

Biomass Gasification Based Power Production in India

A Sample of the Market Intelligence Report from EAI

*This e-book provides representative sample content to assist in evaluating the Biomass
Gasification Based Power Production Report*

Preface

Biomass gasification, with its capability to work in kW scales (as low as 20 kW) and its ability to utilize a wide and diverse range of biomass feedstock (including agriculture and crop waste) is ideally suited for the power needs of many segments, especially those in rural areas without access to power but with easy access to significant amount of cheap (and many times no cost) biomass.

EAI predicts that biomass gasification based power production in India could grow from about 80 MW currently to over 500 MW by 2015.

This is a preview of the report “Biomass Gasification Based Power Production in India”. This report has been developed to assist entrepreneurs, businesses and companies keen on exploring this important avenue of renewable power generation.

This is one of the most comprehensive and detailed reports on the subject, and was last updated in April 2011.

The report has been prepared by Energy Alternatives India (EAI), a leader in business intelligence and market research for the Indian renewable energy and cleantech industries.

Key Takeaways from This Report

- With over 60,000 villages not connected to the grid, distributed renewable power sources is the need of the hour for India; among the renewable power sources, biomass could play an important role owing to its easy availability in rural areas, and biomass gasification an even more important role owing to its ability to operate at very low scales.
- Among the biomass power production routes, combustion and gasification are the two primary routes being used today. Biogas gasification works well for small scale power production, upto a maximum capacity of 2 MW. Combustion, on the other hand, works well at MW scales.
- The gasifier is the key component in a biomass gasification system. There are two main categories of gasifiers – fixed bed and fluidized bed. Within fixed bed, there are two types – updraft and downdraft gasifiers. The most common gasifier used in India is the downdraft gasifier, which is more suited than others for biomass gasification.
- A wide variety of feedstock can be used in biomass gasifiers, and India is endowed with significant quantities of these feedstocks.
- The key market segments in India for biomass gasification are the small/medium industries, commercial sector and rural communities. Currently, biomass gasification is used by some entities in each of these segments, though the scale of gasifiers and the biomass feedstock used by each, differ.
- One of the critical bottlenecks faced by biomass gasification power plants is the uninterrupted supply of biomass at low prices. This supply chain aspect is by far the most critical determinant of success. As a result, a number of power producers are resorting to long term contracts, choosing the optimal location and sizes for their power plants based on local availability, or are opting for dedicated energy crops for captive consumption and to overcome supply uncertainty.

Key Takeaways from This Report

- The capital cost per MW for a biomass gasification plant is about Rs 5.5 crores, while the operational expenses (excluding the cost of biomass) are about 0.75 Rs per kWh. The levelized cost of power from biomass gasification will be in the range of Rs 2.25-4/kWh, depending mainly on the cost of the biomass.
- Under optimal conditions, biomass gasification based power production presents a good business opportunity with attractive IRRs (over 25%) and payback periods (fewer than 3 years).
- The special feed in tariffs for biomass based power varies from state to state – from Rs 3.5 per kWh to about Rs 5 per kWh. Biomass gasification power production can also avail capital subsidies and other government incentives such as based accelerated depreciation.
- The three main governmental bodies in the context of renewable energy funding are IREDA, Power Finance Corporation and Rural Electrification Corporation. A number of commercial banks, venture capital and private equity firms have also started taking an interest in financing renewable energy projects, and some biomass gasification power plants have already been funded by venture capital firms.

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Indian Power Scenario and the Need for Biomass Power

This chapter focuses on the Indian power production scenario, and provides a summary of the potential and benefits of biomass based power in India.

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- 1.3 Non-renewable and Renewable Power Generation
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Highlights from the Chapter

- India's fast growing economy requires that the country relies not just fossil fuel resources, but also on renewable sources of power.
- With over 60,000 villages not connected to the grid, use of distributed renewable power sources is the need of the hour for India.
- India has already achieved some success in renewable power, having made considerable progress in wind and having started off well in small hydro and biomass.
- Biomass-based power presents a number of benefits that will solve some critical pain points being faced by the country today.

