Converting Waste Agricultural Biomass into Energy: Experiences and Lessons Learnt from a Capacity Building and Technology Demonstration Project in India

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A project was implemented in India to promote conversion of waste agricultural biomass into energy in partnership with Birla Institute of Management Technology. Several capacity building and awareness raising workshops were carried out. The topics covered in these workshops included: assessment of waste agricultural biomass; technologies; methodology for sustainability assessment of technologies; and policies. In India, 415.546 Tg (415.546 million t) of waste agricultural biomass is generated annually equivalent to 103.88 Tg of oil of which 101.88 Tg (equivalent to 25.47 Tg of oil) is estimated to be surplus. The technology demonstration was carried out at M/s Starlit Power Systems Ltd, Sohna, Haryana, which is a lead recycling company. It was decided to replace the diesel oil firing system with syngas produced from a biomass gasifier. A 540 kW (thermal) gasifier installed which led to a saving of 440,000 L/year of diesel and thus avoided 1,160 t/year of GHG emissions. The company invested US$ 160,000 but the savings amounted to US $ 400,000 thus the investment was paid back in just 5 months. A national strategy for enhancing conversion of waste agricultural biomass into energy was developed. A sub-regional workshop was organized to share the results achieved and lessons learnt.

Key Words
Waste agricultural biomass, Energy, Renewable energy, Demonstration project, Assessment of waste agricultural biomass, Policy studies, capacity building

1. Introduction

Biomass is a broad term, which generally refers to any plant or animal matter. The earth has a huge stock of biomass covering the ground and the ocean. The total biomass of the world is estimated to be around 1,800 Pg (1,800 billion t) on the ground and 4,000 Pg in the ocean. On energy basis, the total biomass on the ground is equivalent to about 33,000 EJ (exajoule = 10^18 J), which is about 80 times of the global annual energy consumption 1). An estimated 140 Pg of agricultural biomass waste is produced annually – equivalent to approximately 50 billion t of oil. The term waste agricultural biomass (WAB) refers to those organic materials, which do not directly go into foods or other products. Mostly, this biomass is in the form of residual stalks from crops, leaves, roots, seeds and seed shells etc. Common examples are wheat and paddy straw, bagasse (residue from sugarcane milling in sugar production), seed hulls (rice husk, ground nut husk), waste wood from timber processing, waste from animal husbandry etc. In some case animal metabolic wastes are also considered as biomass. Currently, especially in developing countries, most of the WAB is left in the field to decompose naturally or is open-burnt. Apart from bagasse, and in some cases rice husk, there is hardly any productive use being made of biomass.

A major advantage of using biomass as a source of energy or materials is its renewability. This is a clean source of energy as the carbon cycle loop is closed (the carbon dioxide released by combustion is again sequestered in the next crop) and usually there are no harmful emissions (such as sulfur oxides, heavy metals). The material is available abundantly and is virtually free. Commercial use of biomass can also provide additional income to farmers and poorer sections of society thus helping in poverty alleviation.
The Climate Change (CC) benefits i.e. GHG emission reduction could come from two sources: replacing fossil fuel with fuels derived from waste agricultural biomass and avoiding generation of methane from waste agricultural biomass when left in the field to rot. Details are shown in Table 1.

Over the years several technologies have been developed to use biomass. Both biological means (fermentation) and chemical means (pyrolysis, gasification) can be used to produce liquid and/or gaseous fuels, which can either be directly used as a source of energy or can be further converted into useful chemicals and products. Physical processes such as briquetting and compaction can also be used to make solid fuels.

Already there is a huge global emphasis on making liquid fuels from agricultural sources. However, most of the commercial applications are still based on the main agricultural product itself (such as corn or sugar). In the context of developing countries, the merits of this approach are debatable as it can adversely affect the poor by diverting basic food stuffs to industrial and commercial use and driving up food prices. It can also lead to environmentally undesirable land use practices and distorted land values.

The project was designed with the overall objective of assisting national Governments to promote conversion of waste agricultural biomass into energy through awareness raising, capacity building and demonstration projects. More specific objectives were: a) to raise awareness in developing countries of biomass waste and its possible reuse for conversion into energy, b) to build capacity for assessment of waste agricultural biomass and the identification, assessment, and adaptation of technologies to convert waste biomass into energy, c) to promote industrial and commercial use of systems to convert waste biomass to energy, thus providing alternative energy sources and simultaneous reduction in GHG emissions, and d) to assist national and/or local governments to develop policy packages and facilitate partnerships to promote conversion of waste agricultural biomass into energy and thus scale up demonstration projects.

2. Activity

The project plan included national level assessment and quantification of waste agricultural biomass followed by detailed waste quantification and characterization at selected local sites having particularly high potential with regards to availability waste agricultural biomass. Depending on these assessments identification and assessment of technologies for converting waste agricultural biomass into fuels was to be carried out to attract businesses and governments for taking up these technologies for implementation. To further support implementation of technologies, activities related to establishing business partnerships, match-making between technology suppliers and technology users etc. were also planned to be carried out. In all these activities, capacity building in partner institution on various aspects of converting waste agricultural biomass into energy was to be an integral part. Finally, policy interventions were to be developed to create an enabling policy framework to support conversion of waste agricultural biomass into energy.

The details of major planned activities are shown in Table 2.

The project was implemented with the support of an institution as a project partner to carry out the national/
level activities. Birla Institute of Management Technology was the selected institution. It is a reputed management school which, apart from other specializations, runs a postgraduate programme on sustainable development. The institute has specialists in energy management, sustainable development, waste minimization etc. The institute also has a Centre for Innovation and Entrepreneurship Development.

Other organizations that also contributed to the success of the project are: a) BGCT K.K. - a Japanese technology supplier which supplies technology for green coal – fuel, and b) M/s. Starlit Power Systems Limited – lead recycling industry in India.

2.1 Awareness raising and capacity building

A set of training materials were developed which were made available to the participants. The list of training materials prepared is given in Table 3.

1) Training on assessment of waste agricultural biomass and assessment of management systems, 1-2 December, 2012, Greater NOIDA, National Capital Region, India

In the workshop, which attracted 22 participants, the core participants were members of the project team. However, participants from other relevant institutions were also invited to participate. A brief description of the topics covered during the work is given in Table 4.

2) Training on technologies for converting waste agricultural biomass into energy and methodology for sustainability assessment of technologies, 27-28 February, 2013, Greater NOIDA, National Capital Region, India

The objectives of the training workshop were (i) to present the characterization of waste agricultural biomass for energy applications (ii) to show the overview of technologies for converting waste agricultural biomass into energy, (iii) to explain different technologies for converting waste agricultural biomass into energy; and how to use the methodology of sustainability assessment of technologies.

The topics covered were: characterization of waste agricultural biomass for energy applications; overview of technologies for converting waste agricultural biomass into energy; physical conversion technologies; thermo-chemical conversion technologies; gasification and pyrolysis; biological conversion technologies; and methodology for sustainability assessment of technologies followed by group exercise.

In the workshop, which attracted 20 participants, the core participants were members of the project team. However, in this training participants from business, technology suppliers and other relevant institutions were also invited to participate.

3) Awareness raising and training conducted by partner institution

With the inputs provided in the abovementioned training the partner institution carried out local level training and awareness raising workshops. The following workshops were carried out:

1) Awareness raising workshop on policies for converting waste agricultural biomass into energy – 25 participants, 19 September, 2013, Greater NOIDA, National Capital Region, India.

