decades after independence, the fuel input for power generation in Mauritius was almost entirely imported fuel oil. This led to huge import bills and devaluation of the Mauritian currency. The bagasse energy development program (BEDP) initiated by the government in 1991 aimed to arrest this.

Initially in Mauritius, all electricity generation was done by Central Electricity Board (CEB). However, this scenario changed considerably with the emergence of Independent Industrial Producers (IIPs) and the BEDP. Mauritius produces between 4 to 5 million tons of sugar annually and more than one thirds of that quantity is available as bagasse. However, the bagasse is resold as an input fuel to ensure profitability of sugar plantations. CEB now purchases power from the IIPs, sometimes at much higher tariffs, and resells them to the consumers at more reasonable rates. In 2010, IIPs produced 59.1% of the total electricity.

Table 1 – Electricity produced from Bagasse in Mauritius between 1996-2005

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<tr>
<td>GWh</td>
<td>119.0</td>
<td>124.6</td>
<td>194.3</td>
<td>188.5</td>
<td>278.5</td>
<td>296.5</td>
<td>299.1</td>
<td>317.9</td>
<td>301.6</td>
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The electricity generation from bagasse was 366.4 GWh in 2008 and 353.6 GWh in 2009.


The IIPs are either firm or continuous power producers. Both use bagasse as the input fuel during the crop season, however, firm producers generated electricity all year round by using coal when bagasse is unavailable. Table 2 shows names of IIPs in Mauritius.

The BEDP program coupled with the shift to more easily available imported coal has been successful and this can be gauged by studying the statistics for electricity production by source. For e.g. the share of fuel oil for generating electricity reduced by nearly 20% (from 58% to 35%) over a span of 10 years from 1994 to 2003. During this period, the use of coal to generate electricity experienced an increase of 24%. As of 2010, the share of coal is the largest at about 60% with bagasse and fuel contributing nearly the same share.

**Looking ahead**

In October 2009, the government of Mauritius elaborated the Long Term Energy Strategy and Action Plan. The plan lays emphasis on the development of renewable energy, reducing dependence on imported fossil fuel and the promotion of energy efficiency. This is in line with the Government’s objective to promote sustainable development in the context of the **Maurice Ile Durable vision**.

Specifically for bagasse energy, the Master Plan for Renewable Energy has certain clear objectives. These objectives are enumerated below:

- Use bagasse more efficiently with a view to increasing the contribution of bagasse based electricity in the medium-term from the present level of 350 GWh to 600 GWh annually.
- Additional electricity from the same amount of bagasse currently available from the 5 millions tons of cane can be generated by the sugar industry through investment in power plants operating at higher pressure.
- Benefits from the use of additional bagasse be reaped by all stakeholders of the sugar industry to IPP’s. Accruals from CER’s to be passed on to the CEB.
- Maximize the amount of energy generated from available bagasse, while minimizing the use of coal. Within this framework, achieve the target of 600 GWh of electricity from bagasse in medium term.
- Promote research and development in the sector to develop new varieties of sugar cane with higher biomass production.

**References and Further Reading**

- http://en.wikipedia.org/wiki/Mauritius
- Hassen, Sayed S.Z. and Bhurtan, C., Trends in the Power Sector in Mauritius, Department of Electrical and Electronic Engineering, University of Mauritius
- Digest of Agricultural Statistics 2009, Central Statistics Organization, Government of Mauritius

**Table 2: IIPs in Mauritius**

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<tr>
<th>Firm Producers</th>
<th>Continuous Producers</th>
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<td>F.U.E.L.</td>
<td>Medine</td>
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<tr>
<td>Compagnie thermique de Belle Vue</td>
<td>Union St. Aubin</td>
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<td>Consolidated energy limited</td>
<td>Mon Loisir</td>
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<td>Compagnie thermique du Sud</td>
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<td>Compagnie thermique de Savannah</td>
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Energy Alternatives India (EAI) provides customized business intelligence and market research tailored to individual business needs. The availability of an existing intelligence database ensures quick turnaround times and low costs. EAI predicts that biomass gasification based power production in India could grow from about 80 MW currently to over 500 MW by 2015. This comprehensive guide provides business intelligence in areas of biomass energy development and would be indispensable to anyone keen on setting up biomass power plants. This report has been developed by EAI, India’s leading renewable energy consulting and business intelligence firm. Founded by professionals from IITs and IIMs, EAI is today considered a critical catalyst and partner for the Indian cleantech industry. Last updated on May 2011, this report contains comprehensive inputs and in-depth insights on:

- Biomass gasification market status and trends in India
- Types of biomass and their availability in various regions in India
- Supply chain for the various types of biomass
- Economics of power from biomass gasification - capital and operational costs (and break-ups of these costs), levelized cost of power, financial scenario analysis
- Success strategies adopted by power production companies in this sector
- Gasification technology and components
- Updates on the latest in biomass based power in India
- Financing options for biomass gasification based power plants
- Central and state government incentives, feed in tariffs.