Sample Content

Biomass Power in India – Now and Future

Biomass Power in India – Now and Future

Parameter	Now (2010)	Future (2020)
Distributed electricity generation	Biomass has a minor contribution	Biomass will be a major contributor
Use in co-firing in power plants	Fewer than 1% of large power plants use biomass	A much larger % of utility power will be from biomass
Use of feedstock	Primarily waste biomass and assorted	Dedicated energy crops
Related revenue streams	Some additional revenue streams already present	A more established end user market for co-products such as charcoal/biochar/activated carbon
Standalone renewable electricity source?	Primarily standalone mode	Will be used in conjunction with other renewable electricity sources

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Biomass-based Power Production Technologies

This chapter provides detailed inputs on the various routes for power production from biomass, which are combustion, gasification, anaerobic digestion and pyrolysis.

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2.2 Primary Routes for Power from Biomass

2.2.1 Combustion

2.2.2 Gasification

2.2.3 Anaerobic Digestion

2.2.4 Pyrolysis

2.3 Comparative analysis of biomass power generating technologies

Highlights from the Chapter

- There are four routes for biomass based power – combustion, gasification, anaerobic digestion and pyrolysis - with the first three already being applied for power production in the country.
- Biogas gasification works well for small scale power production, upto a maximum capacity of 2 MW. Combustion, on the other hand, works well at MW scales. Anaerobic digestion can work well for both small and medium scales while pyrolysis can work well in the range of 2-30 MW.
- All the four routes mentioned have their own unique characteristics and will provide more benefits than other under specific circumstances.

Sample Content

Primary Routes for Power from Biomass

The three primary routes for biomass to power are: Combustion, Gasification and Anaerobic Digestion.

- **Combustion** is easy to understand – instead of using coal or other fossil fuel, use biomass to produce steam that runs a turbine. Combustion of biomass for power could either be in the form of co-firing (when it is burned along with coal) or pure play biomass based combustion.
- In the case of **gasification**, the biomass is first gasified and this gas turn produces power in a gas engine.
- **Anaerobic digestion** is usually applied to biomass that typically have a high amount of water in them (anaerobic digestion is most used for treating organic waste such as kitchen waste and sewage waste into energy). Under this route, microorganisms act upon the organic matter present in the biomass under anaerobic (absence of air) and convert it into biogas.
- An emerging route for biomass based power is **pyrolysis**. In this, the biomass is rapidly heated to 450 - 600 °C in absence of air, and results in a bio-oil called the pyrolysis oil, which can in turn be used for firing the boilers. Typically, 50 - 75 % (by weight) of the feedstock is converted into pyrolysis oil.

Summary of Suitable Biomass for Anaerobic Digestion

Agricultural Origin

- Livestock manure
- Agricultural residues
- Animal mortalities
- Energy crops

Municipal Origin

- Sewage sludge
- Municipal solid waste
- Food residuals

Industrial Origin

- Wastewater
- Industrial sludge
- Industrial by-products
- Slaughterhouse waste
- Spent beverages
- Biosolids

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Biomass Gasification Technology

This chapter discusses the environmental and economic benefits from biomass gasification, types of gasifiers, and provides a comparative study of available gasification technologies.

- 3.1 Introduction
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- 3.3 Components of a Biomass Gasification System for Power Production
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Highlights from the Chapter

- Biomass gasification based power production provides significant environmental and economic benefits.
- The main components of a biomass gasification system are the gasifier and the gas engine.
- There are two main categories of gasifiers – fixed bed and fluidized bed. Within fixed bed, there are two types – updraft and downdraft gasifiers.
- The most common gasifier used in India is the downdraft gasifier, which is more suited than others for biomass gasification.

