UK INDIA BUSINESS COUNCIL

Sustainable Municipal Waste Management in India

White Paper on Removing Barriers to Sustainable Municipal Solid Waste Management using Anaerobic Digestion in India

Delhi, India

Table of Contents

UK INDIA
BUSINESS COUNCIL

Executive summary

India is the 5th largest economy in the world today with an ambition to become a USD 3 trillion economy (making it the 3rd largest economy in the world) by 2025. Accompanied by this ambitious target is the fact that in a similar timeframe India will be the most populous nation with its urban population increasing at a rate of 3-3.5% per annum.

Nonetheless, this surge brings about an increase in urbanisation and demand across utilities such as food, water, energy, housing, and sanitation. These multifaceted requirements are crucial for the economic growth, but it must be ensured that the economic growth is backed by sustainability and judicious utilisation of natural resources.

As we see today, with the rapid increase in India's industrial landscape and population, and Government of India's vision for "Power for All", the energy demands have grown manifold and the energy consumption for India is expected to surge from 6 percent at present to 11 percent by 2040. While power generation is expected to increase by 207% to 478% TWh by 2040. To ensure fulfilment of these demands an inevitable pressure will be put on the natural resources. Though there is growth in usage of renewable sources to cater to the growing energy demands, there will continue to be dependence on coal to a very large extent to be the primary energy source almost accounting to 80% of total output by 2040.

It is no doubt that usage of coal to this large extent will only add to India's growing environmental concerns and augmenting CO_2 emissions. Being a signatory to the Paris Agreement and adopting the United Nations 17 Sustainable Development Goals (SDGs), India today must adopt alternatives means of energy generation. And one of the key resources here would be "Waste" – the municipal solid waste, which India generates per annum.

Waste management holds an important key to India's economic development in a sustained and environment friendly manner, by providing a means to effectively utilise the 62 million tonnes of waste which is annually generated in India. Presently, waste contributes to 0.17% of energy generation from the total capacity of 80GW, and this presents a huge opportunity for India, where otherwise the waste is largely disposed of in a non-environment friendly manner in landfills.

Not only from the point of environment, waste management and utilisation of waste as an energy resource will lead to preservation of finite natural resources, free electricity charges from volatility and external influences, reduce dependence on imports, while simultaneously improving India technology and innovation space, create opportunities for direct and indirect employment, and augment the clean water and air sanitisation efforts in a cost effective and sustainable manner.

However, India lacks proper regulatory mechanisms and policy framework, which necessitates the government at all levels Centre-State-Municipality to develop conducive and coherent policies allowing technology usage and technology transfer for effective waste management. Further, availability of less expensive alternatives for waste disposal, lack of indigenous technologies, high capital, high maintenance, and operational costs of waste-to-energy treatment systems have rendered a slow growth to the sector.

Incineration is the most widely used method in India when it comes to generating energy from waste. Even the central finance assistance scheme encourages use of incineration along with composting as the appropriate usage for energy, but still the effect incineration has on the environment cannot be negated.

Presently, methods being used for waste to energy conversion work best with dry organic waste, but in a country such as India, where segregation of waste is a challenge and with presence of mixed waste, technologies such as Anaerobic digesting, composting are also gradually gaining ground and should be considered as positive alternatives to achieve the 5690 MW of energy potential from waste.

The optimal technological solution is one that has the lowest carbon emissions and maximises recycling and energy recovery. Recycling should be maximised at households and through the engagement of the informal sector. Food waste and readily biodegradable waste should be sent to localised distributed anaerobic digestion facilities, either with renewable electricity, heat and cooling generation or the production of biomethane for grid injection or vehicles. Composting is optimal for green waste streams that cannot be digested. The remaining stream, subject to having high calorific value, can then be used in smaller efficient energy from waste (incineration) facilities that can be linked into district cooling schemes.

In February 2020, the Ministry of New and Renewable Energy issued revised guideline for its Waste to Energy Programme, where along with industrial, urban, agricultural and residual waste, municipal solid waste was also included. This led to the revision of the central financing assistance guidelines that earmarked Rs 400 Crore towards energy generation from MSW with the target of generating 200 MW of energy. This is a positive step towards recognising the value of municipal solid waste and technologies which can be harnessed to generate energy.

Also, our learnings from the recent situation of the COVID-19 pandemic showcases the utmost requirement attached to proper hygiene and a sanitised environment as an imperative for the economic environment to remain stable and functional, thus mandating the requirement of environmentally friendly solutions and technologies to be used for managing waste and generating energy from waste.

This focus of this paper, therefore, is on the different technologies that are available, such as anaerobic digestion, composting, incineration, and the technologies that would be advisable for India to fulfil its Paris Agreement, SDGs as well as achieving sustainable economic growth. The paper also focuses on the regulatory and policy framework on how India has assimilated “municipal solid waste” as a means for energy generation and conservation.

Authors

Surbhi Mathur, UKIBC
Abhijit Rajguru, Clarke Energy
Alex Marshall, Clarke Energy

Table of acronyms

BM	Bio Mass
BU	Billion Units
Bio-CNG	Bio-Compressed Natural Gas
BioSNG	Bio-synthetic Natural Gas
CHP	Combined Heat and Power
Cogen	Cogeneration
CO_2	Carbon-dioxide
Cr/Mw	Crore per Megawatt
Const.	Construction
GHG	Greenhouse gas
Gt	Giga tonnes
GWh	Gigawatt Hours
GW	Gigawatt
GoI	Government of India
kWh	Kilowatt Hour
MJ/Kg	Megajoule per kilogram
MJ/m3	Megajoule per cubic meter
MW	Megawatt
MSW	Municipal Solid Waste
MNRE	Ministry of New & Renewable Energy
MoEF&CC	Ministry of Environment, Forest & Climate Change
NPK	Nitrogen, Phosphorous, Potassium
NGT	National Green Tribunal
PPP	Public Private Partnership
PPA	Power Purchasing Agreement
RE	Renewable Energy
RES	Renewable Energy Sources
RDF	Refuse-Derived Fuel
RNG	Renewable Natural Gas
SDG	Sustainable Development Goal
SWM	Solid Waste Management
TPI	Tecno Project Industriale
Tpd	Tonnes per Day
TWh	Terawatt Hour
ULB	Urban Local Bodies
WtE	Waste to Energy