This report provides information on key technology routes to obtain power from biomass. It gives information on who are the key Indian vendors, suppliers and technical consultants who can assist in setting up biomass gasification power plants. It answers to the most frequently asked questions on biomass gasification – questions on technology, operations, biomass supply and costs. It provides guidance on the financial returns in biomass gasification based power production for different scenarios. Also presents a clear picture of what is the current state of biomass gasification based power production in India – potential, companies, biomass availability and government incentives.

This is the only comprehensive report available for this important segment. It clearly spells the advantages, costs and the bottlenecks in biomass gasification based power production. It is written with actionable inputs – including data on the suppliers of gasifiers, gas engines and turnkey consultants after extensive primary research and thus contains the insights and perspectives from all the key stakeholders in the market. It also comes with additional research support from EAI. It is useful to entrepreneurs and businesses keen on setting up biomass gasification based power plants, also to organizations and government bodies keen on understanding the potential and actionable steps for biomass gasification. It could also provide information to business research companies and consultants whose clients are keen on entering this sunrise industry. Technology consultants and implementation companies keen on supporting companies in setting up biomass gasification based power plants can benefit from this report.

Source: http://www.eai.in/ref/reports/biomass_gasification.html
2nd Biomass Pellets Trade Asia  
September 07-08, 2011, Seoul, S. Korea

Biomass Pellets Trade Asia aims to provide first-hand insights on the demand dynamics in North Asia, supply outlook and investment opportunity in this value chain. According to Poyry, biomass is the only renewable energy source that is tradable and as policy incentives are getting stronger the biomass markets are growing.

Warranted by its Renewable Portfolio Standards, wood pellets suppliers from the West are looking towards East, South Korea and Japan, for exports opportunities. Palm kernel shells (PKS), favored for its high energy/calorific values, and rice husks, are also sought after by North Asian power utilities and industrial plants. Thus, with economically viable policy and incentives, will South Korea and Japan set to drive demand for biomass up? CMT’s 2nd Biomass Pellets Trade Asia is calling for all participants in the value chain of the “biomass to power generation” to Seoul this September to make this “Global Buyers & Asia Sellers Meet” happen.

Biomass Pellets Trade Asia aims to provide first-hand insights on the demand dynamics in North Asia, supply outlook and investment opportunity in this value chain. According to Poyry, biomass is the only renewable energy source that is tradable and as policy incentives are getting stronger the biomass markets are growing.

Also, the conference presents the 2nd edition of the post conference workshop on Torrefaction Technologies and Economics. Facilitated by commercial and technology experts in this field, this half-day workshop will make exclusive focus on the economics, processes, specification and handling of converting agro-biomass into torrefied materials and pellets. Be at this exciting event and make trade happen.


2011 Algae Biomass Summit  
October 25-27, 2011, Minneapolis, USA

The 5th annual Algae Biomass Summit will take place October 25-27, 2011 at the Hyatt Regency in Minneapolis, MN. This dynamic event unites industry professionals from all sectors of the world’s algae utilization industries including, but not limited to, financing, algal ecology, genetic systems, carbon partitioning, engineering & analysis, biofuels, animal feeds, fertilizers, bioplastics, supplements and foods.

Organized by the Algae Biomass Organization and coproduced by BBI International, this event brings current and future producers of biobased products and energy together with algae crop growers, municipal leaders, technology providers, equipment manufacturers, project developers, investors and policy makers. It's a true one-stop shop – the world’s premier educational and networking junction for all algae industries.

The Algae Biomass Summit is the largest, fastest-growing algae event of its kind. In 2011, this event is expected to draw nearly 900 attendees and exceed the previous year’s attendance by almost 20%. This growth is powered by the current strength of the industry and the positive outlook for future algae producers. The summit will help you — as an algae industry stakeholder — identify and evaluate technical and economic solutions that fit your operation. It's time to tap into your green power. Get started today by registering for the 2011 Algae Biomass Summit!


Call for Advertisements

We invite organizations to advertise their profiles and products in the Bioenergy India magazine. Advertisements focusing on the biomass energy sector will be offered a space in the magazine. Special discount is available for insertions in more than two issues. For details, please contact Sasi M at sasi@winrockindia.org

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The country is aiming to generate about 10,000MW of energy from biomass over the next decade, Deepak Gupta, Secretary of the Ministry of New and Renewable Energy (MNRE).

Mr Gupta was speaking at the inauguration of National Workshop on Dedicated Plantation-Based Biomass Power and Energy, reports Express Buzz. He said power shortage was a big problem in the country and with a question on the safety of nuclear energy, there was an urgent need to resort to other sources of energy.

He added that currently up to 70 per cent of the electricity and other energy generation in the country depends on imports. He said if something was not done, by 2030, around 90 per cent of India's energy generation would depend on imports.