2) Awareness raising workshop on technologies for converting waste agricultural biomass into energy – 25 participants, 20 September, 2013, Greater NOIDA, National Capital Region, India.
Thus overall, 92 persons directly participated in the training and awareness raising workshops organized under the project.

2.2 Assessment of waste agricultural biomass

Following the training on assessment of waste agricultural biomass, the project teams in each country carried out an assessment of waste agricultural biomass. The assessment, based on UNEP-IETC guidelines, was made at two levels: overall assessment at national level assessment as well as detailed assessment in selected regions. The broad results of assessment are presented below.

1) Overall assessment of waste agricultural biomass in India

The methodology of assessment comprised of assessing the total crop production and based on this estimating the annual generation of waste agricultural biomass using standard crop to residue ratios. Considering that there are two distinct crop season – Rabi and Kharif – and different crops are grown in these two seasons, separate estimates were made for the two cropping seasons. Further in view of the large size of the country and consequent regional variations, estimates were made for different provinces. Keeping in view that in several provinces, considerable amount of waste agricultural biomass is already being used for purposes like animal feed, domestic fuel in rural areas etc. estimates were also made for surplus waste agricultural biomass which could be diverted to generate energy without affecting the present usages of the biomass.

2) Detailed assessment of waste agricultural biomass in provinces of Uttar Pradesh

The state of Uttar Pradesh was selected as the province for detailed assessment not only because it is one of the largest producer of waste agricultural biomass but also because it tops the list of states which have gone in for power generation from agricultural biomass. An elaborate and generic assessment exercise was carried out. Initially, 18 technologies were listed. These were subjected to a screening analysis for which 5 generic screening criteria were identified. Each technology was assessed against these criteria. The screening analysis resulted in a shortlist of 7 technologies which were taken up for further analysis.

A second round of screening analysis weeded out three more technologies. The remaining four technologies were:

1. Briquetting
2. Charring
3. Gasification – thermal mode
4. Gasification – electrical mode

These technologies were subjected to a detailed operational assessment. A set of Technical (10 criteria), Financial (8 criteria), Social (5 criteria) and Environmental (6 criteria) were identified. The technologies were assessed against these criteria on a weight-score method. In a stakeholder consultation first the weightage for each of the 4 categories of criteria was decided. Each criteria was then assigned a weightage. A valuation plan was developed to assess each technology for each criteria.

2.3.2 Technology specification

In order to ensure that the demonstration company is able to order and procure the appropriate technology, it is important to develop correct technology specifications. The project team was therefore provided guidance for developing technology specifications.

2.3.3 Technology implementation

The selected technology were finally implemented in the demonstration company. The technology was implemented at Starlit Power Systems Ltd. It is a flagship company of Starlit Group (www.starlitgroup.net) having focus on manufacturing, trade, import and export of lead based products such as refined lead, lead alloys and red lead from scrap lead such as old lead acid batteries. The annual capacity of the plant is 12 Pg (12,000 million t) with an equivalent 12 -15 Pg of smelting capacity. The technologies which are technically/economically not viable.

Currently, technology assessments methodologies are typically based on OECD experiences and may not be directly relevant to developing countries. It is important to adapt them to suit the conditions in developing countries. Accordingly, based on the technology assessment methodology titled 'Sustainability Assessment of Technologies developed by UNEP-IETC', a specific version of this methodology applicable for assessment of technologies for converting waste agricultural biomass into energy was developed.

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The plant is equipped with modern machinery and state-of-the-art pollution control equipment. The production facility of the company is located at Sohna, Haryana. It is a complete integrated lead recycling plant with systems for dismantling of waste products such as lead acid batteries up to production of final value added products. The schematic process flow chart is given in Fig. 1.

The calculations of economic savings are given in Table 5.

Thus use of waste agricultural biomass through briquetting-gasifier route to replace diesel oil is not only environmentally desirable but also economically a very attractive proposition.

### 2.4 Estimation of GHG emission reduction potential in selected industrial sectors/industries

The overall energy potential of waste agricultural biomass in terms of t of oil equivalent has been described in section 2.2. It may not be prudent to attempt to estimate the GHG reduction potential at the national level because of uncertainties with respect to the field of application of waste agricultural biomass as a source of energy (e.g. substitution of domestic fuel like kerosene, substitution of industrial fuels like oil and coal). It is also difficult to estimate how much fossil fuel will actually get replaced as it depends on various factors such as type of application, conversion efficiency etc. Thus a more practical estimation of fossil fuel replacement

### Table 5 Calculations of economic savings by using waste agricultural biomass

| Item                                                                 | Calculation                                      |
|----------------------------------------------------------------------|--------------------------------------------------|
| The cost of annual diesel oil consumption is 440,000 ltrs.x 56 (Rs./Ltr) | Rs. 24,640,000                                   |
| Cost of waste agricultural biomass                                    | Rs. 1,200 per ton                               |
| Variable cost of Briquetting & per kg. of briquettes                  | Rs. 2,000 per ton                               |
| Total cost of briquettes                                             | Rs. 3,200 per ton                               |
| 1 L of diesel oil                                                    | 3.359 Kg. of briquette, considering the calorific value of briquette as 10.5 MJ/kg (2,500 kcals/kg) |
| Total equivalent briquette requirement                               | 440,000 x 3.359 = 1,478,320 kg or 1478.32 t/year |
| Total cost of briquettes                                             | 1478.32 x 3.200 = Rs. 4,730,643 per year        |
| Net savings by use of briquettes in a gasifier and the syngas in place of diesel oil | 24,640,000 - 4,730,643 = Rs. 19,909,357          |
| Total savings per annum = Savings due to gasifier + opportunity cost of Char production | 19,909,357 + 720,000 = Rs. 20,609,000            |
| Total investment                                                     | 3,964,420 (Gasifier) + 4,000,000 (Briquetting plant) = Rs. 7,964,420 |
| Pay-back period                                                      | 7,964,420/20,609,000 = 4.6 months               |

1 USD = Rs. 50
and consequent GHG emission reduction potential was made in the demonstration industry.

2.5 Policy studies and development of a national strategy

Enhanced and sustainable use of waste agricultural biomass is to a large extent dependent on the supportive policy framework. The project therefore had an activity related to policy studies.

After briefly describing the status of generation and availability of waste agricultural biomass, the project team carried out an analysis of related policies that could influence conversion of waste agricultural biomass into energy. In this analysis the gaps and supportive factors in other policies were identified. Finally, a national strategy for enhancing conversion of waste agricultural biomass into energy was developed.

2.6 Sub-regional dissemination of results

The sub-regional dissemination workshop in India was organized on November 12-14, 2013 at Greater Noida, National Capital Region, India. The workshop was attended by 31 participants from 7 countries (Bangladesh, Bhutan, Cambodia, India, Japan, Nepal and Sri Lanka).

During the workshop the project team made a detailed presentation on various aspects of the project including capacity building activities, assessment of waste agricultural biomass, technology assessment and selection, and policy studies. In addition, the representative from the demonstration factory made a presentation, sharing the details of the technology demonstrated and their experience in its implementation. To cross-fertilize the knowledge and experience, a presentation was made by a representative from Cambodia where a similar project has been carried out.