Introduction

India, home to 1.38 billion people with an annual growth in the population of 1.08 percent, is now the world's 5th largest economy. At the same time, India is one of the fastest growing economies in the world, achieving annual economic growth of around 6 percent in the last decade. India has set an ambitious growth target of being a $5 trillion economy by 2030, which would make it the 3rd largest economy in the world and by 2050 it is predicted to be the 2nd largest economy.

Not just in terms of economic superpower, India is also witnessing an upsurge in population growth and is expected to be the most populous nation before 2027, which is a very near future. The urban population stands at around 35 percent of the total population with an increase of 3-3.5 percent expected annually. This rapid urbanisation growth brings with itself multifaceted challenges, which, if approached judiciously can be converted into opportunities contributing significantly to the economic growth of the nation.

One such challenge is management of 'waste', which is now globally defined as a 'resource' for recycling into useful products or for generating energy. Industrialisation and urbanisation together have a cumulative effect on generating significant amounts of urban solid waste which leads to increasing threats to the environment. Waste management is an important area to be prioritised given the role it plays in creating sustainable cities and improving quality of life through improvements in public health and hygiene and simultaneously generating opportunities of employment and protecting environment.

Robust growth in prosperity and population size drives a massive increase in India's primary energy consumption (for example, India at present is incurring Rs. 4.5 lakh crore on crude imports), which expects to expand by 1.2 billion tonnes of oil equivalent, or 156 percent, by 2040, making India by far the largest source of energy demand growth. This growth in absolute terms will mean that India's share of global primary energy demand jumps from 6 percent today to 11 percent by 2040. Power generation increases by 207 percent to 4,781 TWh by 2040, accounting for 61 percent of world primary energy demand growth. With this, the pressure on natural resources to fuel the demand would only rise in the future.

Despite growth in renewables, coal would continue to dominate India's power generation mix, accounting for 80 percent of output by 2040. India's total net CO_2 emissions roughly double to 5Gt by 2040, meaning India's share of global emissions increases from 7 percent today to 14 percent by 2040. It is thus imperative for the country that in addition to utilising renewable sources like wind and solar, India harnesses the energy locked in its waste by applying appropriate waste to energy technologies contributing positively to climate change.

India’s power and energy sector – A Changing Landscape

During the last decade total electricity generation in India grew from 805.4 Billion Units (BU) in 2009-10 to 1389.1 BUs in 2019-2020. The Government of India’s (GoI) focus on attaining ‘Power for All’ has accelerated capacity addition in the country. At the same time, the competitive intensity is increasing at both the market and supply sides (fuel, logistics, finances, and manpower).

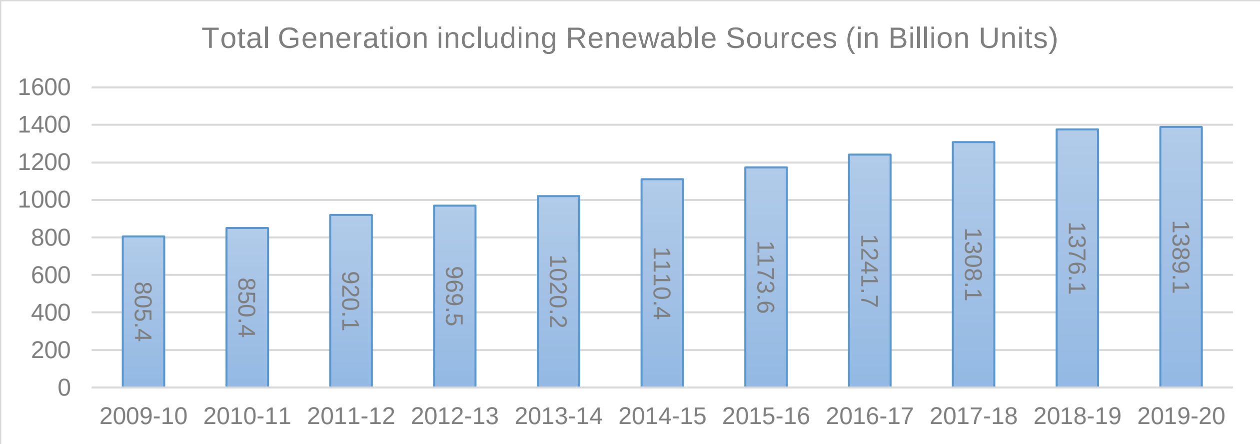


Chart 1: Electricity Generation (in Billion Units) (Sources: Central Electricity Authority, 2. Ministry of Power 2. Ministry of New and Renewable Energy)

It is equally important to note that going forward renewable sources such as wind, solar, biofuels and water will contribute a big way in meeting the electricity demand within the country. India currently has an installed renewable energy capacity of around 80 gigawatts (20 percent of the country’s total installed capacity) and is planning to achieve 175GW (100GW solar + 60GW wind power + 10GW Bio-power + 5GW small hydro) of renewable energy by 2022 and 225GW including large hydro. The share of renewable energy in India's electricity mix (including hydro) is set to increase to around 55% by 2030, as the country continues to expand its installed capacity in the face of growing power demand.

