Rapid Market Assessment

Waste-derived Energy Products

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BILL & MELINDA GATES foundation

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About the Author

This report is created under the Bill and Melinda Gates Foundation's Water, Sanitation, and Hygeine ("WSH") initiative. The work strives to inform future WSH opportunities aiming to improve faecal sludge management on technical and financial feasibility of resource recovery efforts under different scenarios in Indian Cities. However the context of the work is global and models presented here can be customized to suit local conditions.

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About EVI

Founded in 1999, Emergent Ventures was established with the twin goal to accelerate action against climate change and to foster sustainable development. EVI works with the governments, government supported institutions, international development organizations and industries in public and private sector to deliver consultancy services across the full spectrum of sustainable development issues.

EVI's team comprises of professionals from technology, finance, policy and strategy areas with expertise and experience in energy & climate policy, corporate sustainability, carbon markets, sustainable transportation, waste management, and renewable energy (wind, solar, biomass). With a mix of market understanding, sectoral expertise and innovative analytics, it works throughout the life cycle of programs. EVI is currently working on over 300 diverse projects across geographies in Asia (India, Srilanka, Bangladesh, Pakistan, Singapore, Malaysia, Thailand, Indonesia, Philippines, Nepal, Bhutan), Africa (Nigeria, Egypt, Algeria), Americas (USA, Mexico) and Europe. EVI clients include governments, UN Organizations, international donor agencies, NGOs and corporate. EVI covers sectors - Oil & Gas, Utility, Cement, Steel, Textile, Fertilizer, Pharmaceutical, Hospitality, Aviation, Financial, Food & Beverage among others including companies in fortune 500 list. EVI is considered thought leader in its domain of work.

Summary

This report provides an overview of potential markets for waste derived energy products in urban India. The findings are based on rapid market assessment and secondary data available in public domain. The report includes an analysis of the value chains and market prices for various waste-to-energy products i.e. Bio-diesel, Biogas (Transport grade i.e. CNG), Compost, Waste derived solid fuel, Electricity and Synthesis gas (Syn Gas).

The report is based on secondary data collected from source i.e. literature, study reports, government programs and policy documents etc. The values have been cross-checked wherever available with primary data collected during the study. Primary data has been collected through identified list of stakeholders involved in the value chain of waste-to-energy products through phone calls, emails and by having in-person meetings. Their willingness to accept energy products derived from faecal sludge has also been studied during primary data collection.

In this report, the applicable policy frameworks and government's initiatives for identified waste derived products have been discussed to provide overview of enabling policy environment for such products.

The report has been structured in the various sections as under:

Product: A brief description for each identified waste derived product has been provided with details on following sub-sections:-

> ***Value chain:*** Elaborates the present value chain for identified product. This section includes the profile of producer, intermediary and end user of that production.
>
> ***Price:*** This section provides the current market price for identified products.
>
> ***Supply Demand:*** This section provides the present and forecasted supply demand situation for identified products.
>
> ***Policy Environment:*** This section provides the relevant government programs and policies for respective products wherever applicable.
>
> ***Case of FS derived product:*** Elaborates the feasibility of acceptance of products derived from faecal sludge.

Recommendations: The section dwells on the perceived challenges associated with identified products and suggested recommendations. This section also provides challenges associated with FS derived energy products. The major challenge is social acceptability of products and commercial viability of FS management processes. There is a need for demonstration of benefits from FS derived products for alleviation of social barrier. There is also a need for external financial support to make these processes commercially viable.

Conclusion: Provides for each identified product, information on price, demand, government policy framework and acceptance of FS derived products in the market.

Limitation: Though adequate care has been taken while preparing this report, there are certain limitations which have been observed during data collection. The same has been documented in this section.

The summary of rapid market assessment has been provided in the table below.

Product	Demand	Supply	Government /policy support	Substitute in the market	Price	Feasibility of FS
Bio-diesel	High	Low	20% blending of biodiesel with diesel by 2017	Diesel	47-48 INR/liter	Yes
Biogas	High	Low	Capital subsidy on plant & machinery cost	CNG, PNG	34-60 INR/kg for CNG, 22-31 INR/scm for PNG	Yes in transportation, Not for cooking
Compost	High	Low	Promotion of compost from MSW (organic waste)	Chemical fertilizer	1.65-2.0 INR/kg	Yes
Solid fuel	High	Low	Promotional policies for energy generation from renewable sources	Biomass, RDF from MSW	0.9-2.5 INR/kg for biomass, 0.7 INR/kg for RDF	Yes
Electricity	High	Low		Electricity	3.75-11.90 INR/kWh	Yes
Syn gas	Nil	Nil	Not available	Not available	Not available	Not applicable

1. Waste-derived Energy Products-Markets and Value Chain

1.1. Biodiesel

Biodiesel is the name given to the fuels produced from renewable sources of energy like oil seeds. It can be blended with petroleum diesel in a certain percentage and used in automotive engines without requiring any modification. Bio-diesel can also replace furnace oil in the industries. Biodiesel fuels are clean and biodegradable. Biodiesel can be produced using local resources and thus can help countries that hugely depend on imports for their fuel needs. Faecal Sludge is one such source of biodiesel production.

A chemical process known as Trans-esterification is used to produce bio-diesel from volatile fatty acids (VFAs) extracted from seeds and methanol in the presence of Sodium Hydroxide or Potassium Hydroxide. Others feeds used for the production of Biodiesel include Faecal Sludge, *Jatropha curcas*, Palm Oil, Neem Oil among others.

1.1.1. Value Chain

The diagram below provides the value chain of bio-diesel produced from plantation.

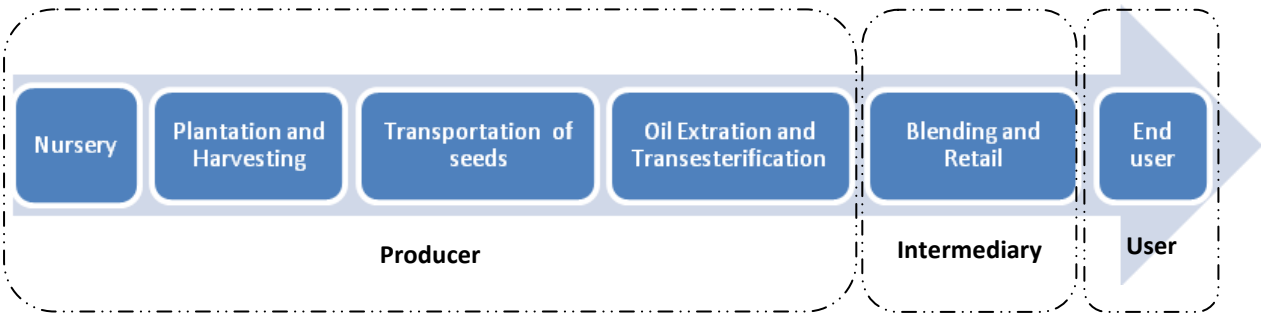

FIGURE 1: VALUE CHAIN OF BIO-DIESEL

The value chain has been grouped into three categories – Producer, Intermediary and User. Profile of each category has been described in this section.

1.1.1.1. Producer Profile

In India, Biodiesel is produced mainly from *Jatropha curcas, Pongamia pinnata, and Madhuca indica.* However bio-diesel can be produced from other types of seeds also. The list of raw feeds used for biodiesel production has been provided in the table below.

TABLE 1: SOURCES OF BIO-DIESEL

Sources of Biodiesel
Jatropha curcas Seeds
Pongamia pinnata Seeds
Madhuca indica Seeds
Neem Seeds
Sal Seeds
Cotton Seeds

Sunflower
Rice Bran
Rape Seed
Soyabean
Castor Seeds
Waste Vegetable Oil
Fish Oil
Animal Fat
Faecal Sludge
Rubber

Biodiesel is primarily produced by private entities in India. According to the Biodiesel Association of India, there are about 20 biodiesel producers in the country[1]. However many government organizations have also announced to set up bio-diesel plants in India. In February 2011, the Indian Railways announced that they would set up four Biodiesel plants[2]. Similarly Indian Oil Corporation Limited also announced to set up biodiesel production plant in India.

A list of a few producers of Biodiesel in India is given below:

TABLE 2: SELECT LIST OF BIO-DIESEL PRODUCERS IN INDIA

Producer	Location
Skyline Enterprises	Jodhpur, Rajasthan
Krishi Oils Ltd	Dhar, Madhya Pradesh
K 1 Oils and Soaps	Tumkur, Karnataka
Chhattisgarh Biofuel Development Authority	Raipur, Chhattisgarh

1.1.1.2. User Profile

Biodiesel finds use in transportation and in industries. However the evidence of use of bio-diesel in transportation is very limited and it's still under development stage in India.