Sample Content

Efficiency of Different Technologies of Gasification

Characteristics	Fixed bed		Fluidized bed	
	Updraft	Downdraft	Bubbling	Circulating
Carbon conversion	****	****	**	****
Thermal efficiency	*****	****	***	****
CGE	*****	***	***	****
Turndown ratio	***	**	****	****
Start-up facility	*	*	***	***
Management facility	****	****	**	**
Control facility	**	**	****	****
Scale-up potential	***	*	***	*****
Sized feed elasticity	****	*	**	**
Moisture feed elasticity	****	**	***	***
Ash feed elasticity	*	*	****	****
Fluffy feed elasticity	****	**	*	***
Sintering safety	*	*	***	*****
Mixing	*	*	****	*****
Cost safety	*****	****	**	**
Tar content	*	*****	**	***
Particulate content	*****	***	***	**
LHV	*	*	*	**

Please Note: *Poor, **Fair, ***Good, ****Very good, *****Excellent.

Source: Modified data by Juniper, 2000; Bridgwater, 1994 a

Gasifier Systems and Gasifier Fuels

Biomass fuel	Gasifier type	Capacity	Application
Wood blocks	Fixed-bed/down-draft	<500 kWel	Electricity / shaft power
Charcoal	Fixed-bed/down-draft	< 50 kWel	Electricity / shaft power
Rice husks	Fixed-bed/down-draft (also called Fixed-bed / open-core)	< 200 kWel	Electricity / shaft power
Coconut shells	Fixed-bed/down-draft	< 500 kWel	Electricity / shaft power
Wood / charcoal / coconut shells	Fixed-bed/cross-draft	< 5 MWth	Electricity / shaft power

Note: kWel = kilowatt electric; MWel = megawatt electric.

(Source: World Bank Technical Paper No. 296- Energy Series)

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Indian Biomass Gasification Scenario

This chapter discusses the different types of feedstock for biomass gasification, and the key market segments in India for biomass gasification. It also provides case studies and a list of suppliers and consultants.

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Highlights from the Chapter

- India has a wide variety of crop and agricultural biomass that will suit as feedstock for biomass gasification
- The key market segments in India for biomass gasification are the small and medium industries, commercial sector and rural communities
- India already has a considerable number of biomass gasification plants in operation, at different scales and using diverse biomass.

Sample Content

Current Status of Biomass Gasification in India

Size (Capacity) Distribution for Gasification and Combustion Technologies

	Combustion	Gasification
Size		
Small (10 kW – 25kW)	Not prevalent	Prevalent
Small-medium (25kW – 250kW)	Not prevalent	Prevalent
Medium (250 kW – 2 MW)	Not prevalent	Prevalent
Large (2 MW and above)	Prevalent	Not prevalent

Chapter - 5

Costs and Economics of Biomass Gasification based Power

While biomass gasification based power production provides a number of benefits, especially to remote electricity needs, it is imperative that it is economically sustainable to operate. The primary cost components of a biomass gasification system comprises feedstock cost, capital costs (gasifier + gas engine + supporting equipments + land + installation) and operating expenses (including maintenance and repairs).

This chapter discusses the costs of biomass gasification based power production and the cash flow projections including the operational parameters and revenues from the plant.

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5.2 Cost of Power Production from Renewable Energy Sources

5.3 Costs of Biomass Gasification Based Power Production

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5.3.3 Costs of Feedstock

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5.3.6 Levelized Cost of Electricity (LCOE)

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Highlights from the Chapter

- The key cost component in biomass gasification based power production is the cost of the biomass, which can have significant impact on the economic attractiveness of the operations
- Per MW, the total capital cost for a biomass gasification plant will be about Rs 5.5 crores
- The operational expenses (excluding cost of biomass) for a biomass gasification power plant will be about Rs 0.75 per kWh
- The levelized cost of power from biomass gasification will be in the range of Rs 2.25-4/kWh, depending mainly on the cost of the biomass.
- Under optimal conditions, biomass gasification based power production presents a good business opportunity with attractive IRRs and payback periods.

Sample Content

Levelized Cost of Electricity (Lcoe) from Primary Renewable Power Sources

Let's consider the approximate costs of electricity generation from various sources today (in Rs/kWh)

Energy Source	Levelized cost of electricity production* (Rs/kWh)
Coal / natural gas	2.5
Wind	2.25-3.0
Biomass gasification	2.25-3.25
Diesel generator sets	12-13
Solar PV	11-12
Solar CSP	10-11

*: Levelized cost denotes the total cost, after taking into account all direct and indirect variable expenses such as insurance, and depreciation of capital costs. All investments assume a 70:30 debt:equity split.