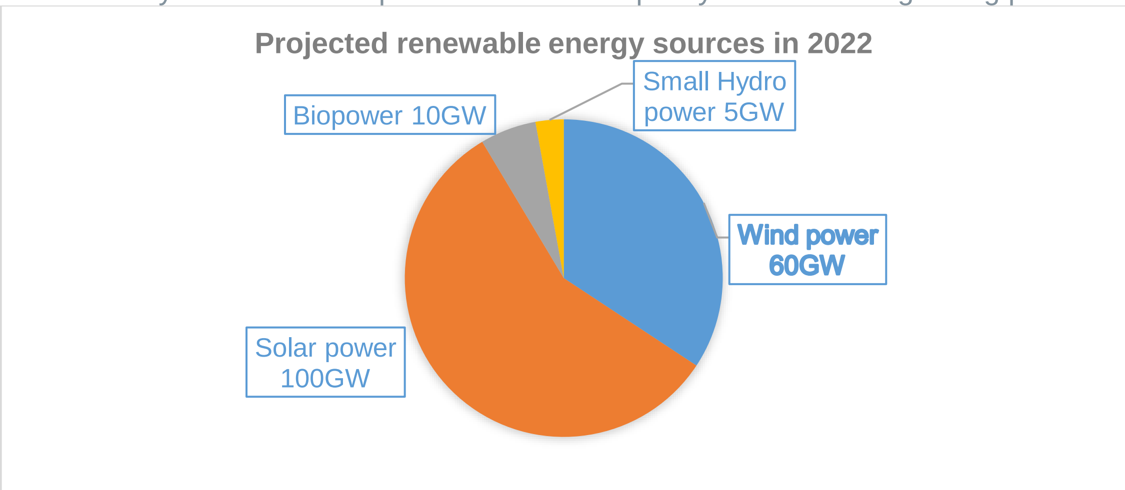


Chart 2: Projected Renewable Energy Sources in India in 2022 (in GW) (Sources: Central Electricity Authority, 2. Ministry of Power 2. Ministry of New and Renewable Energy)

As part of the Paris Agreement, India committed to produce 40 percent of its installed electricity capacity from non-fossil fuel sources by 2030 and as per latest reports, India must achieve around 30% including power produced from hydro power plants.

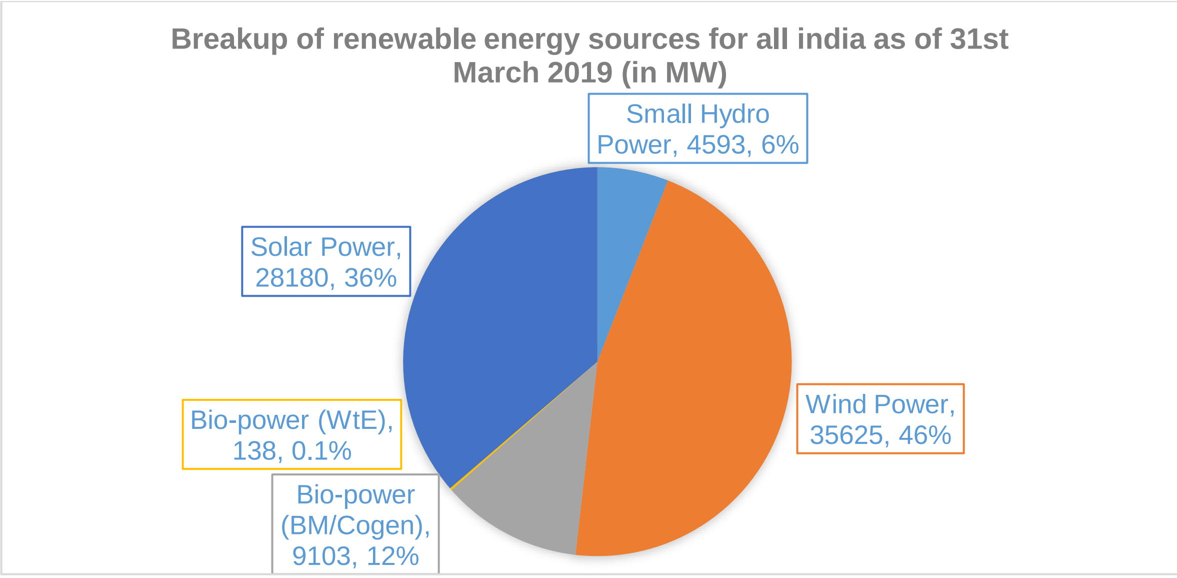


Chart 3: Renewable Electricity Mix as on 31st March 2019 (Sources: 1.Central Electricity Authority, 2. Ministry of Power 3. Ministry of New and Renewable Energy, 4. http://swachbharaturban.gov.in/)

Referring to the chart above, amongst the renewable energy sources, wind power has the highest contribution followed by solar. Together, they contribute to 82 percent of India's renewable energy. Waste to energy projects contribute circa 138.3 MW (current electricity production level from WtE projects 61MW as per Government of India http://swachhbharaturban.gov.in/) to the total capacity of approx. 80GW, which translates to 0.17% contribution.

Meeting a large portion of the power needed for India's growing economy with renewable energy could potentially bring vast benefits. To capture the benefits, India would need to raise the necessary capital, and get comfortable with managing the variability and uncertainty of renewable energy generation. Renewable energy brings enormous benefits — zero fuel, electricity prices free from volatility and external influence, reduced imports, dramatically reduced pollution, and water use. To take advantage of India's renewable energy potential, policies and programmes were put in place and going forward both State and Central Government have agreed to support the engagement, participation, and new behaviours of power sector stakeholders including RE industry and developers, grid operators, public and private finance, and consumers.

With increased support of the government, the sector has become attractive from the investor perspective. Government plans to establish renewable energy capacity of 500 GW by 2030.

One important aspect associated with wind and solar photovoltaic is output being variable, and in the case of wind, subject to uncertainty. Under these circumstances, considering the dual pressing needs of waste management and reliable renewable energy source, policy makers are seriously looking at the waste to energy sector in India.