The research unit of the Indian railways designed and successfully tested locomotive engines that would run on biodiesel. The railways are planning to implement blending

[1] www.biodieseltechnologiesindia.com/recent.html
[2] http://www.livemint.com/Companies/FD92n1f3JoNm9lmU1xDnJI/Biodiesel-producers-looking-for-tieups-with-telecom-tower-f.html

proportions in three phases with the proportions being 10, 20 and 50 per cent respectively[3]. Hence Indian railways are a potential user of Biodiesel in the near future.

Biodiesel has a huge potential for use in on-road transportation too. However as of now, biodiesel is sold to state owned transport companies for the purpose of trial runs only[4]. Several trial runs have been conducted by Mahindra & Mahindra on their vehicles, Haryana Roadways by IOCL, BEST Buses by HPCL, Daimler Chrysler on their cars etc among many others[5]. Biodiesel produced from *Jatropha Oil* is also sold to the commercial ventures for use in gensets[6]. There are some companies like Earth-100, which procure bio-diesel from suppliers to use it in their own fleet of vehicles.

1.1.1.3. Intermediary Profile

In the year 2009, the petroleum ministry directed the state governments to ban the sale of biodiesel as transport fuel directly to consumers[7]. Oil Marketing Companies were given the rights instead. These companies include Indian Oil Corporation, Bharat Petroleum Corporation Ltd, and Hindustan Petroleum Corporation Limited among others. The procurement price offered by these companies initially (effective from 1 November 2006) was 25 INR/liter which was then increased to 26.50 INR/liter in October 2008[8].

1.1.2. Price

As discussed in the above section, bio-diesel can't be sold directly to consumers. Oil marketing companies buy bio-diesel from the producers. The offered price is 26.5 INR/liter. However this offered price is less not enough to cover the production cost of bio-diesel which is 30-40 INR/liter. Because of this reason the commercial sale of biodiesel across the bio-diesel purchase centers set up by the government of India is almost nil[9]. To make the biodiesel production and market sustainable, a minimum support price of 37 INR/liter is therefore required[10]. In some cases, bio-diesel is sold directly in the market in the name of bio-oil. The market price of bio-oil and diesel has been provided in the table below.

TABLE 3: MARKET PRICE OF BIO-OIL

City	Price of Diesel (INR/liter)	Price of Bio-oil (INR/liter)
Ahmadabad	55.91	47.00
Kolkata	54.56	48.00
Mumbai	57.79	48.00

[3] http://www.biodieseltechnologiesindia.com/recent.html
[4] http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_New%20Delhi_India_7-1-2011.pdf
[5] http://www.tifac.org.in/index.php?option=com_content&view=article&id=776:biodiesel-fuel-for-the-future&catid=120:publication-bioprocess-a-bioroducts&Itemid=1380
[6] http://www.biodieseltechnologiesindia.com/recent.html
[7] http://www.biodieseltechnologiesindia.com/recent.html
[8] http://www.iadb.org/intal/intalcdi/PE/2012/11035.pdf
[9] http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_New%20Delhi_India_7-1-2011.pdf
[10] www.iadb.org/intal/intalcdi/PE/2012/11035.pdf

1.1.3. Supply-Demand

The current production of bio-diesel in India is only 1% of the global production[11]. The main reason for low production of bio-diesel in India is the high cost of production and ban on direct selling of bio-diesel in the market. Only oil marketing companies can buy bio-diesel from producers at an offered price of 26.5 INR/liter, which is not enough to cover the production cost of bio-diesel. However the government policy on bio-fuel 2008 can help create demand for bio-diesel. The current and projected demand has been provided in the table below.

TABLE 4: BIO-DIESEL DEMAND[12]

Year	Projected Demand
2011-12	3.35 million tons @5% blending of biodiesel with diesel
2016-17	Forecasted Demand: 16.72 million tons @20% blending

Assuming that 1 million ton of biodiesel requires a plantation of 1.06 million hectare[13], the corresponding area of plantation required by 2016-17 will be ~17.7 million hectare. Though India has huge landholdings classified as wastelands, however, biodiesel production using plantation e.g. *Jatropha* still has not been commercially successful at large scale.

1.1.4. Policy Environment

The Government of India issued "The National Biofuel Mission" in year 2003 and issued "The National Policy on Biofuel" in October 2008. The key features of the policy are:

1. 20% of fuel used should be bio-fuel by 2017 though RFS (Renewable Fuel Standards).
2. Biodiesel is exempted from excise duty (no other central taxes and duties are proposed to be levied).
3. Custom and excise duty concessions are provided on plant and machinery for production of bio-diesel, as well as for engines run on bio-fuel for transport, stationary and other applications, if these are not manufactured indigenously.
4. Seeds to be used for the production of Biodiesel can only be produced in the country, with a ban on their import.
5. Plantation of Biodiesel sources to be carried out only on wastelands and not fertile land
6. The Government sets a Minimum Purchase Price (MPP) for the seeds to be used for the production of Biodiesel and a Minimum Purchase Price is also set for the Biodiesel. This price is however said to be insufficient for biodiesel producers to turn in reasonable profits.

[11] http://www.biodieseltechnologiesindia.com/recent.html

[12] http://www.biotechnologie.init-ag.de/BIO/Redaktion/PDF/de/laenderfokus/indien-biofuel-unctad,property=pdf,bereich=bio,sprache=de,rwb=true.pdf

[13] http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_New%20Delhi_India_7-1-2011.pdf

7. The retail sale of Biodiesel directly by Producers to end-Users is not allowed. The Oil Marketing Companies are to buy biodiesel from the producers and then sell it to the end-users.

1.1.5. Case for FS Derived Bio-diesel

As explained above, there is a huge demand for biodiesel, mainly from transport sector. Production of bio-diesel from *Jatropha* at such a large scale is still a challenge. Biodiesel production using Faecal Sludge could be a viable option provided its production cost is maintained lower than the price offered by oil marketing companies for bio-diesel. Stakeholders interviewed during the study have shown their willingness to adopt biodiesel produced from Faecal Sludge.

1.2. Biogas

Biogas is produced by the anaerobic digestion of biodegradable materials such as faecal sludge, sewage, municipal waste, green waste, plant material, and crops among others. Biogas comprises primarily methane (60-66%) and carbon dioxide (32-34%) and may have small amounts of hydrogen-sulphide (~1%) and moisture. The methane content can be increased considerably by upgrading the biogas to Bio-CNG or Bio-Methane, removing the CO2, making it of suitable quality for use as transport fuel. Biogas can also be used in cooking, lighting through mantle lamp, electricity generation and refrigeration. Biogas can be a good substitute for CNG (Compressed Natural Gas) and PNG (Piped Natural Gas). Hence in this report the market assessment has been done for CNG and PNG.

The biogas yield from waste varies greatly with the type and quality of waste, digester technology and the correct operation of the facility. Yield can be increased by mixing with other types of waste and selecting proper digester technology. The energy content of biogas with 55% methane is around 4700 kcal/cu. m.[14]. A thousand cu. ft. (30 cu. m.) of biogas is equivalent to 600 cu ft of natural gas, 6.4 gallons of butane, 5.2 gallons of gasoline or 4.6 gallons of diesel oil.

1.2.1. Value Chain

The diagram below provides the present value chain of biogas.

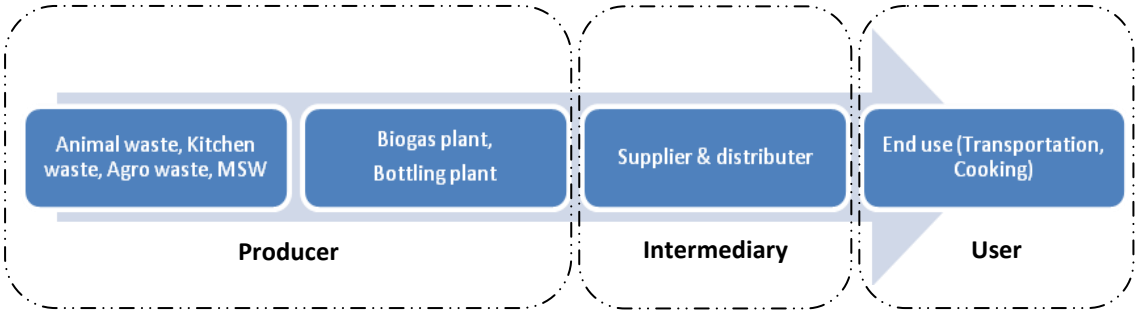

FIGURE 2: VALUE CHAIN OF BIOGAS

The value chain has been grouped into three categories – Produce, Intermediary and User. Profile of each category has been described in this section.