Representatives from different countries then presented their country papers which covered aspects such as the situation of WAB, technologies practiced and available in the country, relevant policy aspects and their needs for carrying out further work.

A plenary session was then held to discuss strategies for enhancing conversion of waste agricultural biomass into energy in countries in the regions. The session was structured around the topics shown in Table 6.

3. Results and discussions

3.1 Awareness raising and capacity building

The training workshop on assessment of waste agricultural biomass and assessment of management systems was found to be very instructive and useful by the participants. They appreciated learning a systematic assessment methodology. The group exercise conducted was particularly useful as it provided a sort of hands on training. The training helped in conducting the activity 2 of the project.

The training workshop on technologies for converting waste agricultural biomass into energy and methodology for sustainability assessment of technologies was found to be very instructive and useful by the participants. They appreciated learning different technologies for converting waste agricultural biomass into energy, their applicability and constraints and their technical feasibility in India. The methodology of sustainability assessment of technologies (SAT methodology) was the first ever technology assessment methodology that the participants had come across and they highly appreciated it. The group exercise conducted was particularly useful as it provided a sort of hands on training especially with the role play. The training helped in conducting the activity 3 of the project.

The awareness raising and training workshop conducted by the partner institution helped to raise the interest in the subject of waste agricultural biomass and enabled participants to realise the immense potential in India. Exposure to different policy and technology aspects was also highly appreciated.

3.2 Assessment of waste agricultural biomass

The Fig. 2 shows the overall agricultural residue generation, surplus and burned in the field in India.

As could be seen from the Tables 7A and 7B, the total annual generation of waste agricultural biomass is 415.546 Tg (415.546 million t), out of which 101.880 Tg is

| S.No. | Topic discussed during the plenary session |
|-------|--------------------------------------------|
| 1.    | What are the drivers to support conversion of waste agricultural biomass into energy (WAB2E) in the sub-region |
| 2.    | What are the barriers hindering or limiting WAB2E in the sub-region |
| 3.    | What enabling measures will help overcome the barriers |
| 4.    | What could be the vision and main elements of a national/regional strategy to enhance WAB2E |
| 5.    | What could be the main action areas |
| 6.    | How can an organization like UNEP-IETC support greater WAB2E in the region |
Table 7A India State-Wise Generation of Waste Agricultural Biomass for Season: Agro-Kharif5)

| State              | Area (1,000 ha) | Crop Production (Gg/year) | Biomass Generation (Gg/year) | Biomass Surplus (Gg/year) | MTOE | Power Potential (MW-el) |
|--------------------|-----------------|---------------------------|-----------------------------|--------------------------|------|------------------------|
| Punjab             | 2723.0          | 9357.1                    | 16387.1                     | 12298.7                  | 3.07 | 1464.3                 |
| Uttar Pradesh      | 7605.1          | 13646.4                   | 24895.1                     | 7614.3                   | 1.90 | 914.7                  |
| Maharashtra        | 10485.3         | 13232.5                   | 24512.9                     | 5721.2                   | 1.43 | 731.3                  |
| Madhya Pradesh     | 8891.4          | 10424.8                   | 20951.1                     | 4574.7                   | 1.14 | 583.6                  |
| Haryana            | 1778.9          | 34126.6                   | 64388.8                     | 41206.0                  | 1.03 | 494.0                  |
| Karnataka          | 57004.4         | 100805.5                  | 186080.0                    | 3702.3                   | 0.93 | 466.4                  |
| Andhra Pradesh     | 6285.7          | 10439.5                   | 192444.4                    | 3336.4                   | 0.83 | 399.5                  |
| Gujarat            | 5274.4          | 6076.6                    | 141587.7                    | 2927.9                   | 0.73 | 372.0                  |
| Orissa             | 5929.3          | 10026.9                   | 171186.1                    | 3147.2                   | 0.79 | 364.2                  |
| Bihar              | 8206.5          | 6776.7                    | 121263.5                    | 29807.7                  | 0.75 | 352.0                  |
| Chhattisgarh       | 4082.7          | 61136.6                   | 104534.4                    | 19401.4                  | 0.49 | 224.6                  |
| Kerala             | 5305.0          | 3399.3                    | 5388.1                      | 1358.8                   | 0.38 | 195.9                  |
| Tamil Nadu         | 1313.1          | 2997.9                    | 4116.2                      | 1500.8                   | 0.38 | 193.5                  |
| West Bengal        | 2377.6          | 8336.3                    | 14273.2                     | 1436.0                   | 0.36 | 172.1                  |
| Rajasthan          | 6081.3          | 35524.4                   | 77189.9                     | 1310.1                   | 0.33 | 368.5                  |
| Himachal Pradesh   | 384.8           | 814.9                     | 1792.6                      | 818.1                    | 0.20 | 104.1                  |
| Assam              | 11009.0         | 2628.4                    | 3873.0                      | 685.7                    | 0.17 | 81.8                   |
| Uttarakhand        | 468.3           | 783.5                     | 12501.0                     | 3514.3                   | 0.09 | 420.0                  |
| Jharkhand          | 472.1           | 919.5                     | 11381.1                     | 2273.5                   | 0.06 | 28.6                   |
| Jammu & Kashmir    | 5070.0          | 4039.0                    | 9254.0                      | 1464.4                   | 0.04 | 196.0                  |
| Manipur            | 3391.1          | 434.4                     | 9054.9                      | 1113.3                   | 0.03 | 139.0                  |
| Nagaland           | 178.6           | 275.6                     | 488.9                       | 83.0                     | 0.02 | 97.0                   |
| Meghalaya          | 144.6           | 235.8                     | 345.0                       | 55.8                     | 0.01 | 6.5                    |
| Arunachal Pradesh  | 1795.0          | 212.4                     | 331.8                       | 49.3                     | 0.01 | 5.9                    |
| Goa                | 706.0           | 232.4                     | 400.4                       | 48.9                     | 0.01 | 5.6                    |
| Sikkim             | 43.3            | 59.0                      | 1307.1                      | 14.1                     | 0.00 | 1.8                    |
| Mizoram            | 1.9             | 22.6                      | 51.6                        | 5.3                      | 0.00 | 0.6                    |
| Total              | 75507.9         | 124673.4                  | 225070.0                    | 60746.6                  | 15.19| 7416.8                 |