As per latest reports, India has so far installed 96 waste to energy projects for generation of power based on urban, industrial, agricultural, and municipal solid waste and the total estimated energy generation potential from urban and industrial organic solid and liquid waste in India is approximately 5690 megawatt.

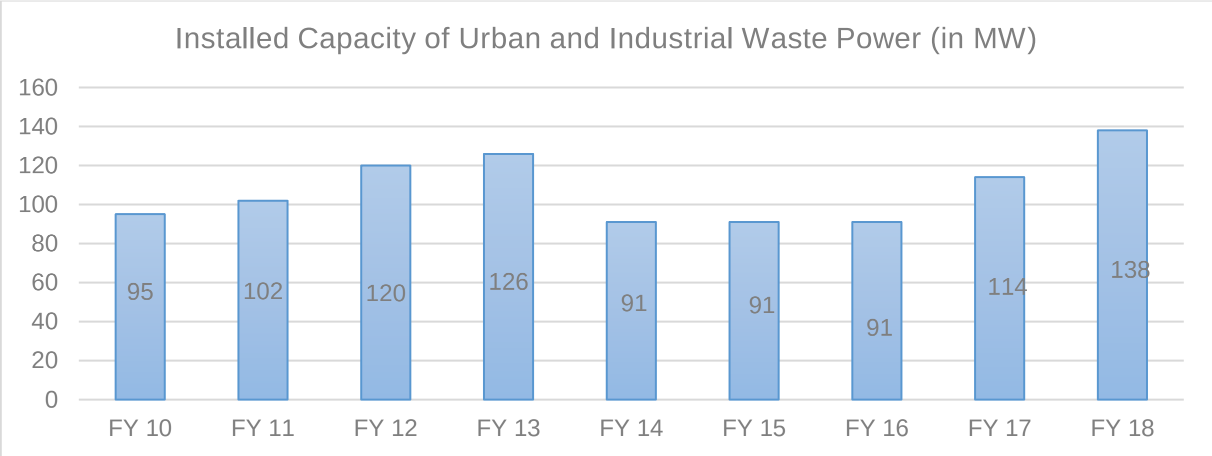


Chart 4: Installed Capacity of Urban and Industrial Waste Power (in MW) (Sources – 1. Ministry of Power, 2. Central Electricity Authority)

However, lack of efficient mechanism to segregate waste into biodegradable, dry and wet carbonaceous materials remains a major challenge for waste to power plants. Moreover, availability of less expensive alternatives for waste disposal such as municipal landfills, lack of indigenous technology, and high capital and operation and maintenance costs of waste-to-energy systems are challenges hindering the growth of these plants.

Waste and sustainable development goals

India's sustainable development goals (SDGs) cannot be met unless waste management is addressed as a priority. SDG 1 aims for No Poverty. In India, many people in the urban population make their living from recovering recyclable materials from waste (SDG 8 – Decent Work and Economic Growth). These informal waste champions provide a valuable and often no-cost service, and it is important that we recognise their role in urban sanitation and resource efficiency (SDG 10 – Reduced Inequalities). Failing economic models treat resources as if they were infinite (SDG 12 – Responsible consumption and production) and consumption patterns favour the disposable. How can we continue with a growing and increasingly urbanised global population without getting waste sorted? If we want clean water and sanitation (SDG 6), we need to consider waste.

Waste from the manufacture of food products can be fed to animals, and inedible remains converted into biogas and clean renewable energy (SDG 7). The formal waste management sector, employing another 20 million globally, is a current hotbed of inspiration and innovation (SDG 9 – Industry, Innovation and Infrastructure). Attracting millennials, entrepreneurs and industry heavyweights, waste management provides excellent opportunities in science, technology and engineering, humanities, business studies and IT (SDG 4 – Quality Education).

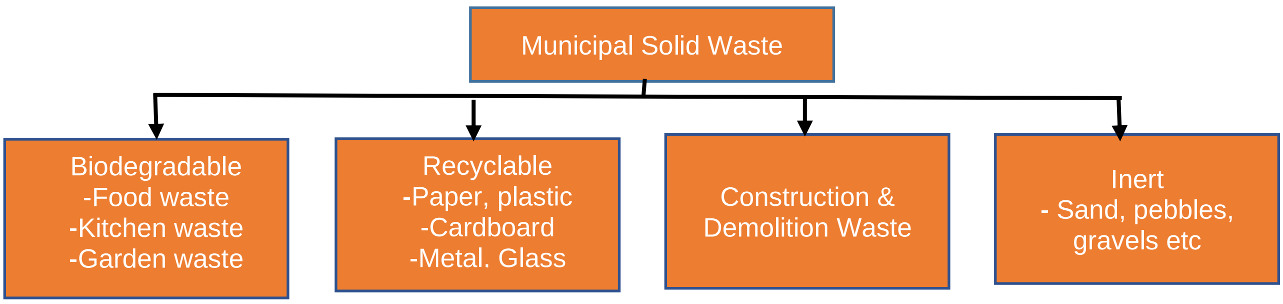
The rewards of waste management are huge. For our communities to prosper as healthy and resilient places to live, governments must urgently invest. Even the poor choose to pay for waste management (or participate in it) when they see its benefits. Producer responsibility schemes and crucially – fiscal transparency – can help ensure everyone pays their fair share to keep the planet clean.

Regulatory framework on waste management in India

Classification of waste is based on:

- Physical state - Solid waste, liquid waste and, gaseous waste
- Source - Household/domestic waste, industrial waste, agricultural waste, commercial waste, demolition and construction waste, mining waste and biomedical
- Impact on environment - Hazardous waste and non-hazardous waste

Now, let us see the classification of municipal solid waste:



As shown above, municipal solid waste (MSW) includes commercial and residential wastes generated in municipal or notified areas in either solid or semi-solid form excluding industrial hazardous wastes but including treated bio-medical wastes. It consists of household waste, wastes from hotels and restaurants, construction and demolition debris, sanitation residue, and waste from streets.