[14] http://www.mnre.gov.in/schemes/offgrid/biogas-2/

1.2.1.1. Producer Profile

In India, biogas plants are set up at domestic (family type biogas plant) and commercial level from wastes like kitchen waste, animal waste, waste from agro-forestry, agro industries (agro/food processing), municipal solid waste. The size of family type biogas plant varies from 1 to 10 cu. m. per day and the size of commercial type biogas plants varies from 25 to 5000 cu. m. per day.

A cumulative total of 4.31 million family type biogas plants have been set up under National Biogas Manure Management Program[15] by Government of India by Dec 2010.

Under technology demonstration of new RDD&D Policy of MNRE during the year 2008-09, the Ministry approved 14 numbers of biogas-fertilizer plants (BGFP) projects with aggregate capacity of 23,116 cu. m./day[16]. There are also many community based biogas plants commissioned in India by Sulabh International. Based on the 'Sulabh Model' design, around 200 community-based biogas plants of 35 to 60 cu. m. capacity have been constructed in different parts of the country so far[17].

1.2.1.2. User Profile

Biogas can be used in cooking, transportation, lighting, refrigeration and power generation. Biogas produced from domestic, family or community type biogas plants are mainly used in cooking or warming water for cleaning purpose or during winters.

Biogas produced from biogas fertilizer plants (BGFP) are purified by scrubbing carbon dioxide and Hydrogen Sulphide. After scrubbing, the remaining gas is pure methane gas, which is pressurized to make bio-CNG. Pressurized gas is dispensed by filling in cylinders/gas-bottles or using a gas filling station. The gas can be used in vehicles. The performance of automotive engine on biogas has been tested by "Biogas Development and Training Centre" (BDTC) of IIT Delhi. As per the report publish by BDTC, there is large potential of this technology in buses, tractors, cars, auto rickshaws, irrigation pump sets and in rural industries[18].

1.2.1.3. Intermediary Profile

Biogas produced from domestic type or family type of biogas plants are used for captive consumption. Here there are no intermediaries involved. Biogas produced from community based biogas plants are also used for captive consumption. In some cases it is supplied directly to local households for cooking purpose.

The compressed bio-CNG can be used as a substitute for CNG in vehicles and for PNG in cooking. At present CNG and PNG are supplied through various gas agencies in India. A list of some of those gas agencies have been provided in the table below:-

TABLE 5: LIST OF GAS AGENCIES

SN	Gas Agencies
1	Indraprastha Gas Ltd
2	Karnataka Natural Gas Limited
3	Banaras Gas Service
4	Bendigeri Indane Gas Distributor[19]

[15] http://www.mnre.gov.in/schemes/decentralized-systems/schems-2/
[16] http://www.mnre.gov.in/schemes/r-d/rd-projects/
[17] http://www.sulabhinternational.org/content/biogas-technology
[18] http://web.iitd.ac.in/~vkvijay/June_Enewsletter.pdf
[19] More agencies can be located at http://www.iocl.com/lpgdistributors.aspx

5	H P Gas
6	Aavantika Gas
7	Adani Gas

1.2.2. Price

Biogas produced from biogas plants is mainly used for captive consumption only. In some cases it is supplied to households at nominal cost. There is no formal information on market price of biogas. However because it can be a substitute for CNG and PNG, this section discusses the market price of CNG and PNG. The price of CNG and PNG has been provided in the table below for various cities of India[20].

TABLE 6: MARKET PRICE OF CNG USED IN VEHILCES FOR DIFFERENT CITIES IN INDIA

CNG (Transportation)		
City	**Gas Agency**	**Price (INR/kg)**
Ahmadabad	Adani Gas	60.15 (Relatively high)
Delhi, NCR	IGL	39.90
Mumbai	Mahanagar Gas Ltd	34.00
Pune	MNGL	42.00
Lucknow	Green Gas	43.48
Agra	Green Gas	50.76
Indore	Aavantika	61.00

TABLE 7: MARKET PRICE OF PNG USED IN COOKING FOR DIFFERENT CITIES IN INDIA

PNG (Domestic)		
City	**Gas Agency**	**Price (INR/scm)**
Ahmadabad	Adani Gas	31 (Relatively high)
Delhi, NCR	IGL	22.00
Mumbai	Mahanagar Gas Ltd	22.00
Pune	MNGL	21.28
Lucknow	Green Gas	20.50
Agra	Green Gas	21.12
Indore	Aavantika	35.00

The price of CNG and PNG is Ahmadabad is relatively high because Adani Gas, which distributes gas in Ahmadabad, is entirely dependent on imported gas in absence of access to cheaper domestically produced gas. The above prices of substitute products give guidance on possible biogas prices that can be fetched from the market provided its quality is brought similar to CNG/PNG.

1.2.3. Supply-Demand

As per one report published by global consultancy firm McKinsey in 2010, India's natural gas demand is expected to nearly double to 320 million scm per day by 2015. The price of diesel has gone up from 17 INR/liter in 2002 to 50 INR/liter in 2013[21]. At

[20] http://www.dnaindia.com/india/1789834/report-ahmedabad-gas-prices-among-the-costliest-in-country
[21] http://www.mypetrolprice.com/diesel-price-chart.aspx

this level, the use of CNG becomes economical, despite the switching costs and additional investment required in vehicle. This has led to higher demand of CNG in India.

According to the India Hydrocarbon Vision 2025 Report, the demand for natural gas is expected to show a sharp rise in future because of its environment friendliness and cost competitiveness[22]. As against this requirement, the present domestic gas supply is 65 MMSCMD[23] and the trend is also declining as major gas fields are entering into declining phase.

Commercial biogas plants have not been successful in India so far. As per present information provided at MNRE site, only six projects have been commissioned out of 14 sanctioned Biogas bottling plants in India. Their aggregate capacity is only 4700 cu. m./day[24].

1.2.4. Policy Environment

Government of India has various programs for the promotion of biogas plants in India as discussed below:-

1) *Family Type Biogas Plants Program/National Biogas Manure Management Program*

National Biogas and Manure Management Program provides central subsidy for cattle dung based biogas plants. The size of biogas plant varies from 1 cu. m. to 10 cu. m. The program is implemented by State Nodal Departments / Agencies and Khadi and Village Industries Commission (KVIC), Mumbai. Government of India also provides training support to users. As per XI five year plan (2007-12), a target of setting up about 0.65 million family type biogas plants had been fixed with a planned outlay of INR 5620 million.

2) *Technology demonstration of new RDD&D Policy of MNRE*

Under the demonstration phase, the Ministry has sanctioned a Central Financial Assistance (CFA) upto 50% of the cost (excluding cost of land) for a limited number of such projects for implementation following an entrepreneurial mode on reimbursement basis. The size of installation varies from 500 cu. m. to 5000 cu. m. per day. 14 No. BGFP projects with aggregate capacity of 23,116 cu. m./day have been sanctioned.

3) *Biogas based Distributed / Grid Power Generation Program*

The Ministry started a scheme "Biogas based Distributed / Grid Power Generation Program" in 2005-06 (4th January 2006) with a view to promote biogas based power generation, especially in the small capacity range, based on the availability of large quantity of animal wastes and wastes from forestry, rural based industries (agro / food processing), kitchen wastes, etc.

The central financial assistance for such projects is limited to a maximum of INR.30,000 to 40,000 per kW depending upon capacity of the power generating projects in the range of 3 kW to 250 kW of different rating limited to 40% of the plant cost.

A cumulative total of 348 projects with biogas generation capacity of 65,287 cu. m. and power generation capacity of 6.62MW have been sanctioned out of which 98 biogas

[22] http://gail.nic.in/energyzone/demand.pdf
[23] www.petroleum.nic.in/vision.doc
[24] http://www.mnre.gov.in/schemes/r-d/rd-projects/

based power generation plants have been installed in the country with power generation capacity of 0.793 MW by Feb 2011[25].

1.2.5. Case for FS Derived Biogas

There is a good demand for natural gas, mainly for transportation and household applications. Biogas can be a good substitute for CNG and PNG but only after quality improvement. Government promotes biogas technology through its various programs. Biogas production from faecal sludge can benefit from such programs. The use of biogas from faecal sludge has limited scope in cooking due to social and cultural issues.

1.3. Compost

In the process of composting, organic matter like kitchen waste, leaves & plants and animal waste[26] undergoes aerobic biological decomposition and gets converted into simpler and stable form of organic matter. Worms and fungi break up the material. Aerobic bacteria manage the chemical process by converting the inputs into heat, carbon dioxide and ammonium. The ammonium is further converted by bacteria into plant-nourishing nitrites and nitrates through the process of nitrification.

The product obtained, known as Compost is beneficial for farm land in many ways as a soil conditioner, fertilizer, for providing vital humus or humic acids, and as a natural pesticide for soil. In ecosystem, compost is useful for erosion control, land and stream reclamation, wetland construction, and as landfill cover.