1Gg = 1,000 t
### Table 7B: India State-Wise Generation of Waste Agricultural Biomass for Season: Agro-Rabi5)

| State           | Area (kha) | Crop Production (kT/Yr) | Biomass Generation (kT/Yr) | Biomass Surplus (kT/Yr) | MTOE Power Potential (Mwe) |
|-----------------|------------|-------------------------|---------------------------|------------------------|-----------------------------|
| Punjab          | 3526.6     | 15715.1                 | 28304.6                   | 71236.6                | 1.78                         |
| Rajasthan       | 8244.1     | 11538.6                 | 19843.4                   | 7098.5                 | 1.77                         |
| Uttar Pradesh   | 6454.3     | 16772.3                 | 30017.3                   | 5054.3                 | 1.26                         |
| Haryana         | 3229.0     | 10762.2                 | 19899.2                   | 4821.5                 | 1.21                         |
| Maharashtra     | 4595.5     | 33904.1                 | 7374.3                    | 2141.1                 | 0.54                         |
| West Bengal     | 3386.8     | 12085.1                 | 20469.2                   | 2140.9                 | 0.54                         |
| Madhya Pradesh  | 3767.8     | 3206.2                  | 88870.0                   | 19578.0                | 0.49                         |
| Bihar           | 3393.9     | 6612.1                  | 12374.3                   | 1930.9                 | 0.48                         |
| Andhra Pradesh  | 2230.9     | 5970.5                  | 10771.7                   | 1910.6                 | 0.48                         |
| Tamil Nadu      | 2128.9     | 4880.4                  | 7258.5                    | 1899.3                 | 0.47                         |
| Karnataka       | 2348.6     | 2745.9                  | 62090.0                   | 1262.2                 | 0.32                         |
| Assam           | 2037.5     | 39097.7                 | 6735.8                    | 1251.6                 | 0.31                         |
| Jharkhand       | 1375.7     | 14724.1                 | 25035.5                   | 662.2                  | 0.17                         |
| Gujarat         | 1067.1     | 1780.1                  | 3207.7                    | 649.5                  | 0.16                         |
| Orissa          | 1560.4     | 1526.0                  | 2993.8                    | 444.8                  | 0.11                         |
| Uttarakhand     | 4470.0     | 7499.9                  | 13406.0                   | 224.5                  | 0.06                         |
| Himachal Pradesh| 400.3      | 620.6                   | 1100.8                    | 215.9                  | 0.05                         |
| Chhattisgarh    | 669.2      | 5087.7                  | 8187.7                    | 187.7                  | 0.05                         |
| Jammu & Kashmir | 242.5      | 3699.9                  | 6659.9                    | 133.2                  | 0.03                         |
| Arunachal Pradesh| 24.9     | 24.5                    | 54.1                      | 14.2                   | 0.00                         |
| Meghalaya       | 11.9       | 120.0                   | 236.0                     | 4.86                   | 0.00                         |
| Sikkim          | 14.7       | 101.1                   | 18.8                      | 3.68                   | 0.00                         |
| Mizoram         | 24.2       | 179.0                   | 3.80                      | 0.97                   | 0.00                         |
| Nagaland        | 0.39       | 0.45                    | 0.76                      | 0.14                   | 0.00                         |
| Total           | 51160.3    | 106664.7                | 190476.3                  | 41333.9                | 10.28                        |

Note: Rabi and Kharif are two major cropping seasons in India – analogous to winter and summer crops.

expected to be surplus biomass. In thermal energy terms, the total waste agricultural biomass is equivalent to 103.88 Tg (103.88 million t) of oil, whereas the surplus waste agricultural biomass is equivalent to 25.47 Tg of oil. Note that wherever biomass amount is mentioned in weight, the moisture content is on ‘air dried’ basis.

Crops like Maize, Bajra, Gram, Arhar Jowar Mustard and Urad (local names of coarse grains and different types of lentils) contribute the major shares of residues in that order. While there are many other crops which generate agricultural residues, their share is negligible. These residues, as and when and wherever available, will have to be used in combination with the major residues in the area. Fig. 3 depicts the district-wise annual generation of waste agricultural biomass and surplus available (including Kharif and Rabi seasons) in the state.

![Fig. 3 Uttar Pradesh: Surplus Biomass and Power Generation Potential](image_url)
An assessment was also already carried out of the prevailing management system of waste agricultural biomass based on UNEP-IETC guidelines. This included an overview of crop residue management in some selected countries; problems and challenges of waste agricultural biomass to power generation; brief assessment of policies, laws and regulations; assessment of institutions working in the field of biomass based renewable energy; financing mechanisms available for converting waste agricultural biomass into energy and a review of various fiscal incentives for biomass based power generation.

### 3.3 Assessment of technology options and technology demonstration

An elaborate and generic assessment exercise was carried out. Initially, 18 technologies were listed. These were subjected to a screening analysis for which 5 generic screening criteria were identified. Each technology was assessed against these criteria. The results of screening analysis are shown in Table 8.

The screening analysis resulted in a shortlist of 7 technologies which were taken up for further analysis. A second round of screening analysis weeded out three more technologies. The remaining four technologies were:

1. Briquetting
2. Charring
3. Gasification – thermal mode
4. Gasification – electrical mode

These technologies were subjected to a detailed operational assessment. A set of Technical (10 criteria), Financial (8 criteria), Social (5 criteria) and Environmental (6 criteria) were identified. These are detailed in Appendix 1. The technologies were assessed against these criteria on a weight-score method. In a stakeholder consultation first the weightage for each of the 4 categories of criteria was decided. Each criteria was then assigned a weightage. A valuation plan was developed to assess each technology for each criteria. The marks obtained by each technology for each criteria was then multiplied by respective weightage to arrive at the final score as shown in Appendix 2. The result is depicted in star diagram in Fig. 4.

The overall score of each technology (also represented by the area within the curve of the respective technology) is given in Table 9.

As could be seen the gasification-thermal mode technology scored the highest rank. Accordingly, and also for other reasons, this technology was selected for implementation in the demonstration company.

In India, there are quite a few suppliers of technologies for converting waste agricultural biomass into

### Table 8 Screening Analysis of Technologies

| Technology                                      | Criteria for Screening   | (Selected / Not selected) |
|------------------------------------------------|--------------------------|---------------------------|
| Briquetting (Screw type machine)                | ✓ ✓ ✓ ✓ ✓                 | Selected                  |
| Small scale charcoal kiln                       | ✓ ✓ ✓ ✓ ✓                 | Selected                  |
| Paddy husk cook stove                          | ✓ ✓ ✓ ✓ ✓                 | Selected                  |
| Paddy husk gas stove                           | ✓ × ✓ ✓ ✓                 | Not selected              |
| Charring                                       | ✓ ✓ ✓ ✓ ✓                 | Selected                  |
| Paddy husk stove cum cabinet dryer             | × ✓ ✓ ✓ ✓                 | Not selected              |
| Paddy husk stove cum tray dryer                | × ✓ ✓ ✓ ✓                 | Not selected              |
| Direct combustion / direct heating             | ✓ × ✓ ✓ ✓                 | Not selected              |
| Boiler steam turbine                           | × ✓ ✓ ✓ ✓                 | Not selected              |
| Gasifier in electrical mode                    | ✓ ✓ ✓ ✓ ✓                 | Selected                  |
| Gasifier in thermal mode                       | ✓ ✓ ✓ ✓ ✓                 | Selected                  |
| Straw baler                                    | ✓ ✓ ✓ ✓ ✓                 | Selected                  |
| Press or extruder                               | × ✓ ✓ ✓ ✓                 | Not selected              |
| Paper pulping                                  | × ✓ ✓ ✓ ✓                 | Not selected              |
| Biogas digester – continuous type              | ✓ × ✓ ✓ ✓                 | Not selected              |
| Biogas digester with IC engine                 | × ✓ ✓ ✓ ✓                 | Not selected              |
| Composting                                     | ✓ × ✓ ✓ ✓                 | Not selected              |
| Densified TMR block making plant               | × ✓ ✓ ✓ ✓                 | Not selected              |

Note: ✓ indicates that the technology meets the criteria; × indicates that the technology does not meet the criteria.
energy. Hence there was no need to approach technology suppliers in other countries. Detailed technical specifications were developed to match the energy requirement of the demonstration company. These are given in Table 10.