Mr Gupta pointed out that India had under-utilised its potential to generate energy from biomass. He said India could generate around 16,000 megawatt from biomass but was producing only around 1,000 megawatt. He said wasteland could be used to raise dedicated and high-yielding plants for biomass generation.

A.K. Verma, MD, Karnataka State Forest Industries Corporation Ltd, highlighted the importance of plantation, especially bamboo, to provide sustainable supply of feedstock for power generation.

Mark Quinn, Chairman and CEO said: "The power plant location is ideally located for the supply of local biomass which will provide operating cost efficiencies and increased profitability. The plant was granted a license to expand to 21MW by the State Government in 2006 and has sufficient supplies of local biomass to support the scale up of the operation. Within 30 km of the plant there is available over 1,300 acres of land that can be sub let to support the cultivation of energy crop plantations."

Dr D.K. Khare, Director of MNRE, said absence of clear state policy, clarity in procedures, and getting clearance from the Government and Forest Department for the plantation land were another roadblocks.

The secretary to the MNRE said the ideas and recommendations put forth in the workshop would be taken up and forwarded to government for implementation if they were found feasible and genuine.
Indian, Pakistani Companies Win Green Energy Awards

Two Indian companies which recycle waste products into sources of power and a Pakistani firm that fits energy-saving devices in homes were honoured with major green energy awards. Ashden Awards for Sustainable Energy, is one of the world’s most prestigious green energy honours, with £20,000 ($32,200, 22,800 euros) prize money.

The British awards, which started in 2001, aim to encourage the greater use of local clean energy and to address climate change and alleviate poverty.

Ghanaian firm Toyola Energy Ltd. won the top prize, the £40,000 Gold Award, for its success in making stoves that burn less charcoal than traditional models and that are accessible to low-income families.

The Indian firms, Abellon CleanEnergy Ltd. and Husk Power Systems, and Pakistani company, The Aga Khan Planning and Building Service, were among four other international winners.

“Our dream is a world where access to clean, affordable electricity and fuel can be enjoyed by the poor, transforming living standards, reducing CO₂ emissions and easing the pressure on dwindling forests,” said awards director Sarah Butler-Sloss.

“The 201 1 Ashden Award winners are making this vision a reality, and their potential for expansion and replication is high.” Abellon CleanEnergy Ltd., based in Gujarat state, western India, was recognised for its business of producing biomass pellets from crop waste to fuel industries in the area.

As well as replacing traditional industrial fuels with a cleaner alternative, the business also gives farmers a market for waste products.

A power plant fuelled by waste products and solar energy could provide researchers with a business and technological blueprint capable of addressing rural poverty across India. So business and engineering academics from Aston University and the Indian Institute of Technology in Delhi are overseeing the construction of a combined heat and power plant (CHP) in a remote village in northern India.

Fuelled by crop waste such as rice husks and prosopis wood, the 300kw biomass-solar plant will provide heat, steam and electricity to downstream plants, which are also being built as part of the three year project. This includes a rice mill, fruit and vegetable processing plants and a water distillation unit. The combination of solar and biomass power will reduce fuel consumption while allowing round the clock operation.

Husk Power Systems, based in Bihar state, eastern India, was honoured for using a common waste product, rice husks, to produce electricity for remote villages in the area.

The Ashden Awards judges said that the novel way of producing electricity provided a reliable supply and was cheaper than alternatives.

Pakistani firm, the Aga Khan Planning and Building Service, was selected for helping families in mountain villages save energy and make their homes warmer through a range of locally-produced devices.

Carpenters and metal workers employed by the company make products including fuel-efficient stoves, water heaters and wall and floor insulation.

Aston University Planning CHP Against Fuel Poverty in India

The plant will allow regional farmers and their families to access a cheap, renewable and reliable energy source that in-turn can help remote villages to generate an income and escape from a cycle of ‘fuel poverty’. The research team wants to use this pioneering project to create a blueprint for renewably powered combined heat and power boilers, capable of being replicated throughout India.

Dr Prasanta Dey, Reader in Operations Management at Aston Business School said: “We want to develop a holistic business model which can be replicated to grow wealth in rural communities. In India, over 70 per cent of people live in rural communities. We believe this project will empower and benefit the villagers involved, create sustainable rural development and encourage entrepreneurialism.”

Dr Philip Davies, Associate Dean of Research at the School of Engineering and Applied Science at Aston, argued: “A reliable and readily available energy supply is critical for economic development. Bringing renewable and sustainable energy supplies to areas of rural India can ensure we can help people escape from a cycle of poverty. Most India farmers are small holders with limited technology for processing and preserving food. Reliable energy systems are needed to power such technologies and at the same time create employment. This research will create a wealth of ecological and economic benefits along the entire biomass chain, and will offer valuable new research in an evolving industry.”
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.