1.3.1. Value Chain

The diagram below provides the present value chain of compost from various sources.

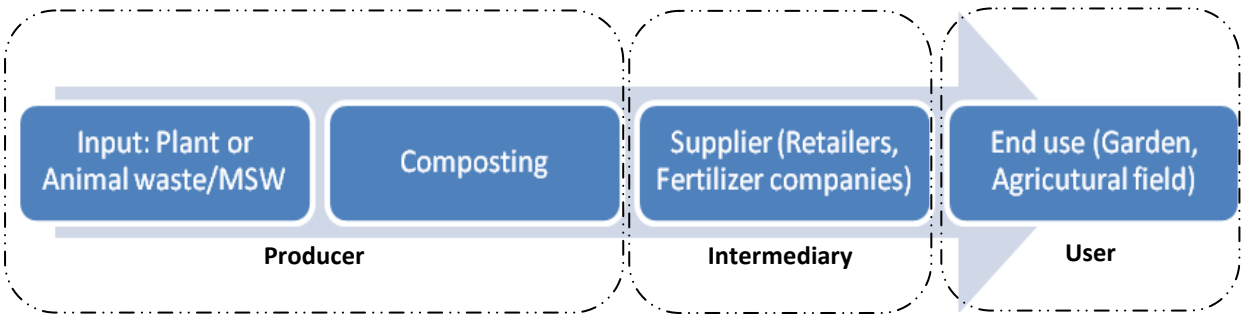

FIGURE 3: VALUE CHAIN OF COMPOST

The value chain has been grouped into three categories – Produce, Intermediary and User. Profile of each category has been described in this section.

1.3.1.1. Producer Profile

Compost is produced in India both at commercial level by private entities and locally by farmers, gardeners for their own use. Compost is also produced at composting plants run by Municipal Corporations using Municipal Solid Waste. Faecal sludge that gets accumulated in Pit Latrines also undergoes degradation to form Compost over a period of time. The slurry of biogas plants which comes out as a by-product can also be used as compost after drying. Following sources are used for compost production:-

[25] http://www.mnre.gov.in/schemes/offgrid/biogas-2/
[26] http://budgeting.thenest.com/examples-organic-fertilizers-31395.html

TABLE 8: SOURCES OF COMPOST

Sources of Compost
Garden waste
Grass clippings
Dead leaves
Shredded paper
Cotton and wool materials
Sorted MSW
Faecal sludge
Kitchen scraps
Manure
Tea-bags
Egg shells
Animal Carcasses
Bio-solids from Waste water sludge

A list of some compost producers have been provided in the table below:-

TABLE 9: SELECT LIST OF COMPOST PRODUCING COMPANIES

SN	Company
1	Indore Biotech Inputs & Research (p) Ltd.
2	MD Biocoals Pvt. Ltd
3	Sri Gayathri Biotec - India
4	Poonam Natural

1.3.1.2. User Profile

Horticulturalists (including gardeners) and farmers are the primary users of Compost. Compost is used in addition to Chemical/Organic fertilizers. Compost provides nourishment to soil and hence to the food web that exists in the soil thus improving the

quality of the soil, whereas, chemical fertilizers provide nutrients for the needs of the plants that grow in the soil.

1.3.1.3. Intermediary Profile

Compost is primarily sold through small retailers in local market. Compost is also sold to fertilizer companies that sell to farmers along with chemical fertilizers.

1.3.2. Price

There is no established market for sale of compost at wholesale in India. Selling of compost takes place at low volume through retailers in local market only. This is mainly due to low awareness among farmers and its low N-P-K value compared to chemical fertilizers[27]. N-P-K (Nitrogen, Phosphorous, Potassium) are the elements that most plants require for growth. Composts are considered to be bulky and hence their transportation cost is also high. This has not helped in increasing its demand putting pressure on the market price of compost.

The market price of compost produced from MSW is about 1650 INR/ton[28]. The price of compost produced from animal manure (cow dung) is about 2000 INR/ton.

1.3.3. Supply-Demand

According to the Ministry of Chemicals and Fertilizers' report "The Working Group on Fertilizer Industry for the Twelfth plan", in order to ensure reasonable health of the Indian soils, there is a need for about 850 to 1200 million tons of organic fertilizers[29].

India has an estimated potential of producing about 4.3 million tonnes of compost each year from MSW[30]. The potential of supply of compost is much less given the demand in India.

1.3.4. Policy Environment

As per the report of the working group on Fertilizer Industry for the twelfth plan, there is a need for approximately 850 to 1200 million tons of organic fertilizers to maintain reasonable health of the Indian soils. This may create a demand for compost produced from faecal sludge in the market.

1.3.5. Case for FS Derived Compost

There is a need for compost to improve the soil condition. As per the information provided by some suppliers, there is lack of awareness among farmers regarding the use of compost in field. They also mentioned that the acceptance of compost produced from FS will be low due to likely presence of pathogens and associated social-culture issues.

1.4. Solid Fuel

Solid fuels like biomass, pellets made from different types of biomass and RDF (Refused Derived Fuel) from MSW are most commonly used in energy intensive industries. These types of solid fuels are described below.

Biomass

[27] Mrs Almitra H. Patel, 24/12/2001, Policies to encourage use of city compost in India,
[28] http://www.environment.delhigovt.nic.in/ppt/august/Waste%20Management_22.08.08.pdf
[29] http://planningcommission.nic.in/aboutus/committee/wrkgrp12/wg_fert0203.pdf
[30] http://www.cleanindiajournal.com/composting_in_swm%E2%80%93a_report/

In India, there is surplus availability of biomass. There are many government policies which are also promoting the use of biomass in power generation.. It can be burnt directly or subjected to various methods of processing and the product obtained can be used as a fuel. However, the fuel density of raw biomass is much less than its processed counterpart. Thus it is beneficial to process biomass before using it as a fuel. The processing method may be a physical, chemical or thermal process. Physical processes include: Cutting to uniform length; chipping; shredding and grinding; reducing moisture content by passive drying, active drying and blending. The Thermal processes include Pyrolysis and gasification. The Chemical processes include biochemical process like anaerobic digestion and fermentation. Calorific value of biomass varies from 2500 kcal/kg to 4000 kcal/kg depending upon impurities and moisture content. Following types of biomass are used as solid fuel in India.

TABLE 10: LIST OF BIOMASS FUELS

SN	Biomass
1	Wood: Bark, logs, sawdust, wood chips
2	Industrial Waste e.g. Paper pulp
3	Food waste
4	Agricultural Waste: Bagasse, Ground Nut shell, Cotton Stalk, Husk of Soyabean, Coffee, Rice, Peddu, sunflower, Chana etc, Jute Waste et al.

Refuse Derived Fuel (RDF)

A part of municipal solid waste (MSW) can be converted into RDF and the same can be used as fuel in many industries. The calorific value of RDF may be in the range 2500-3000 kcal/kg. This can be used as substitute for fuels like coal or biomass.

1.4.1. Value Chain

The diagram below provides the present value chain of solid fuels from source to its end use.

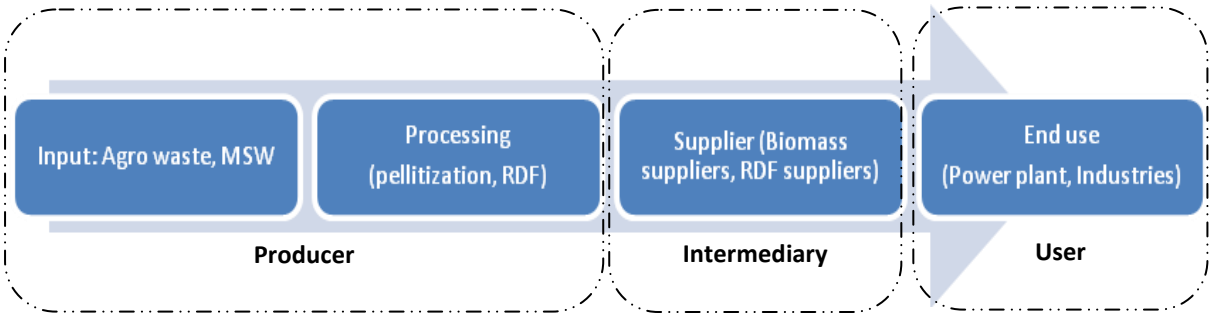

FIGURE 4: VALUE CHAIN OF SOLID FUEL

The value chain has been grouped into three categories – Produce, Intermediary and User. Profile of each category has been described in this section.

1.4.1.1. Producer Profile

The producer profile of biomass and RDF has been discussed in this section. Agro waste based biomass is produced by farmers as a result of their farming activities. Some of the biomass is burnt directly by farmers for their own energy needs. The pre-processing of biomass is done by agencies involved in the business of pre-processing. They procure biomass from farmers, process it and then sell to the end users.