The proposed system should be able to assure the following outputs for Gasifier and Gas Treatment unit as given in Table 11. The quotation given by the technology vendor was evaluated by the demonstration company as per their internal procedures and the contract was awarded.

The process plant has the following heat consuming equipment: i) the melting and refining furnace, ii) the oxidation furnace and iii) the reduction rotary kiln.

The heating needs of the various operations are as in the Table 12.

It was decided to introduce a gasifier system which can produce electricity in a dual fuel mode and also provide the needed thermal energy for the processes. This was planned to be a co-generation system.

Accordingly, it was decided that a 540 kW-th equivalent of gasifier system (with approximately 180 kg-

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Table 9 Overall score of four technologies under detailed operational assessment

| S.No | Technology     | Overall Score |
|------|---------------|--------------|
| 1    | Briquetting   | 228          |
| 2    | Charring      | 232          |
| 3    | Gasifier – Thermal mode | 240 |
| 4    | Gasifier – Electrical mode | 126 |

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Table 10 Technical specifications of the biomass Gasifier

- Ash storage and removal: Wet ash continuous discharge
- Start-up and operation: Through electrical blower and Ignition torch
- Fuel type and size: Briquetted Biomass 1" - 4"
- Permissible moisture content: 20% maximum
- Biomass charging: Online charging every one hour
- Typical conversion efficiency: 75% 
- Typical gas composition By volume: CO 19+3%, H2 18+2%, CO2 10+3%, CH4 up to 3%, N2 50%
- Cooling tower: Natural draft cooling tower Capacity 20 m3-N/h
- Power requirement for Gasifier: 15 kW
- Blower type: Centrifugal type
- Grate shaking mechanism: Rotating grate with 1.5 kW (2 HP) motor

Table 11 Performance guarantee parameters for the Gasifier

| Parameter                           | Guarantee Value |
|-------------------------------------|-----------------|
| Syn Gas Volumetric flow rate        | >425 m3-N/h     |
| Calorific value of Syn Gas          | >4.19 MJ/m3-N   |
| Thermal Efficiency                  | >75% for the Gasifier |
Table 12. Thermal energy requirement of various operations

| Heat requiring process | Operation       | Thermal energy requirement in Kcal/h | Diesel Oil Requirement in L/h * | Agro-waste requirement in kg/h ** |
|-----------------------|-----------------|---------------------------------------|---------------------------------|------------------------------------|
| A                     | Refining furnace| 100,000                               | 20                              | 80                                 |
| B                     | Refining furnace| 100,000                               | 20                              | 80                                 |
| C                     | Oxidation furnace| 50,000                                | 10                              | 40                                 |
| D                     | Reduction furnace| 175,000                               | 35                              | 140                                |
|                       |                 | 425,000                               | 85                              | 340 ***                            |

* Assuming 50% efficiency of the furnace

** Considering 4.40 MJ/m³-N gas (1,050Kcal/NM³gas) (1,000 - 1,100 kcals per kg-biomass) and considering that 1 kg of biomass gives 2.5 m³ of gas, thereby giving 10.5 MJ/kg-biomass (2,500 kcals/kg-biomass).

*** Through discussions, it was established that the plant would be needing heat energy only in any two of the processes at a given point of time. The combinations could be either A and B, or C and D

**** 1 kcal/h = 1.16 kW

As has been the experience in the past, the generator set could not be operated for longer durations and had to be very frequently stopped for cleaning the head and the manifolds. The DG Set was also getting heated even at 60% of electrical load. The company took the hard and painful decision of discontinuing with the power generation options, but decided to continue with the thermal energy generation route.

While waiting for the supply of an appropriate briquetting plant, the company started using waste woody biomass with shrubs trunks and plant stem bio products.

It may be noted that the smelting is a reduction process where oxygen in the feedstock is taken out by burning carbon in oxygen starved reducing atmosphere.

The company had been buying raw charcoal from the open market at an average price of Rs. 18,000 per ton. It was explained to the management that the char produced during the gasification process can be used for the purpose. In a typical biomass or wood chips based gasification, the production of the char is of the order of about 30% by weight of the biomass input. The company can generate about 40 t of the char annually (based on an average 80% capacity utilization), which would be equivalent of about Rs. 720,000 per year. This would emerge as an added bonus from the technology choice.

The demonstration company has a capacity for processing of 18 Gg-lead/year.

The consumption of diesel oil was estimated to be 20 L/h. For a total batch cycle time of 22 hours the diesel oil consumption works out to 440 L per batch of 18 t i.e. 440/18 = 24.44 L/t (lead processed). Thus annual requirement of diesel oil was calculated as 18,000 x 24.44 = 440,000 L/year

The economic benefits of the new technology were thus worked out. The company had invested a total of Rs. 3,936,000 (About US $ 80,000 @ Rs. 50 per USD at that time).
Under a renewable energy support scheme, the company will be receiving a subsidy of about Rs. 364,000 from the Ministry of New and Renewable Energy (MNRE) Government of India. The subsidy amount has not yet been received and hence has not been considered for any economics calculations.

3.4 Estimation of GHG emission reduction potential in selected industrial sectors/industries

In terms of the GHG, this results in reduction of about 1160 t-CO$_2$e. The estimations were made based on the reported figures of 3.15 kg-CO$_2$/ kg-diesel or 2.64 kg/L-diesel.

At the national level, it is estimated that total annual quantity of recycled lead is of the order of 85 Gg (85,000 t) and is expected to rise to 170 Gg by 2020. The projected GHG reduction at the national level from lead recycling industry will be of the order of about 9,000 t of CO$_2$e at current level and about 11,000 t of CO$_2$e by the year 2020.

3.5 Policy studies and development of a national strategy

The policies in India which could influence conversion of WAB into energy and were analysed as shown in Table 13.

Based on this analysis it was realized that appropriate amendments are needed or a new strategy has to be developed to enhance the use of waste agricultural biomass as a source of energy. The main drivers for formulating a conducive policy framework are as follows:

- GHG emission: Reduction in emission of greenhouse gases by substitution of equivalent amount of fossil fuels as waste agricultural biomass being a renewable form of energy is basically carbon-neutral.
- Energy security: With recent concerns over the reliability of petroleum oil supplies, the country needs to increase its energy security by enhancing domestic energy supplies.
- Environmental co-benefits: Enhancing conversion of waste agricultural biomass into energy will also help to achieve other environmental objectives, such as improving air quality (e.g. reducing smoke and particulates emission particularly short lived climate pollutants), and biodiversity conservation.
- Rural development: The increase in biomass feedstock offers the potential to expand market opportunities for agriculture, while providing a new opportunity to stimulate rural industrial development and employment.
- Economic development: At current market prices, the cost of energy produced from waste agricultural biomass is considerably lower than that from fossil fuels particularly oil and gas. Lower energy cost will have a cascading impact on cost competitiveness of goods and services.

Accordingly a national strategy was developed, which will be spurred by the above drivers and will also fill in the gaps in the existing policy framework. The salient features of the strategy are described in Appendix 3.

3.6 Sub-regional dissemination of results

After the project implementation a lot of lessons have been learnt and shared in the sub-regional dissemination workshop with other countries within the region. The key lessons learnt are highlighted below.