For this paper, we will focus only on waste management for biodegradable component of municipal solid waste through new and identified technologies and the impact it will have on the Indian economy, environment, and health.

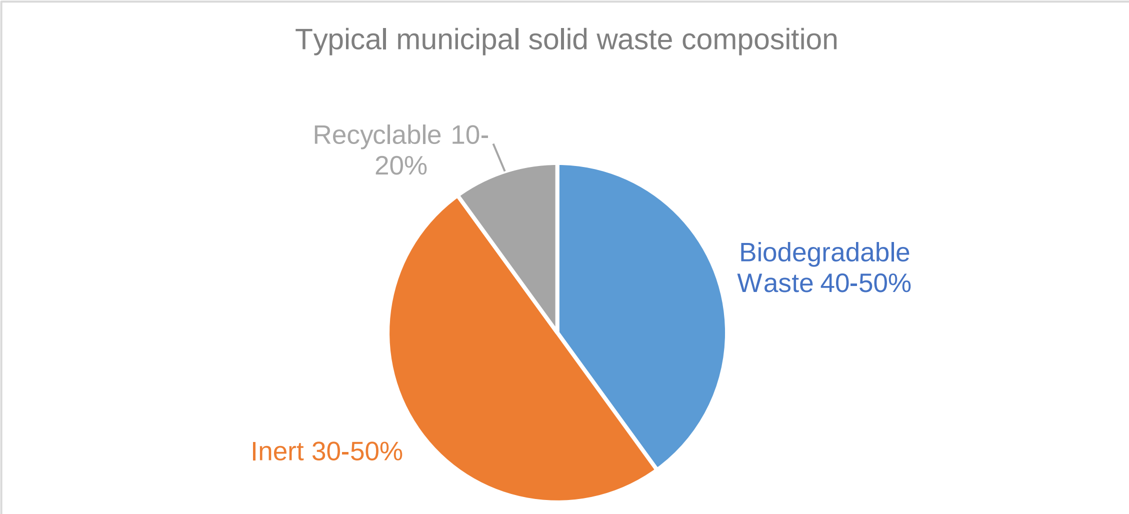
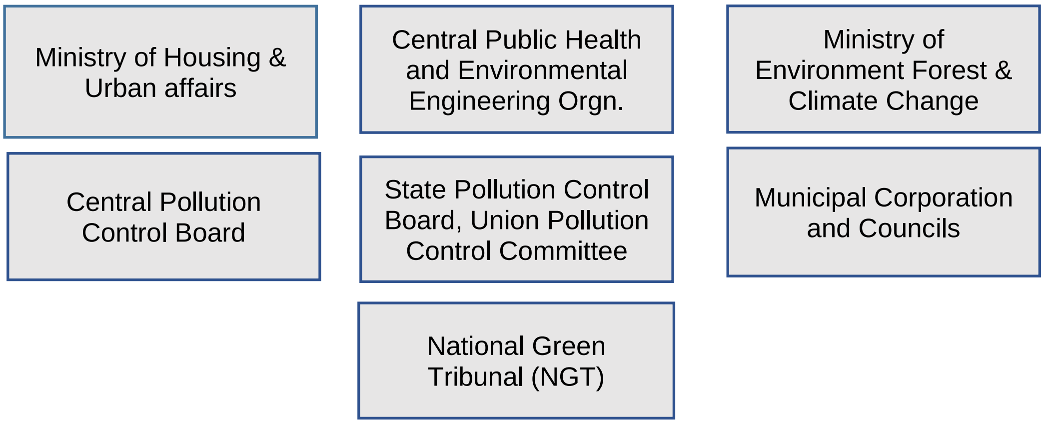


Chart 5: Typical municipal solid waste composition in India (Source: Various sources)

In India, it is the states who are vested with the constitutional right to plan, implement, operate, and maintain water supply projects, sanitation, and solid and liquid waste (sewage and effluent). Thus, waste disposal in India is mostly an act of local administration – of village Panchayats, Town, and City Municipalities with regulatory policies being enforced by State Government. The Central Government also has several major ministries dealing with the subject, primarily due to the role of multilateral funding and multilateral environmental treaties.

Institutional framework for waste management in India:



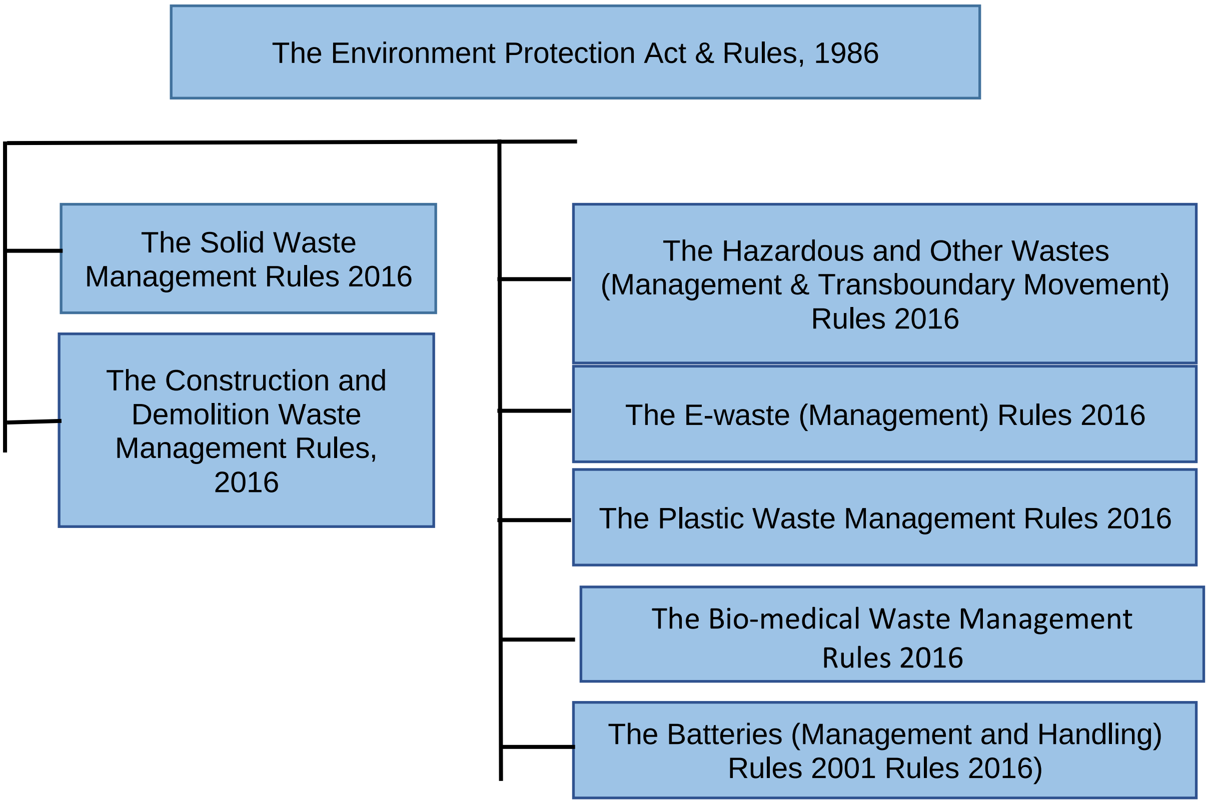
Thus, waste management in India is a multi-stakeholder responsibility. There are also a number of parastatal agencies, corporates, and civil society organizations who play an important role in this sector. One important stakeholder to note is the informal sector or the unorganised sector which involves the rag pickers, manual scavengers, rickshaw pullers or dumpster loaders. This informal sector is the first link which is directly involved in collection and segregation of waste and unfortunately are not governed by any of the governing bodies.

Municipal solid waste which comprises of both commercial and residential waste is governed by the Municipal Solid Waste Management and Handling Rules, 2016 and involves various activities and follows the below value chain:

The collection of waste, which is primary and secondary collection, happens at a door to door level which is also the most significant step in segregating the waste. Subsequently, transportation, intermediary storage in a transfer station, process and treatment and disposal in an environmentally sound manner.

Several studies reveal that small towns and cities are more responsible in handling waste generation than the bigger cities.

In India, waste management has been a critical area since India's independence and the current framework is as given below:



The Union Ministry of Environment, Forests and Climate Change (MoEF&CC) notified the new Solid Waste Management Rules (SWM), 2016, which replaced The Municipal Solid Wastes (Management and Handling) Rules, 2000. The new rules have encouraged centralised treatment by implementing waste to energy projects. The new rule does not take into consideration the role of the informal sector. The new rules are now applicable beyond municipal areas and have included urban agglomerations, census towns, notified industrial townships, areas under the control of Indian Railways, airports, special economic zones, places of pilgrimage, religious and historical importance, and State and Central Government organisations in their ambit.

Additionally, the new rules have mandated the source segregation of waste to channelise the waste to wealth by recovery, reuse and recycle. As per the new rules, it has been advised that the bio-degradable waste should be processed, treated and disposed of through composting or bio-methanation within the premises as far as possible and the residual waste shall be given to the waste collectors or agency as directed by the local authority. Waste processing facilities will have to be set up by all local bodies having a population of 1 million or more.

Niti Aayog, the policy think tank for the government of India, is currently the nodal agency working towards securing India's energy goals and developing the integrated energy policy which will focus on meeting India's growing energy needs through renewable and alternate energy resources and reducing India's dependence on imports and conventional sources of energy.

Waste is one such renewable energy resource which Niti Aayog has been advocating for given its importance in fulfilling Sustainable Development Goals for India and suggested setting up of waste to energy plants to clean up solid waste[10]. However, under waste–to–energy, Niti Aayog suggested municipal solid waste be burnt to produce energy[11].

Now, let us analyse the amount of urban solid waste getting generated in India.

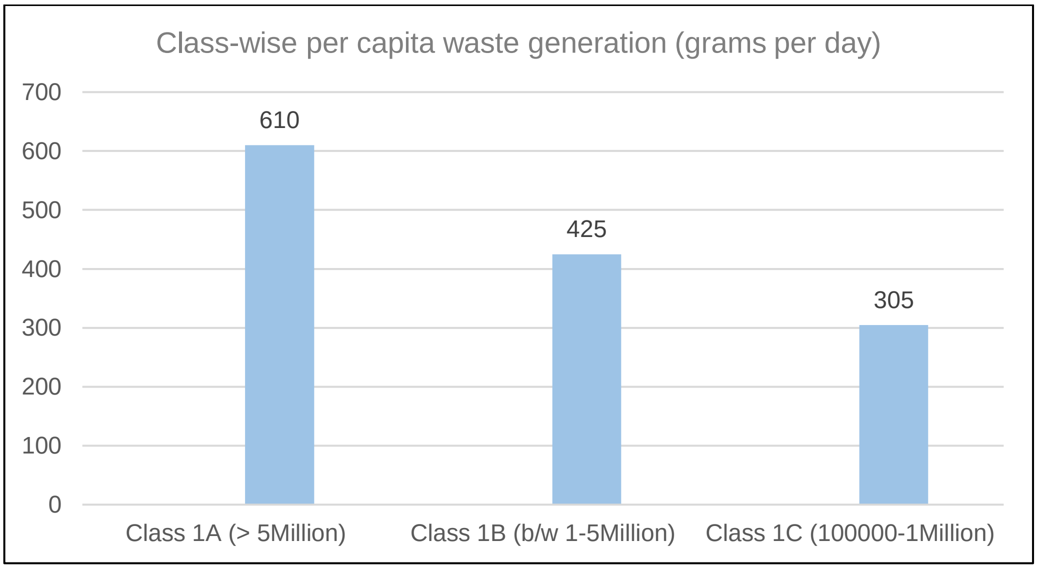


Chart 6: Per Capita waste generation (Source: India Infrastructure Research Report, 2017)