It has been noted that many Municipal Corporations in the country have set up plants to convert suitable components of MSW to RDF. Such projects have been set up on PPP model. Following is a list of a few such plants in the country.

TABLE 11: LIST OF MSW TO RDF PLANTS IN INDIA

SN	Plant Name	Location	MSW processing capacity	RDF production capacity
1	Timarpur Okhla Waste Management Company Pvt Ltd	New Delhi	650 TPD	225 TPD
2	Nashik Municipal Corporation's plant	Nashik	600 TPD	150 TPD
3	East Delhi Waste Processing Co. Ltd	New Delhi	1300 TPD	450 TPD
4	RDF Power Projects Limited	Hyderabad	700 TPD	250 TPD
5	MSW processing plant Jaipur	Rajasthan	500 TPD	150 TPD
6	Shivshankar Engineering Company Pvt Ltd	Bangalore	5 0 TPD	5 TPD
7	SELCO	Hyderabad	700 TPD	200 TPD

1.4.1.2. User Profile

Solid fuels are mainly used in energy intensive industries like power plants, cement industries, paper plant, oil extraction industries, food industries etc for thermal energy generation and power production.

1.4.1.3. Intermediary Profile

Solid fuels are made available to industries through suppliers. In some cases, these are supplied to users directly by farmers. Continuous supply of solid fuels is ensured through short term or long term agreements. The profiles of intermediaries are provided below for biomass and RDF.

As mentioned in previous section, in the case of biomass, agencies that are involved in processing of biomass procure biomass from farmers. Next, the processed biomass is supplied to the end users. Certain types of biomass like rice husk, mustard husk, ground nut husk, soya husk, cotton husk etc can be burnt directly without any pre-processing.

In case of RDF made from MSW, the production is carried out at plants set up by Municipal corporations on their own or in partnership with private entities. The RDF so produced is sold directly to the consumers which are usually power plants, brick kilns, cement kilns etc.

1.4.2. Price

In case of Biomass, the price varies from 900-2500 INR/ ton, depending upon the quality of the biomass. RDF is sold at around 700 INR/ ton.

1.4.3. Supply-Demand

Coal is the dominant source of energy in India. However due to environmental issues and declining coal reserves, other types of non-conventional source are being promoted. Coal can be fully or partially replaced by biomass or RDF. Hence in this section the demand of coal has been considered as demand for solid fuel in the country.

Coal

The coal demand in financial year 2011-12 is 770 million MT which is growing at the rate of 6-7% per year and is expected to reach 980 million MT in 2016-17 and 1800 million MT by 2031-32[31]. In the past, the coal production in the country was able to meet the demand, however, over the years gap between demand and supply has increased. This gap in the market can be tapped by waste derived solid fuels including FsDF to some extent.

Biomass

Current supply of biomass in the country is estimated to be about 500 million metric tons per year while there is another about 120 – 150 million metric tons per year (agricultural and forestry residues) which is either left to decay in field or burnt in the field.

RDF

The installed capacity of RDF pellets in the country (considering a list of some existing plants in the country) is about 3160 TPD.

1.4.4. Policy Scenario

There are a number for policies for development of the Renewable Energy sector in India:

1. Accelerated Depreciation 80% in first year (boiler and Turbine).
2. Income Tax Holiday under Section 80 IA for 10 years.
3. Concessional import duty; excise duty exemptions on equipments and components required for initial setting of the project.
4. Sales tax exemption in some states.
5. IREDA provides loans for biomass power projects.
6. Preferential tariff in 14 states.

[31] http://www.cpsi.org.in/documents/Presentation%20for%20China-16%20June%202012.pdf

In case of RDF, there are provisions for Accelerated Depreciation and tax benefits. The government also gives subsidy for setting up of MSW to RDF pellet plants. In addition to this, the responsibility of delivering the MSW to the plant lies with the government agency, costs of which are borne by the government agency itself and plus the plant operating company also gets a certain Tipping fee.

1.4.5. Case for FS Derived Solid Fuel

The coal supply is not adequate to meet the increasing demand of energy in India. In such scenario, there is a good potential for other types of waste derived solid fuels like biomass, RDF and FsDF. There have been some cases like HPS model for power generation from rice husk where decentralized model of energy generation from waste derived solid fuels has been successful.

1.5. Electricity

Electricity is generated from various sources in India. A majority of power comes from Thermal power plants (coal, gas and oil) forming 66.91% of the total power generation in India[32]. The rest comes from Hydro, Nuclear, and Renewable Energy sources. Tariff for electricity in the country depends on a number of factors, a list of which is given below.

TABLE 12: FACTORS AFFECTING ELECTRICITY TARIFF

SN	Factor
1	Type of supply: Continuous or Seasonal
2	Type of End User: Domestic, Commercial or Industrial
3	Consumption levels
4	Purpose of use: Public or private
5	Scale of Industry
6	Energy Source: Coal, Hydro, Natural gas, Oil, Nuclear, and Renewable energy (solar, wind, bio-fuels, waste, etc)
7	Plant location
8	Time of Demand (peak hours/non-peak hours)

[32] http://powermin.nic.in/indian_electricity_scenario/introduction.htm

1.5.1. Value Chain

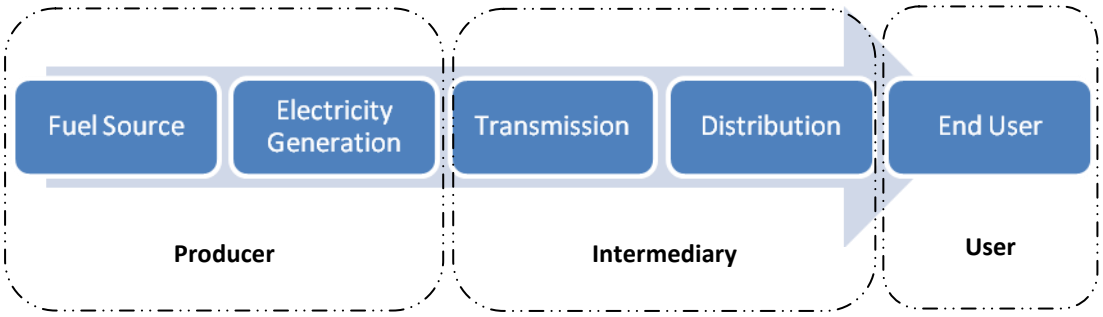

FIGURE 5: VALUE CHAIN OF ELECTRICITY

The value chain has been grouped into three categories – Produce, Intermediary and User. Profile of each category has been described in this section.

1.5.1.1. Producer Profile

In India power generation is mainly done by public sector undertakings at central level. These include: National Thermal Power Corporation (NTPC), National Hydroelectric Power Corporation (NHPC) and North Eastern Electric Power Corporation (NEEPCO). In addition to this, private players also playing a significant role in power generation in the country. Private players come under the category of 'Independent Power Producers'. Private players also run captive power plants to meet their in-house power demand.

The sources of power generation in India include Thermal (Coal, gas and oil), Hydro, Nuclear, and Renewable Energy sources.

1.5.1.2. User Profile

Power generated from various sources is being used to meet the power demand of country. For tariff determination purpose the consumers have been divided into two types of tariff category viz. HT tariff and LT tariff. The list of user categories has been provided below.

TABLE 13: ELECTRICITY CONSUMER CATEGORY

HT Tariff	LT Tariff
Processing, Manufacturing & Preserving	Domestic
Ferro alloys	Non –Domestic (Commercial)
HT other than HT (Commercial)	LT Industries
Lift Irrigation Schemes (Agriculture)	Cottage Industries
Railway Tractor	Agriculture
Town Ships	Public Lighting
	General
	Temporary

1.5.1.3. Intermediary profile

After Power has been generated, the next task is transmission and then distribution to the end consumer. Transmission involves the bulk transfer of electricity from the power generation plants to the substations which are located near the demand centers. Distribution involves the transfer of power from transmission network to the end consumers.

For the purpose of transmission, there are Central and State Transmission Utilities. Central transmission utilizes include Power Grid Corporation and a number of Private Transmission licensees like Torrent power transmission limited, Powerlinks Transmission Limted. For the purpose of distribution, there are distribution utilities which include State electricity boards, State distribution boards, and Private Distribution Companies.

1.5.2. Price

In India, the selling price of electricity or supply side tariff varies with source of generation and location. The tariff is regulated by state agencies under the guidance of central agency. Government is providing higher tariff for power generated from non-renewable sources through various state level policies. Generic Tariff for renewable energy technologies for financial year 2013-14 have been provided below.