3.6.1 Lessons learnt

1) Awareness Raising and Capacity Building

Currently, there are no trainers available on the subject of converting waste agricultural biomass into energy. The project has led to development of good training materials. However, all the materials are in English language and difficult to be understood in countries where knowledge of English language is not that good. There is complete lack of awareness on potential of using waste agricultural biomass as a source of energy and on technologies for doing the same.

2) Assessment of waste agricultural biomass

There are few or no sources of reliable data on generation of waste agricultural biomass. Any assessment of waste agricultural biomass at national or local level requires first hand primary data collection. There are very few facilities/institutions to carry out detailed characterization of specific waste agricultural biomass.

3) Assessment of Technology Options and Technology Demonstration

### Table 13 Policies that could influence conversion of waste agricultural biomass into energy

| S. No. | Policy Analysed |
|--------|-----------------|
| 1.     | National action plan on climate change |
| 2.     | Renewable energy related policy development such as National biomass cook stoves programme; National biomass gasifier programme; Programmes for biomass based electric power; Programmes for biomass based energy in rural areas; Incentives for investing in renewable energy technologies etc. |
| 3.     | Policies by State governments |
| 4.     | Foreign investment policy |
There are few indigenous technology suppliers in developing countries. Even though some technologies, like gasifiers and briquetting have been developed by some local equipment manufacturers, in the absence of a good understanding of various aspects of technology (e.g. material of construction, process control, correct operating and maintenance practices) the local versions have had only limited success. Potential users do not have information about and access to technologies available abroad. The suppliers of technologies in general do not seem to see the business opportunities in the area of waste agricultural biomass to energy. Thus there is lack of interest in developing this area as a potential business area. Businesses having potential for using waste agricultural biomass as a source of energy, instead of fossil fuels, continue to base their technology decisions on economic factors only with environmental or social aspects playing little or no role. Only a few companies are willing to be demonstration companies for such projects.

4) Policy studies and development of a national strategy

There is no specific policy addressing waste agricultural biomass as a source of energy. However, there are linkages in many policies and strategies which could be used to promote greater use of waste agricultural biomass into energy. There is no policy support (subsidies, tax incentive, risk coverage etc.) for potential users of waste agricultural biomass as a source of energy. Thus new users are skeptical and avoid taking any risk.

3.6.2 Required steps

In order to utilize the enormous potential of converting waste agricultural biomass into energy in Asia, a number of forward looking steps will have to be undertaken. Some of the major steps required to be undertaken are discussed here:

1) Awareness Raising and Capacity Building

There is a need to develop a cadre of trainers who can build capacity in provinces without depending on foreign trainers so that capacity building is not only less expensive but is also more sustainable. Local trainers will also be able to provide inputs which are more relevant to local conditions.

Training materials need to be developed in local language and the capacity building in different countries should be carried out in local language. This is particularly important in India where there are 14 different official languages used in different parts of the country.

Concerted efforts need to be mounted to raise awareness on the potential of using waste agricultural biomass as a source of energy as the waste generators and possible waste users are largely unaware of the potential as well as economic and environmental benefits. Conducting awareness raising programmes, use of media, preparation and distribution of awareness raising materials could all be part of this effort.

The major recommendations from the participants of the sub-regional dissemination workshop were: capacity building should be targeted and need based, virtual platforms (like Global Partnership on waste management) for knowledge sharing of best practices and network of experts should be established, regionally applicable guidelines on different aspects of WAB to energy conversion need to be developed, financial mechanisms for funding WAB to energy projects need to be established, and policy briefs for policy makers need to be prepared.

2) Assessment of waste agricultural biomass

A reliable data-base on generation of waste agricultural biomass, availability of surplus biomass, possible areas of application, characteristics of specific biomass etc. is needed. The data-base should also be updated regularly. Currently, this information is at best available on a piece-meal basis which precludes development of a comprehensive plan for using surplus waste agricultural biomass as a source of energy.

Facilities/institutions need to be developed to carry out detailed characterization of specific waste agricultural biomass. Presently, there is lack of institutional capacity to carry out this work.

3) Technologies for converting waste agricultural biomass into energy

The capacity of local technology suppliers and equipment manufacturers need to be improved. Currently available local technologies are rather inefficient and have low reliability. For example, the electricity consumption in briquetting machines is more than double that of cutting edge technologies in Japan. Similarly, the gasifiers need to be stopped after about 100 hours of operation for cleaning and maintenance and then restarted. A technology transfer process could be put in place wherein proven and reliable technologies from abroad are transferred with know-how and process details so as to enhance indigenous availability of reliable technology.

Indigenous research and development could be promoted to develop low cost and locally suitable technologies. This will spur local technology business and usher in a mechanism for continuous improvement.

A compendium of technologies available abroad could be prepared and made available to potential users. Currently, there is lack of availability of a source for comprehensive information on technologies. Availability of such information will facilitate business development
between the local and foreign technology suppliers.

The technology suppliers should be collected and involved to create business opportunity in the country in the area of waste agricultural biomass to energy. With only limited business opportunities there is fierce and often unhealthy competition between the technology suppliers. A group effort to develop business opportunities will be helpful to all.

Technology assessment methodologies (such as UNEP’s Sustainability Assessment of Technologies) should be widely promoted. It may be considered to make it mandatory to use such methodologies for government or institutional technology procurement decision making. This will help to overcome the mistakes made by selecting technologies based only on economic considerations.

4) Policy framework

National level policy directives are very important for developing a new area of intervention. Such directives draw the attention of all stakeholders and enable them to get engaged in a concerted manner. Accordingly, a national strategy for converting waste agricultural biomass into energy needs to be developed. The draft strategy prepared under the project may be taken up by the concerned government authorities, suitably amended and adopted at the national level. Subsequently, provincial level strategies should also be developed and implemented.

The national strategy should make provision for incentives to promote the use of waste agricultural biomass as a source of energy to give the required push.

The Project Country (India) could take the lead in this work in the sub-region and get such a strategy adopted at the sub-regional (SAARC) level as it is the largest economy in the region and should provide guidance and support to other countries.

4. Conclusion

The project has revealed that the first requirement for enhancing conversion of surplus waste agricultural biomass is to carry out a detailed assessment of quantity and characteristics of waste agricultural biomass generated in different regions of a country along with current management practices which will reveal the potential of using it as a source of energy. The technologies for converting waste agricultural biomass into energy are well developed. However, a careful assessment of different technology options needs to be carried out to enable a more informed decision-making on technology selection for the given application. Issues such as voluminous nature of waste agricultural biomass thus leading to large transportation costs, dispersed availability resulting in problems in collection and lack of policy directives have limited the use of waste agricultural biomass as a source of energy. The study revealed that a conducive policy framework, enhanced awareness-raising and capacity building and increased availability of information will lead to a greater exploitation of this energy source. This will have multiple benefits; an additional source of income to farmers, increased business and consequently increased job opportunities, enhanced availability of a cheaper source of energy leading to economic gains, reduced dependency of fossil fuels and above all huge environmental benefits in terms of climate mitigation.

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Appendix 1 Criteria for detailed operational analysis

As per stakeholder consultations, a total of 30 criteria under four broad categories, viz: 11 Technical, 8 Financial, 5 Social and 6 Environmental criteria were identified as shown in Table 14.