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Indian Biomass Gasification Scenario

This chapter highlights the feed in tariffs, capital subsidies and the government incentives for biomass gasification and power projects in general.

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6.3 Capital Subsidies and Incentives

6.4 Government incentives for biomass power projects in general (national level and state level)

6.5 Depreciation Benefits

Highlights from the Chapter

- Many states in India have prescribed special feed in tariffs for biomass based power, though the tariff varies from state to state – from Rs 3.5 per kWh to about Rs 5 per kWh.
- Biomass gasification power production can also avail capital subsidies and other government incentives such as accelerated depreciation.

Sample Content

Depreciation Benefits

Biomass gasification based power plants can also avail of accelerated depreciation benefits, details of the same are provided below.

Item	Description
Accelerated Depreciation	IREDA says 100 % depreciation in the first year can be claimed for the following power generation equipment 1. Fluidized Bed Boilers 2. Back pressure, pass-out, controlled extraction, extraction and condensing turbine for Power generation with boilers 3. High efficiency boilers 4. Waste heat recovery equipment MNRE says 80% depreciation in the first year can be claimed for the following equipment required 1. Back pressure, pass-out, controlled extraction, extraction–cum–condensing turbine for co-generation with pressure boilers 2. Vapour absorption refrigeration systems 3. Organic rankine cycle power systems 4. Low inlet pressures small steam turbines
Income Tax Holiday	Ten years tax holidays.
Customs and Excise Duty	Concessional customs and excise duty exemption for machinery and components for initial setting up of projects.
General Sales Tax	Exemption is available in certain States

Source: <http://www.mnre.gov.in/>

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Availability of Finance for Renewable Energy Investments

This chapter categorizes the sources of finance for biomass gasification based power projects. It also provides VC / PE perspectives and opinions, and prominent investments in Indian renewable energy and clean technology.

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7.2.1 Project Finance

7.2.2 Asset Finance

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7.6 VC / PE Perspectives and Opinions

7.6.1 VC Perspectives

7.6.2 PE Perspectives

7.7 Prominent Investments in Indian Renewable Energy and Clean Technology

7.7.1 Cleantech Funds and Their Investments in India

Highlights from the Chapter

- The main financing routes for new renewable energy projects in India are project finance, asset finance, corporate finance and venture capital/private equity.
- The three main governmental bodies in the context of renewable energy funding are IREDA, Power Finance Corporation and Rural Electrification Corporation
- A number of commercial banks, venture capital and private equity firms have also started taking an interest in financing renewable energy projects, with some of them already having funded biomass based power plants, including that using biomass gasification.

Sample Content

Project Finance

Project Debt Financing for Renewable Energy – Highlights

Parameter	Value
Debt: Equity	70:30
Loan Tenure	6-8 years (including 1 year moratorium)
Interest	11-11.5%

Note: All details provided are only indicative in nature;

List of Private Equity firms in India active in the Renewable Energy Sector

Private Equity	Funded Companies
3i Group (http://www.3i.com)	GVK Power and Infrastructure
ADB (http://www.adb.org)	- CLP WIND FARMS PRIVATE LIMITED (CWFPL) - GUJARAT PAGUTHAN WIND ENERGY - A total of \$7540m was invested in the energy sector (that is about

	33% of the total funding) by ADB
Blackstone (http://www.blackstone.com)	• Moser Baer (solar Energy)
Barings India Private limited (http://www.bpepindia.com)	• Auro Mira (biomass Energy)
Chrys Capital (http://www.chryscapital.com)	• Pratibha Industries Ltd.(Water treatment company)
Green Environment Fund (http://www.globalenvironmentfund.com)	• Greenko Group (Biomass, Hydro, Wind etc)
Shell Foundation (http://www.shellfoundation.org)	• Husk Power systems (Biomass based power generation)
IFC (www.ifc.org)	
DEG	

Other Financial Institutions that Fund Renewable Energy Projects in India

Commercial banks and financial institutions actively involved in RE financing are given below. While there are no specific mandates for banks, organizations such as IREDA provide soft loans for renewable energy projects through certain designated banks.