TABLE 14: ELECTRICITY TARIFF FROM DIFFERENT SOURCES

SN	Source	Tariff range (INR/kWh)
1	Wind	3.93-6.29
2	Hydro	3.75-5.16
3	Biomass	5.49-6.24
4	Solar PV	8.75
5	Solar Thermal	11.90
6	Biomass Gasification	5.85-6.65
7	Biogas Cogeneration	6.91

The demand side tariff varies with the category of consumer. Different states have different tariff structures. As per Economic Survey 2012-13, the average rate of electricity for domestic consumers varies from 1.20 to 6.90 INR/kWh and for industrial consumers it varies from 3.16 to 8.79 INR/kWh[33] across various states in India.

Tariff in India is highly subsidized by government. In many cases the purchasing price is higher than the selling price.

[33] http://data.gov.in/dataset/state-wise-average-rate-electricity-domestic-and-industrial-consumers

1.5.3. Supply-Demand

The generation from conventional sources of energy for the FY 2011-12 was 813,306 GWh while that from non-conventional renewable sources was 51,226 GWh (provisional figures). There is a peak power shortage of 25.4% with an all India average of 11.7%[34].

1.5.4. Policy Environment

Government of India has many policies for promotion of renewable power to meet the power demand of country. This also helps reduce the dependence on conventional fuel sources. The following policies and circumstances are discussed below:

1. **Electricity Act-2003 published in 26th May 2003[35]:** The Act aims to consolidate the laws relating to generation, transmission, distribution, trading and use of electricity and generally for taking measures conducive to development of electricity industry, promoting competition therein, protecting interest of consumers and supply of electricity to all areas, rationalization of electricity tariff, ensuring transparent policies regarding subsidies, promotion of efficient and environmentally benign policies constitution of Central Electricity Authority, Regulatory Commissions.

2. **National Electricity Policy 2005[36]:** The National Electricity Policy 2005 stipulates that progressively the share of electricity from non-conventional sources would need to be increased; such purchase by distribution companies shall be through competitive bidding process; considering the fact that it would take some time before non-conventional technologies compete, in terms of cost, with conventional sources, the commission may determine an appropriate deferential in prices to promote these technologies.

3. **Tariff Policy 2006[37]:** The Tariff Policy announced in January 2006 has the following provision: Electricity regulatory Commission shall fix a minimum percentage for purchase of energy from nonconventional sources taking into account availability of such resources in the region and its impact on retail tariffs. Such percentages for purchase of energy should be made applicable for the tariffs to be determined by the SERCs latest by April 01, 2006. Procurement of nonconventional energy by distribution companies shall be done at preferential tariffs determined by the Appropriate Commission.

4. **State policies:-** State government agencies promote power generation from renewable sources through various tariff orders and they update these orders time to time basis.

1.5.5. Case for FS Derived Electricity

As discussed above, there is a huge demand for electricity in India. As per information provided by electricity consumers, power availability in many urban areas is even less than 12 hours. Transmission and distribution line is also not very efficient. In such scenario, a decentralized type of power generation unit can be a viable solution. Such projects can be implemented in large housing complex and this will also reduce

[34] http://shodhganga.inflibnet.ac.in/handle/10603/8179
[35] http://www.powermin.nic.in/acts_notification/electricity_act2003/pdf/The%20Electricity%20Act_2003.pdf
[36] http://pib.nic.in/archieve/others/2005/nep20050209.pdf
[37] http://www.powermin.nic.in/acts_notification/electricity_act2003/pdf/The%20Electricity%20Act_2003.pdf

dependency on diesel gensets. Similar type of decentralized power generation models like HPS power generation from rice husk has been successful in India.

1.6.Syngas

The gasification process converts carbon containing matter into syngas by means of a thermo-chemical reaction. This constitutes thermal degradation of fuel in the partial presence of oxygen leading to formation of solid (Char), liquid (Tar) and gaseous products (Syn gas). Syngas is primarily hydrogen, carbon monoxide and other gaseous constituents, the proportions of which can vary depending upon the conditions in the gasifier and the type of feedstock. The typical composition of syngas is CO 15-22%, H2 10-20% with other gases making the rest.

Syn gas produced from gasification of biomass is used for power or thermal energy generation in gas engines. Syn gas is also produced from gasification of coal and this is used for in-situ energy generation. Similar type of plant has been set up by Jindal power in India where Syn gas produced from coal is used as reducing agent in DRI plant[38]. In developed countries, Syn gas is used for production of fuel cells[39]. However there has been no such evidence for fuel cells production at commercial scale from Syn gas in India. Syn gas is mainly used for in-situ energy generation. **There has been no record of commercial trading of Syn gas as commodity in India.**

[38] http://www.jindalsteelpower.com/facilities/domestic/orissa/angul.aspx

[39] http://www.pulpandpapercanada.com/news/biomass-derived-syngas-to-power-hydrogen-fuel-cell/1002115125/

2. Recommendations

This section dwells on the perceived challenges associated with the identified waste derived products and suggested recommendations.

Biodiesel

Challenges	Recommendations
The production cost of biodiesel is higher than the price offered by oil marketing companies in India.	The production cost is high mainly due to the limited supply of feed material and associated inbound and outbound transportation costs. The production cost can be reduced by improving the supply feed material. This can be increased by increasing production of feed material. Alternatively government can increase the support price provided by oil & marketing companies.
No direct selling of bio-diesel in the open market.	There is already a huge demand and supply gap for petroleum products including diesel in India. Hence opening up this sector for direct sales in the market would not be a threat to the oil & marketing companies. This will also support the government initiative of 17% blending of bio-diesel with diesel by 2017.
Shelf-life of bio-diesel is only 6 months. Hence storage of bio-diesel for longer time may result in revenue loss.	An improved supply chain and production at multiple locations can reduce the transportation and storage time.
Quality of biodiesel varies a lot for any deviation in processing facility.	The quality of bio-diesel should meet the BIS 15607 standard and this should be monitored at the production site before transportation.
Low awareness among people regarding the usage of bio-diesel	Bio-diesel can be promoted through various incentive programs and through tie-ups with local leaders.

Biogas

Challenges	Recommendations
Quality of biogas is likely to vary with source and environmental conditions	The quality of biogas mainly refers to the percentage of methane, presence of H_2S, CO_2 and moisture in the biogas produced. The quality can be controlled by controlling the C:N ratio of feed stock and processes parameters. Post-processing measures can also be taken to ensure the quality of biogas.
Biogas production is a slow process and higher hydraulic retention time results in lower production of biogas	Production rate can be increased by - Bigger size of biogas plant - Optimizing process parameters - Mixing additives to increase the rate of degradation and biogas production
Secured availability of raw feed on continuous basis	Availability of feed material can be improved by - Tie-up with local bodies for supply of feed stock - Tie-up with ULBs for supply - Mixing more than one feed stock (mix feed)
Social issues associated with biogas from FS	Social barrier can be alleviated by - Providing biogas free of cost to a controlled group of people for demonstration purpose. Gas can be used for low end heating purpose like heating water for floor cleaning or cattle cleaning purpose. After its social acceptance the gas can be supplied to a wider range of households at economical price. - Generating power from biogas and supplying power to households, grid or captive consumers.
Creating awareness among people regarding the use of biogas for households	Biogas can be promoted through various incentive programs and through tie-ups with local gas suppliers.

Compost

Challenges	Recommendations
Health risk due to presence of pathogens	Compost should be properly treated before selling into market
Low awareness among people regarding the benefits from compost	Field trials with farmers at grassroot level should be conducted to gather feedback with respect to the quality and quantity of farm yields. The impact on farm yield should be demonstrated to the farmers to promote the use of compost in the field. Hanjer[40] has promoted the use of compost through similar measures in India.
Compost has got lower N-P-K value compared to chemical fertilizer and hence it has less impact on crop yield and lower market demand.	Taking advantage of recent regulations, according to which fertiliser companies must sell three bags of compost with every six bags of fertiliser, compost production companies can enter into agreements with fertiliser companies to promote the sales of compost.
Cost of transportation is high due to big and bulky volume of compost	It is possible to deliver the compost at lower transportation rate by producing compost across multiple locations throughout India.
There is no established wholesale market for compost. It is sold through retailers in local market only.	As discussed above, an agreement with fertilizer companies would immediately provide access to market.

Waste Derived Solid Fuel

Challenges	Recommendations
There is a large variation in calorific value due to moisture and impurities	Variation in calorific value can be controlled by providing covered transportation and storage place during monsoon season.
Procurement of biomass from distributed sources is a challenge	A minimum support price can be provided to farmers for agro-waste procurement.
Seasonal availability of biomass	A mix of biomass can be used and at the same time biomass can be stored for lean season.

Syn Gas

There has been no record of commercial trading of Syn gas as commodity in India.