Appendix 2 Score of different technologies for each assessment criteria

Table 15 provides the scores obtained by each of the technologies for the 30 criteria under the Technical, Financial, Social and Environmental categories.
Table 14 Criteria Selected for Detailed Operational Analysis

| Category | Criterion                                                                 | Notation |
|----------|---------------------------------------------------------------------------|----------|
| Technical| Suitability to characteristics of available WAB                           | TC1      |
|          | Adequate Availability of applicable WAB                                   | TC2      |
|          | Compliance with prevailing local environmental laws, regulations and standards | TC3      |
|          | Adaptability of technologies                                             | TC4      |
|          | Use of local skills and scope for local capacity building for operation and maintenance | TC5      |
|          | Use of local material and skills for fabrication and operation            | TC6      |
|          | Ease in availability of technical assistance during commissioning and operation | TC7      |
|          | Proven technology, existing working units                                 | TC8      |
|          | Adaptability - Ability to fit into local conditions                      | TC9      |
|          | Adaptability to future scaling up or expansion options                    | TC10     |
|          | Ease of replication                                                       | TC11     |
| Financial| Capital investment                                                        | FC1      |
|          | Operational and maintenance costs                                         | FC2      |
|          | Simple Payback period                                                     | FC3      |
|          | Value addition to WAB                                                    | FC4      |
|          | Techno economic evaluation                                                | FC5      |
|          | Easy availability of finance                                              | FC6      |
|          | Multifold benefits                                                        | FC7      |
|          | Import needs of spares                                                    | FC8      |
| Social   | Potential for Job creation                                                | SC1      |
|          | Compatibility with local culture                                          | SC2      |
|          | Improvement in quality of life by use of this technology                  | SC3      |
|          | Safety and health hazards                                                 | SC4      |
|          | Improvement of local technical skills and knowledge base                  | SC5      |
| Environmental| Additional support services / utilities (water / energy)                   | EC1      |
|          | Environmental emissions                                                   | EC2      |
|          | Noise, vibration and odour                                                | EC3      |
|          | Space and infrastructure requirement                                      | EC4      |
|          | Contribution to WAB management                                            | EC5      |
|          | Net carbon emissions                                                      | EC6      |

Appendix 3 National strategy for enhancing conversion of waste agricultural biomass into energy in India

The estimated potential in the country to generate power from wind, small hydro and biomass is around 80,000 MW. Electricity generation from these sources is becoming increasingly competitive with some preferential treatment being meted out to them. The Government of India’s aim is that 10 percent of the additional grid interactive power generation capacity should come from renewable sources during the 10th & 11th Plan periods. The challenge is to mainstream renewable based power generation in terms of reliability, quality and cost. This can be met to a large extent by addressing issues pertaining to the need to lower the cost of equipment, increase its reliability and set up projects in areas which give the maximum advantage in terms of capacity utilization. Keeping in view the large potential of waste agricultural biomass as a source of energy, the following vision is proposed.

I Vision

Utilize at least 50% of waste agricultural biomass as a source of energy by 2025 and at least 70% by 2030 by building requisite infrastructure and development of human resources.

II Objectives

The strategy is based on the following objectives:

a. Establishment of efficient collection and transportation system for waste agricultural biomass, from the point of generation to the point of application
b. Development, promotion and wide-scale implementation of technologies to either convert waste agricultural biomass directly into energy (such rice-husk or bagasse fired boilers) or convert it into more easily usable fuel (such as briquetting or pelletising to make solid fuel, pyrolysis for making char, thermal gasification and anaerobic digestion to make gaseous fuels).

c. Price equalisation, fiscal incentives and financial subsidies to create greater business interest in waste agricultural biomass to energy projects.
d. Raising awareness among all energy and fuel users to
Table 15  Score of different technologies

| Sl. No. | Criteria | Briquetting | Charring | Gasification (Thermal Mode) | Gasification (Electrical Mode) |
|---------|----------|-------------|----------|----------------------------|-------------------------------|
| 1       | TC1      | 6           | 9        | 8                          | 3                            |
| 2       | TC2      | 9           | 8        | 8                          | 4                            |
| 3       | TC3      | 10          | 9        | 7                          | 5                            |
| 4       | TC4      | 8           | 7        | 8                          | 5                            |
| 5       | TC5      | 10          | 9        | 8                          | 4                            |
| 6       | TC6      | 9           | 8        | 5                          | 5                            |
| 7       | TC7      | 10          | 9        | 10                         | 4                            |
| 8       | TC8      | 6           | 10       | 8                          | 7                            |
| 9       | TC9      | 9           | 9        | 8                          | 5                            |
| 10      | TC10     | 7           | 8        | 9                          | 4                            |
| 11      | TC11     | 9           | 6        | 9                          | 5                            |
| 12      | FC1      | 5           | 8        | 8                          | 5                            |
| 13      | FC2      | 4           | 6        | 5                          | 5                            |
| 14      | FC3      | 7           | 8        | 8                          | 3                            |
| 15      | FC4      | 9           | 5        | 8                          | 4                            |
| 16      | FC5      | 7           | 9        | 8                          | 4                            |
| 17      | FC6      | 9           | 7        | 8                          | 3                            |
| 18      | FC7      | 7           | 5        | 9                          | 5                            |
| 19      | FC8      | 5           | 7        | 8                          | 4                            |
| 20      | SC1      | 8           | 8        | 9                          | 2                            |
| 21      | SC2      | 5           | 7        | 8                          | 3                            |
| 22      | SC3      | 7           | 9        | 8                          | 4                            |
| 23      | SC4      | 9           | 7        | 8                          | 5                            |
| 24      | SC5      | 8           | 6        | 9                          | 3                            |
| 25      | EC1      | 9           | 9        | 7                          | 4                            |
| 26      | EC2      | 7           | 8        | 8                          | 5                            |
| 27      | EC3      | 5           | 9        | 7                          | 4                            |
| 28      | EC4      | 9           | 7        | 8                          | 5                            |
| 29      | EC5      | 6           | 8        | 9                          | 3                            |
| 30      | EC6      | 9           | 7        | 9                          | 5                            |

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switch over from fossil fuels to fuels derived from waste agricultural biomass.
e. Building capacity to support increased application of waste agricultural biomass as a source of energy and carry out research and development of technologies tailor-made to suit socio-economic conditions of India.

III Targets

By 2035, energy generation from waste agricultural biomass reaches 35,000 MW (9 percent of the additional grid interactive power generation capacity). At this level waste agricultural biomass will replace 80 Tg of coal and avoid 40 Tg of GHG emissions annually.

V Scope and Timing

The strategy covers the entire Republic of India and includes all types of waste agricultural biomass as illustrated earlier. The period of strategy implementation is 2014-2035.

VI Relation to other strategies

The strategy complements and supports the renewable energy policy. It is in support of major ongoing programmes of Ministry of New and Renewable energy such as; biomass cook-stoves programme, biomass based electric power generation, and biomass based energy in rural areas. It also supports the climate change related policy (National Action Plan on Climate Change – target of GHG emission mitigation of 98 Tg per year).

VII Specific elements of the strategy

The strategy is built around following key elements, which when implemented will enable the objectives to be met.