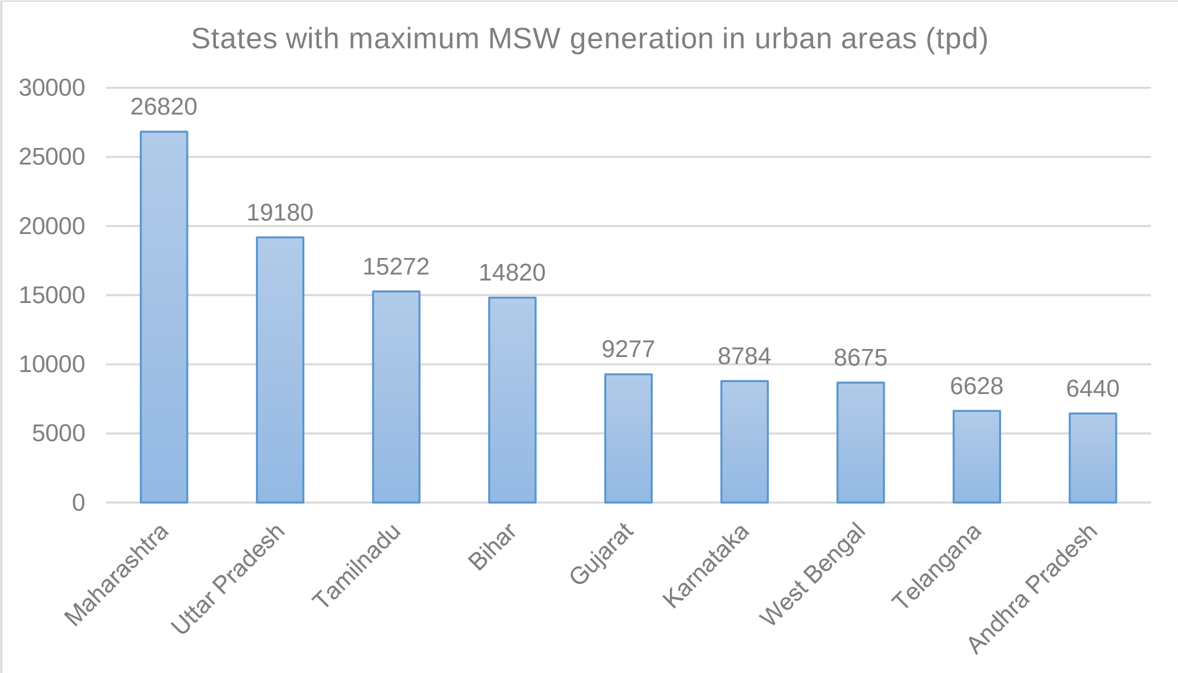


Chart 7: States with maximum MSW generation in urban areas (Data Year' 2017) (Source: India Infrastructure Research Report, 2017)

Note: Data pertaining to Delhi has not been captured above.

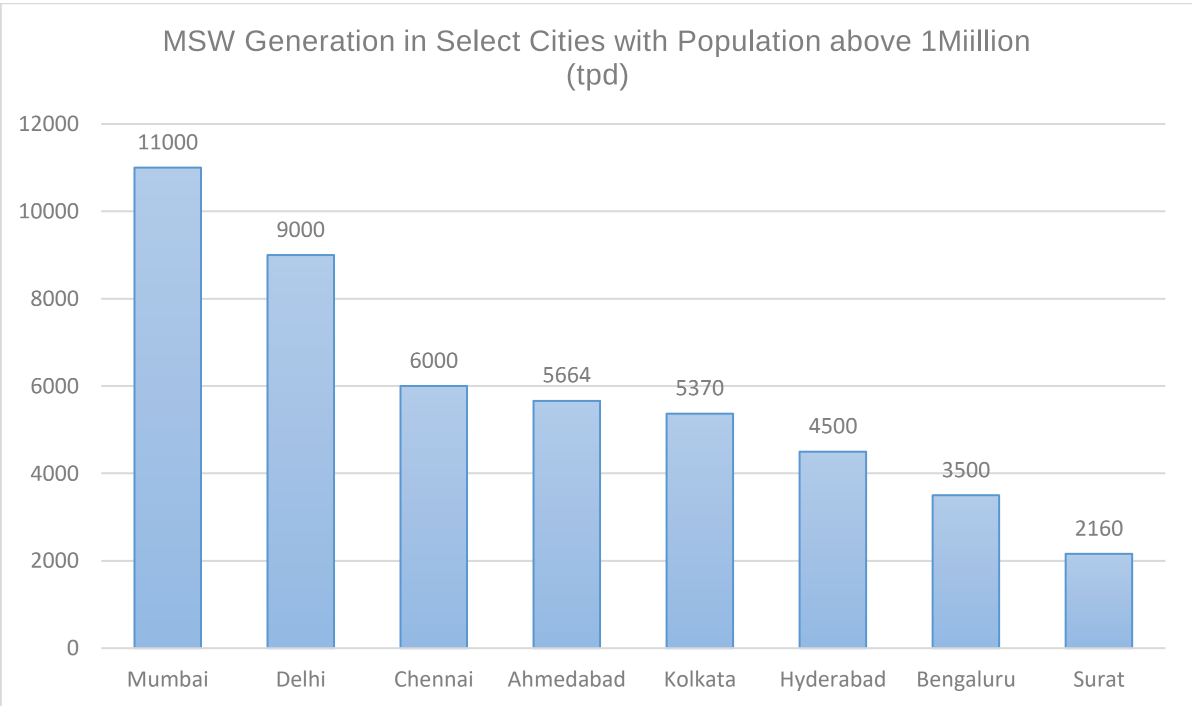
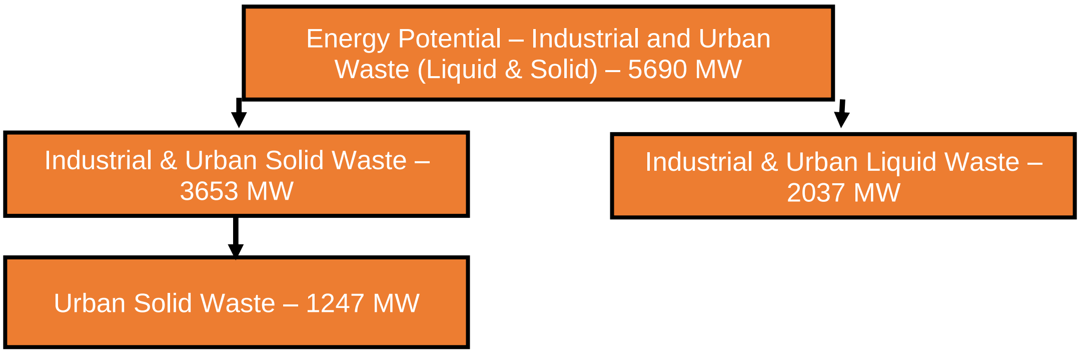