[40] http://www.hanjer.com/

Other General Recommendations applicable to all FS derived energy products

Challenges	Recommendations
Social issues associated with FS derived energy products	FS derived products like biogas, compost, FsDF has relatively low social acceptance compared to electricity and bio-diesel produced from FS. Hence there is a need for promotion of these products. Benefits of these products can be demonstrated to local consumers to overcome the social barrier. Manual handling of FS is neither safe nor socially acceptable hence this should be avoided during operation of plant on FS. The process should be automated.
Securing quantity and quality of FS	ULBs can provide off-take guarantees to project developer for supply of FS. This will ensure the quantity of FS. Project developer can have its own FS collection mechanism to ensure the quality of FS at a large extent.
Usage of FS in existing waste to energy plants	There is a pre-processing need to meet the feed stock characteristics required by existing waste to energy plants. This requires technology retrofit or this can be outsourced also. Government should allow such pre-processing measures and retrofits in existing waste to energy facilities considering them environment friendly.
Commercial viability of FS to energy plants	FS to energy processes are not financial viable on its own. However any such process would result in avoided cost[41] to the government. Those avoided cost can be provided as subsidy to these plants to improve their financial viability.

[41] Avoided costs are those costs which would occur in the absence of FS management. This includes the cost of severe line, expenditure on water prone diseases, expenditure on cleanliness of city etc

3. Conclusion:

Biodiesel

1. There is policy from government to blend 20% bio-diesel with diesel by 2017. However ban on direct selling of bio-diesel has made this business unsustainable. The offer price for bio-diesel by oil marketing companies is less than the production cost of bio-diesel. Many of the bio-diesel production plants are shut down due to this reason.
2. The supply chain for bio-diesel in not well established in India.
3. Bio-diesel is being traded as bio-oil to circumvent ban on biodiesel.
4. There are limited producers and users in the market.
5. There is huge demand for bio-diesel against the limited supply of bio-diesel.
6. Awareness among people is also low.
7. Perception is that production of bio-diesel from biomass may also lead to problems like food security.
8. Intermediaries are willing to buy and sell bio-diesel produced from FS provided it meets the BIS 15607 and price is lower than the market price of bio-diesel.

Biogas

1. Government of India is promoting commercial scale biogas fertilizer plants by providing subsidy upto 50% of capital cost (excluding land cost).
2. There is huge demand and supply gas for CNG and PNG. Production of enriched quality of biogas may fill the gap.
3. The supply chain for biogas is not established in India.
4. Awareness among people is low.
5. There is huge potential for biogas production from organic waste from MSW generated in urban cities.
6. Biogas produced from FS can be used in transportation however it has limited scope in cooking due to social and cultural issues.

Compost

1. Use of compost improves the soil condition however due to its lower N-P-K value it has low demand in the market. Farmers are more inclined to chemical fertilizers as they increase the crop yield by providing nutrients to the plants.
2. Compost is used mainly for captive use in farms or gardens.
3. There is low demand of compost in the open market. Due to this reason the price of compost is also low.
4. Only a few intermediaries are involved because the demand is low.
5. Compost produced from FS would have high N-P-K value. However this may not accepted by farmers due to presence of pathogens and social and cultural issues.
6. Compost should be produced and sold in nearby market to avoid high transportation cost.

Solid fuel

1. There is demand for solid fuels in Indian industries. The fuel sector is dominated by coal. However reducing coal reserves and rising environmental issues have forced government to promote non-conventional source of energy. This has promoted use of biomass and RDF in energy intensive industries.
2. There is lot of surplus biomass available in country which can be used as fuel. The production of RDF from MSW can also replace the use of coal in many industries.
3. The supply chain market for coal and biomass are well established in the market. Other types of solid fuel may also be sold through this supply chain provided there is demand.
4. FS (FsDF) can be used as fuel in many energy intensive industries like power plant and cement industries. However the scope of usage in food products and other related industries are limited.

Electricity

1. In India, there is a huge gap in demand and supply. The government of India is promoting power generation form non-conventional sources through various policies.
2. The infrastructure for power evacuation is not efficient. This has led to high transmission and distribution loss of power.
3. Higher power tariff has been offered for power generated from non-conventional sources.
4. The cost of production is high hence many plants are shut down once government support is withdrawn.
5. The late payments from electricity board make the business less sustainable.
6. The purchase price of electricity varies with location, usage type (residential, industrial, and commercial) and with time of usage.
7. Power generation from FS can be used for captive consumption as well as the same can be supplied to grid depending upon the scale of production.

Syn gas

1. There has been no record of trading of Syn gas as commodity in India.
2. Pure hydrogen can be made from syngas for use in stationary fuel cells or fuel cell vehicles. However the fuel cell industry is still at development stage in India.

4. Limitation:

Though adequate care has been taken while preparing this report, there are certain limitations which have been observed during data collection. The same have been listed below:-

1) The value chain has been divided into three major groups - producer, intermediary and user. Companies have been selected for primary data collection from all these profiles to ensure quality of data. However the list doesn't cover other stakeholders like government, banks, NGOs etc.

2) The selection of companies is random even though the data consistency has been confirmed from reliable secondary data sources.

3) Many of the companies were not ready to disclose information on pricing and demand etc. Hence study relies on the information gathered from limited sources in a few cases.

4) The market assessment for CNG and PNG has been done because there is no formal market for biogas.

5) There is no organized market for Synthesis gas in India. Synthesis gas is an intermediate product and it is used at the site of its production. There has been no record of open trading of Synthesis gas in the country.

Annexure

List of companies/ individuals interviewed

SN	Product	Segment	Name of Organization	Address
1	Biogas	Intermediaries	Indraprastha Gas Ltd	Indraprastha Gas Limited, IGL Bhawan, Plot No. 4, Community Centre, Sector 9, RK Puram, New Delhi 110022, Phone 91-11-46074607, email- customercare.png@igl.co.in, website-www.iglonline.net
2	Biogas	Intermediaries	Karnataka Natural Gas Limited	Khanija Bhavan 49, 4th Floor, East Wing, Race Course Road, Bangalore - 560 001 Phone: 91-080-2225 8131/133 Email: ksiidc@airtelmail.in; ksiidcit@gmail.com Website: http://www.ksiidc.com/
3	Biogas	Intermediaries	Banaras Gas Service	A-10, DDA Market, Mata Sundari Road, New Delhi-110002. Phone: 011-23236956/23221189 Email: uday_indane@rediffmail.com Website: http://www.iocl.com/lpgdistributors.aspx
4	Biogas	Intermediaries	Bendigeri Indane Gas Distributor	Shop No.9, Vrindavan Apartments, Vidya Nagar, Hubli – 580031 Phone: 0836-2372599/ 2271229 Email: uday_indane@rediffmail.com Website: http://www.iocl.com/lpgdistributors.aspx
5	Biogas	Intermediaries	H P Gas	Gul Ali,19A,Near Swami Samarth Mandir, Bhawani Peth, Pune-411042 Phone: 91 - 20 - 26387268 Email: NA Website: http://www.indiacom.com/pune/h-p-gas_pune_pne_942836.html
6	Biogas	Producer	Anand Energy	Alamgarh Road Village Dharampura Teh.: Abohar, Dist.- Ferozepur (Punjab) Phone: 91-9780808478 01634-221453 (O) Email: anandenergy@ymail.com Website: NA

7	Biogas	Producer	Sanjh Deep Gas Energy	Village/PO Mehma Sarja, Tehsil: Bhatinda, Dist.: Bhatinda (Punjab) Phone: NA Email: sanjhdeep2010@yahoo.com Website: NA
8	Biogas	Producer	Shashi Energies	Near Green Vally Public School, Ratiya Road Tohana, Tehsil.- Tohana, Dist.- Fatehabad(Haryana) Phone: 91-9416087875 Email: maryadeepak@gmail.com Website: NA
9	Biogas	Producer	Option Energy Pvt. Ltd.	**Plant**: Shree Haryana Gaushala Village & Block – Hansi, Dist. Hissar (Haryana) **Office**: B 9, Shekhar Apartment, Mayur Vihar,Phase I Extn., New Delhi-110091. Phone: +91- 9717650090 (Delhi) +91- 8295633224 (Hansi Plant , Haryana) Email: abhaysinha12@hotmail.com Website: http://optionenergy.in
10	Biogas	Producer	Ashok Biogreen Pvt. Ltd	Location of Project: Vill. Talwade, Tahasil Trimbak, Dist.-Nasik, Maharashtra Phone: 91-253-3011705, 9552837631, 9893020653 Email: manik.dhanorkar@ashokabiogreen.com Website: www.exportersindia.com/ashokabiogreenpvtltd/
11	Biodiesel	Producer	Skyline Enterprises	22, High Court Road, Jodhpur, Rajasthan India Phone: 91-291-2550726 / 2540308 91-9314711158 Email: NA Website: http://www.exportersindia.com/skylineenterpises/contact.htm
12	Biodiesel	Intermediaries	Royal Carbon Black Private Limited	New Era Mill Compound Magal Lane Matunga W Mumbai - 400016 Maharashtra India Phone: 91-22-40829529 08376808432, (91)-9930836361 (91)-9867222202, (91)-9029945194 Email: marketing@royalcarbonblack.com Website: http://www.royalcarbonblack.com/