ADB	http://www.adb.org
DEG	http://www.deginvest.de
DBS	http://www.dbs.com
ICICI Bank	http://www.icicibank.com
IDFC	http://www.idfc.com
IFC	http://www.ifc.org
IL&FS	http://www.ilfsindia.com
IREDA	http://www.ireda.in
PFC	http://www.pfc.gov.in
Proparco	http://www.proparco.fr
Rabobank	http://www.rabobank.com
SBI	http://www.statebankofindia.com
SBI Caps	http://www.sbics.com
UCO Bank	http://www.ucobank.com/
Yes Bank	http://www.yesbank.in

Chapter - 8

India's Regulatory Framework for Renewables

This chapter familiarizes potential investors and developers with the Indian government's regulatory framework for the renewable energy industry and provides an overview of the government bodies that handle the regulatory framework.

8.1 Introduction

8.2 Regulatory Policy Framework

8.3 Regulatory Bodies

Highlights from the Chapter

- Some of the instruments being used by India's regulatory authorities to accelerate the adoption of renewable sources for power are: Renewable Purchase Obligations (RPO), Renewable Energy Certificates (REC), Renewable Portfolio Standards (RPS) and CDM (Clean Development Mechanism).
- The key regulatory bodies in the context of renewable power are Ministry of Power(MOP), Central Electricity Authority (CEA), Ministry of New and Renewable Energy (MNRE), State Nodal Agencies (SNA), Central Electricity Regulatory Commission (CERC) and State Load Dispatch Centers (SLDC)