VII.1 Comprehensive data base on availability of waste agricultural biomass

There is lack of authentic and readily usable data on availability of crop residues and waste agricultural biomass, agro industrial by-products and coarse cereal grains. There is a need to build an actual database, on surplus agricultural, forestry and other similar bio wastes, to be used for more effective and realistic planning of generation of energy.
Particularly in case relatively large scale projects such as power projects the price of biomass increases very fast after the commissioning of the project. The government should, therefore, implement a biomass tariff policy with provisions for periodic revisions.

Transportation cost constitutes a significant portion of the costs associated with the establishment and running of biomass power plants. There is need of processing in form of shredding the biomass onsite before transportation to increase its density when procurement is done from more than a particular distance. Transportation of waste agricultural biomass of any kind and in any form becomes unviable over distances of 50 Km. European power plants are importing their biomass in form of pellets and briquettes from other countries to meet the requirement of the huge bio-power plants.

To ensure that the benefits of such technology development are transferred to the farmers, and providing them a competitive cost of the agricultural waste, local entrepreneurs should be motivated to take up the responsibility of supplying biomass to pre-processing facilities. Collection centres covering a group of villages can be set up to facilitate decentralization of biomass pre-processing and supply mechanism.

Another area which indirectly affects the pricing of waste agricultural biomass is the subsidies being given to fossil fuels. In India, the substitute commercial fuel for biomass in the domestic cooking sector is kerosene. In commercial energy market, the biomass competes with kerosene in domestic use and with diesel in irrigation pumping and rural electricity generation. Both diesel and kerosene enjoy substantial subsidy as these are considered to be the fuels for meeting the needs of poor strata of society. The implicit price of biomass on the market is equivalent to replacement price of kerosene and diesel. With subsidies under-pricing kerosene and diesel, the energy producers from biomass are unable to fetch economic prices in commercial energy markets.

VII.5 Fiscal Incentives

Some fiscal incentives for the biomass power generation projects have already been provided. These include accelerated depreciation, income tax holiday, customs/excise duty exemption, exemption from central and state sales taxes etc. These should be continued. Additionally, exempting the biomass power plants from payment of electricity duty will help in accelerating the growth of this sector.

Equally important is the shift of the emphasis of the MNES from direct financial subsidy and demonstration projects to relying more on fiscal subsidies which usually
encourage serious renewable energy developers and users. The provision of soft loans will leverage private-sector investment, and increase the funds available with IREDA. Though financial subsidies will have to be continued to be provided for some more time, these should be phased out fairly rapidly as the fiscal incentives being strengthened.

VII.6 Financial subsidies

The rationale for financial subsidies in this field should be based on the scope, potential and impact on:
- Reducing greenhouse gas emissions;
- Making energy available to every nook and corner of the country;
- Environmental co-benefits like biodiversity, natural resource conservation; and
- Supporting or strengthening of various socio-economic initiatives, such as rural income generation and rural employment creation.

Financial subsidies may also be required to promote technological innovation and reducing technology costs. However, such incentives should be given only to the first few and original developers of a specific concept and process. It is because an analysis of the past trend in India has revealed that there is a mad rush by unscrupulous players who are just interested in the incentive. The ventures undertaken by such players have often failed.

The financial subsidy schemes (and also the fiscal incentives) should be so designed so that it facilitates a balance between creating demand for energy from waste agricultural biomass and feedstock supply. The schemes should specifically target areas where fossil fuels are favoured because of the corresponding subsidies. It should be ensured that the technologies used conform to appropriate international standards, and that there are codes of best practice in place to ensure that carbon savings are delivered and wider environmental benefits are maximized. Clear lines of communication should be established between technology and feedstock suppliers, processors and potential users, and also across relevant government agencies responsible for the bio-economy, especially agriculture, environment, energy, industry, science and technology.

The transportation costs are the primary reason for not using all of the available biomass which is spread across the country, mainly on economic and cost grounds. Financial subsidies to promote the application and use of compaction and other pre-processing technologies for waste agricultural biomass can be provided under specific incentive schemes.

Such financial incentive measures will help close the gap between production costs and market prices for biomass products relative to those based on fossil fuels. The policies should aim at focused maximization of environmental benefits, encourage innovation and reduce technology costs in the utilization of biomass for energy.

VII.7 Awareness raising

The rate of development of agricultural biomass and related bio products, are also considered to be influenced by institutional infrastructures and public education. Developing a sound institutional infrastructure for the biomass industry can act as an engine of growth, particularly if the institutional links are developed both horizontally and vertically in the industry. Raising public awareness of the benefits of biomass, particularly for the local communities where production and processing capacity might be developed, is also viewed as an important prerequisite to engage local communities in trying to achieve the success of these projects. Such a step would also help in decelerating the exodus of rural population to larger towns and cities.

VII.8 Capacity building

There is an acute shortage of trained manpower in the field of converting waste agricultural biomass to energy. Intensive capacity building is required in all areas ranging from assessment and characterization of waste agricultural biomass to design and implementation of technologies.

There are a number of institutions which develop and deliver such capacity building programmes. For example, The National Small Industries Corporation (NSIC), under the Ministry of Industry and Commerce, provides assistance through a number of schemes, which include financial and marketing services, technical services and training, etc. Specifically NSIC arranges training in technical trades, both traditional and high-tech.

Capacity building materials that need to be developed should include: compilation of best practices and guidelines for replication, assessment tools such as Life-Cycle Analysis (LCA) and Sustainability Assessment of Technologies (SAT).

Capacity building schemes should also take in to account the potential for productive deployment of various provisions under other governmental institutions like the Mahatma Gandhi National Rural Employment Guarantee Act (NREGA), many other rural employment schemes, provisions under the Ministry of Rural Development, the Industrial Training Institutes (ITIs), The National Small Industries Corporation (NSIC) etc.

Such an approach will help serve some major objectives of possible employment shortage of semi-skilled workers by training the rural youth and providing them with bio energy specific technical knowhow.

Indirect programmes like awareness-raising activities such as seminars and business meets, technical support
like making available services of international experts and organizing interaction meetings among the stakeholders like state governments, utilities, financial institutions, manufacturers, consultants and project parties should also be promoted.

In summation, what is needed in India is a shift in perspective of biomass energy strategies in the following respects:

i) Treating biomass as a competitive modern energy resource rather than a traditional, inefficient unclean and non-commercial "poor man's fuel".

ii) Enlarging biomass energy applications beyond decentralized niche markets to competitive energy service markets, and,

iii) Reorienting the technology policy from supply push to demand (market) pull approach,

iv) Integrating biomass energy policies with developmental and environmental policies.

VIII. Implementation and delivery mechanism

An implementation mechanism was proposed to achieve the objectives of the strategy through addressing the various elements.

IX. Conclusion

Energy generation from waste agricultural biomass in India is a must for sustainable development and meeting the national plan targets.

Investments in renewable energy sector will be sluggish in the short term globally, including in India. The global investments in renewable energy sector are likely to continue to decline in the short term. Very much like the global trend, there is a short-term setback in renewable energy investments in India, assigned to lack of implementation of Renewable Energy Purchase Obligation (RPO) by the distribution utilities and designated consumers.

However, the scope and potential for global renewable energy industry seem to be attractive in the future times to come, as technology improves and costs decline. About 118 countries have renewable energy targets in place and the demand for clean energy is also on the rise. Undoubtedly, waste agricultural biomass will play a very important role in coming years on the renewable energy scene in India.