13	Biodiesel	Intermediar-ies	Earth-100 Biofuels Private Limited	05 and 05 A, 2nd Floor, Jmd Regent Plaza,M.g. Road-122002, Gurgaon, Haryana India Phone: 91-124-4017722 Email: kapil.gupta@e-100.com Website: http://earth-100.com/
14	Biodiesel	Producer	Krishi Oils Ltd	Plot No. 91-94, Sector - 2, Pithampur, Dhar Madhya Pradesh 454775 Phone: 91-7292-253826 Email: sanjivm@sify.com Website: http://www.krishioils.com
15	Biodiesel	Producer	K 1 Oils and Soaps	Village. Dodda Bathi Tumkur Kar-nataka Phone: 91-8192-241845, 91-9448475768 Email: K1jatrophaoils@gmail.com K1jatrophaoils@gmail.com Website: http://www.kayone.in
16	Biodiesel	Intermediar-ies	Bio Diesel Associa-tion of India	B-14 RNA Arcade, Lokhandwala Andheri(W) Mumbai 400053, Maharashtra, India Phone: 91-22-42648228 Email: info@bdai.org.in Website: www.bdai.org.in
17	FSDF, Electricity	User, Pro-ducer	SLT Power & Infra-structure Project Pvt. Ltd	503/B, J. D. Electronics Building Shivam Road, New Nallakunta Hy-derabad Andhra Pradesh 500044 India Phone: 91-9848226472, 91-040-27562378 Email: sltpower@yahoo.com Website: NA
18	FSDF, Electricity	User, Pro-ducer	Subhashri Bio En-ergies Pvt. Ltd (SBEL)	67, Goundampalayam Kumaraman-galam Tiruchemgode - 637205 Namakkal Phone: 04288 234332 Email: mktg@pso6.com Website: http://www.sbelindia.com
19	FSDF, Electricity	User, Pro-ducer	Raus Power Ltd	6-3-347/13, Flat No.201, Tejaswi Apartments, Dwarakapuri Colony, Panjagutta, Hyderabad, Andhra Pradesh 500082 Phone: 91 (40) 23351155 Email: rauspower@gmail.com Website: NA
20	FSDF, Electricity	User, Pro-ducer	Redan Infrastruc-ture Private Limited	Plot No- 30, B.N Reddy Colony, Road No. 14, Banjara Hills Hyderabad Andhra Pradesh 500033 Phone: 91-9885449246 Email: gopi@redaninfra.com Website: redaninfra.com

21	FSDF, Electricity	User, Producer	Corporate Ispat	Insignia Tower, EN1, 3rd Floor, Sector-V, Salt Lake, Kolkata- 700 091,Tel: +91 03340012101-04/14 Phone: 91-9333566525 Email: sp.banerjee@abhijeet.in Website: www.abhijeet.in
22	FSDF, Electricity	User, Producer	Maharashtra Vidyut	7th Floor, Shriram Towers, Kingsway, Sadar, Nagpur – 01 Phone: 91-9370334920 Email: amol.kamble@guptacorporation.com Website: www.mahadiscom.in
23	FSDF, Electricity	User	Aeroplane rice	Amir Chand Jagdish Kumar Exports Limited, 12/14, Libaspur Road, Sameypur, Delhi-110042 Phone: 91-9910003844 Email: internationalmarketing@aeroplanerice.com Website: www.aeroplanerice.com
24	FSDF, Electricity	User, Producer	OGPL	Door No 18 / 3, Rukmani Lakshmipathi Road (Marshalls Road), Egmore, 4th Floor, Sigappi Achi Building, Chennai, Tamil Nadu-600008 Phone: 91-9176697355 Email: rmkrishnan@orientgreenpower.com Website: www.orientgreenpower.com
25	FSDF, Electricity	User, Producer	AA Energy	A.A. Energy Limited, No.101, Nikalas Tower, Central Bazaar Road, Ramdaspeth, Nagpur, Maharashtra, 440 010, India Phone: 91-9822571145 Email: aaenergyltd@yahoo.com Website: www.aaenergy.net
26	FSDF, Electricity	User, Producer	Gaps Power and Infrastructure Limited.	Metro Estate 178 C.S.T Road, Kalina, Santa Cruz (E) Mumbai Maharashtra 400098 Phone: 91-9833737857 Email: sumeet@ichibaanhonda.com sumeet@gapspower.com Website: NA
27	FSDF	User	Gupta Exim (India) Pvt. Ltd (GEPL)	144, DLF Industrial Area, Phase I Faridabad Haryana 121-003 Phone: 91-129-4090400 91-9899884150 Email: info@guptaexim.com skagarwal@guptaexim.com

				Website: www.guptaexim.com
28	FSDF, Electricity	User	Malu Paper Mills Limited (MPML)	4th Floor Heera Plaza Near Telephone Exchange, Central Avenue Nagpur Maharashtra 440008 India Phone: 91-9822942011 Email: info@malupaper.com Website: www.malupaper.com
29	Electricity	Distributer	Reliance Power Transmission Ltd	12th Floor, Tower 10 B, Dlf Cyber City, Dlf Gurgaon, Gurgaon - 122002 Phone: (0124) 3917999, 3917975 Email: Customers: energy.helpdesk@relianceada.com Website: www.rinfra.com/ http://www.tradeindia.com/Seller-5129288-Reliance-Power-Transmission-Ltd-/
30	Electricity	Distributer	BEST Undertaking	Best Bhavan, Colaba, Mumbai – 400005 Phone: 022 2414 3611 Email: NA Website: www.bestundertaking.com
31	Electricity	Distributer	TATA Power	Bombay House, 24, Homi Mody Steert, Mumbai 400001 Phone: 91-22 6665 8282 Email: NA Website: http://www.tatapower.com
32	Electricity	Distributer	BSES	New Delhi, Delhi – 110001 Phone: 011 39999707 Email: NA Website: www.bsesdelhi.com
33	Electricity	Distributer	Kerala State Electricity Board Limited	Vydyuthi Bhavanam, Pattom, Thiruvananthapuram, Kerala 695004 India Phone: 91-9446008040, 9446008200, 9446008002 Email: NA Website: http://www.kseb.in
34	Electricity	Distributer	Calcutta electric supply corporation	Victoria House, Chowringhee Square, Kolkata, West Bengal, India Supplies Department Address: 20/1, KUSTIA ROAD, KOLKATA- 700 039 Phone: 91-9831026446, 91-9831740410 Email: partha.bhattacharya@cesc.co.in abhik.bhattacharya@cesc.co.i Website: http://www.cesc.co.in

35	Electricity	Distributer	Southern Electricity Supply Company Of Orissa Limited (SOUTHCO)	Corporate Office: Courtpeta, Berhampur, Ganjam, Orissa - 760 004 Phone: 91-91674-2558727 Email: southco_berhampur@rediffmail.com Website: http://www.southcoodisha.com
36	Electricity	Distributer	Power Grid Corporation of India	B-9, Qutab Institutional Area, Katwaria Sarai, New Delhi-110016 Phone: 011-26560112, 26560115, 26560193, 26564892 Email: chetan@powergridindia.com Website: http://www.powergridindia.com
37	Compost	Producer	Poonam Natural	132, Poonam Goushala and Farm, Near Vidyamangal School, Village - Navi Pardi, Taluka - Kamrej, Surat, Gujarat India Phone: 91-9825449149 / 8469549149 Email: m.poonamnatural149@gmail.com nilesh_ahir@hotmail.com Website: http://www.poonamnatural.com/
38	Compost	Producer	Indore Biotech Inputs & Research (p) Ltd.	6, Sikh Mohalla, M.G. Road, Opp. Kothari Market, Indore, Madhya Pradesh India Phone: 91-731-2533323 91-0731-2856324 Email: NA Website: http://www.exportersindia.com/indorebiotechinputs/
39	Compost	Producer	MD Biocoals Pvt. Ltd	Near Vidyapeeth, Barnala Road, Sirsa, Haryana India Phone: 91-9468340000 Email: inquiry@mdbiocoals.com Website: http://www.mdbiocoals.in
40	Compost	Producer	Sri Gayathri Biotec - India	Near Ayyappa Swamy Temple, G. B. C Road, Kattempudi., Ponnurr, Andhra Pradesh India Phone: 91-8643-243158 Email: sgbt09@gmail.com Website: www.srigayathribiotec.com/