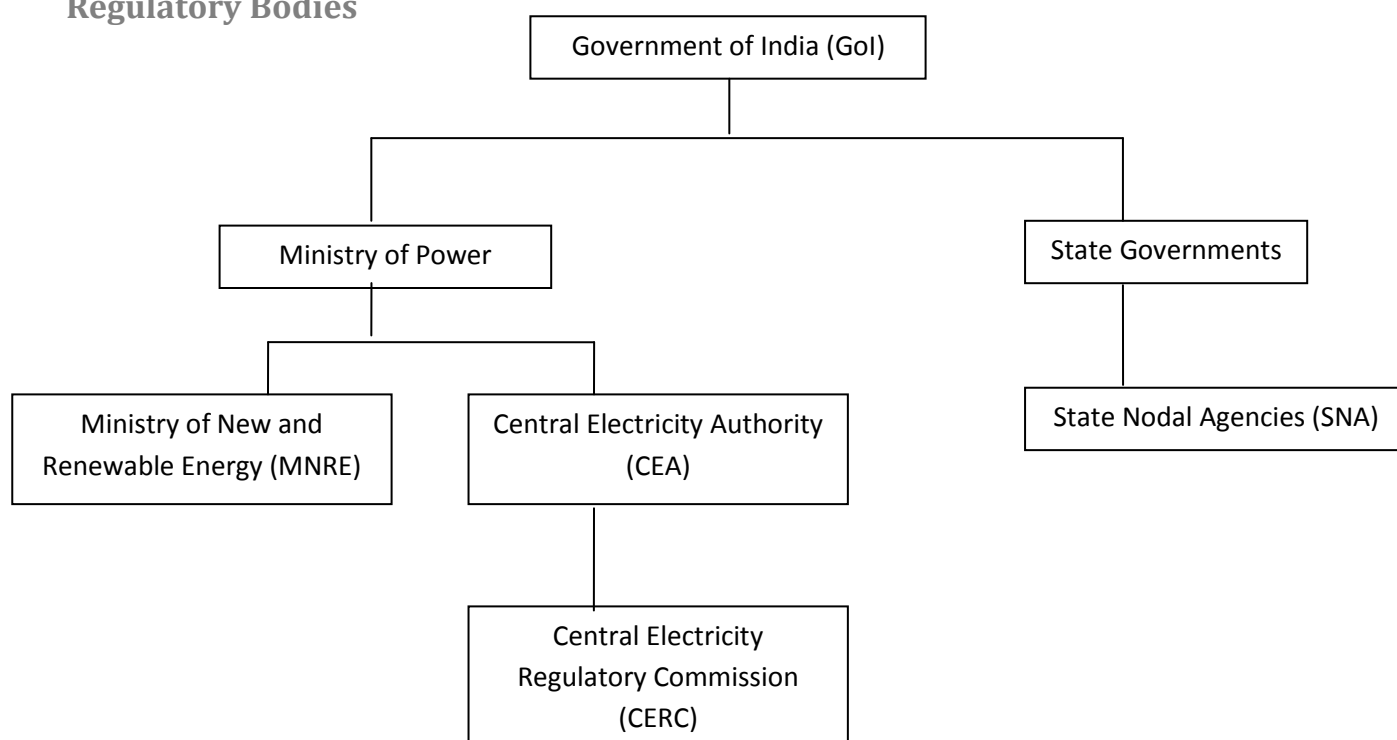
Sample Content

Regulatory Policy Framework

State	Date of issue of order	RPO (per annum)
ANDHRA PRADESH	27-09-2005	5 %
GUJARATH	11-08-2006	2 %
HARYANA	15-05-2007	3 - 10 %
KARNATAKA	11-02-2008	Min 10 %
KERALA	24-06-2006	5 %
MADHYA PRADESH	11-06-2004	10 %
MAHARASHTRA	16-08-2006	3 % (annual increase of 1 %)
ORISSA	23-04-2005	450MU
RAJASTHAN	21-11-2006	7.5 %
TAMI NADU	15-05-2005	10 %
UTTAR PRADESH	12-01-2006	7.5 %
WEST BENGAL	04-05-2006	3.8 %

Solar: Under the National Solar Mission, the GoI has announced a policy change which, if enacted, would specify that solar specific RPO is to start with 0.25% in the 1st phase, and increase to 3% by 2022. Other sector-specific RPOs have not yet been announced.

Regulatory Bodies



Chapter - 9

Indian Biomass Gasification- Market Updates

There has been significant acceleration recently in India in investments and activities for biomass gasification based power production. This chapter provides the latest news and updates in India in this context.

9.1 Introduction

9.2 India Biomass Gasification – Market Updates

Sample Content

Rice husk used for power in one of India's poorest states

The government of Punjab, India, plans to produce about 1,000 MW of green energy from livestock residues by 2015, as large quantities of cattle manure became a main pollutant in the region.

In addition to livestock residues, the state generates about 21 million tons of rice stalks and similar biomass plant wastes every year, which can be used for the production of green power. The state government has plans to use renewable resources as the source of power to contribute 10% of its total energy production in the next five years.

Punjab already runs a biomethanation facility with a capacity of 1 MW located close to Ludhiana that uses methanogens as microbes for the manufacture of methane gas. The facility uses 235 tons of cattle wastes to generate 18,000 kWh of electricity and also produces 45 tons of organic fertilizer every day.

The Punjab Energy Development Agency has developed 318 MW of green power projects, which includes the Ludhiana plant, until today. These projects comprise 37 MW of small hydro facilities, 28 MW of biomass power facilities, 250 MW of biomass co-generation facilities and 2 MW of solar projects.

The agency is currently developing 132 MW of green power projects, which include 11 MW of hydropower, 100 MW of biomass co-generation and 20 MW of traditional biomass. If all become operational, the state will generate 700 MW of green power by 2012. Sukhbir Singh Badal, the deputy chief minister of the state stated that the planters are getting an income of about RS. 4,000 per acre every year by marketing agro wastes to biomass facilities.

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Costs (Capex and Opex) of Renewable Energy Sources (Approximate Estimates)
All estimates are India-specific

Levelized Cost of Electricity (LCoE) from primary renewable power sources

Total capex for a 1 MW power plant

Manpower Cost

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