Chart 8: MSW Generation in Select Cities of India (Data from 2017) (Source: India Infrastructure Research Report, 2017)

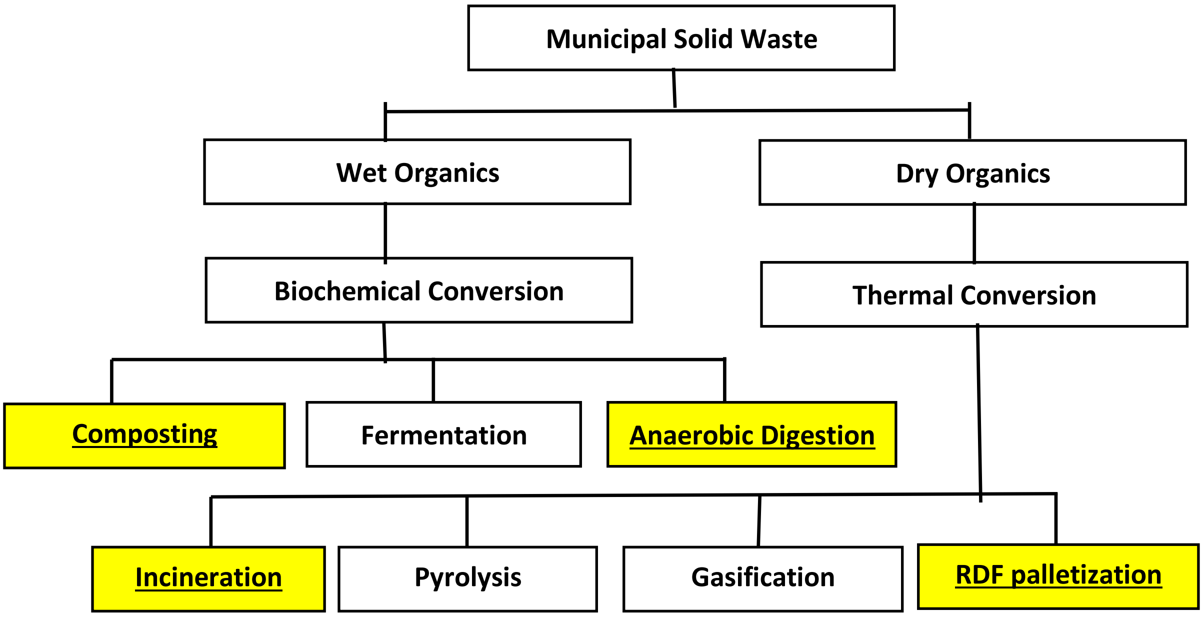
According to latest reports, 62 million tonnes of waste is generated annually in the country at present, out of which about 65-70 per cent of the municipal waste gets collected and only 19-20 per cent of this waste is processed and treated.

Energy can be recovered from the organic fraction of waste (biodegradable as well as non-biodegradable) through thermo-chemical and biochemical methods and the potential is as shown below[13]:



The energy generation potential from urban solid waste is enormous and can be harnessed by using the right technology for treatment.

Biowaste Treatment Technology Options



The above technologies have been taken into consideration by the Ministry of New and Renewable Energy central financing assistance standpoint. In one of the recommendations for modernisation of solid waste management in Class 1 cities within the country, the Supreme Court committee in its report published in March 1999 suggested "composting" of biodegradable waste as method of choice for hygienic waste processing. Although this was reflected in the resulting Municipal Solid Waste (Management & Handling) Rules 2000, the recommendation was politically diluted by the inclusion of loopholes permitting energy recovery and even incineration. As per the new rules 2016, it has been advised that the bio-degradable waste should be processed, treated and disposed of through composting or bio-methanation within the premises as far as possible and the residual waste shall be given to the waste collectors or agency as directed by the local authority. The SWM Rules, 2016 emphasise promotion of waste to energy plants. The rules mandate all industrial units using fuel and located within 100 km from a solid waste-based Refuse-Derived Fuel (RDF) plant to replace at least 5 per cent of their fuel requirement by RDF produced.

Incineration of waste is one of the most common methods of waste disposal that have been adopted in India which can reduce waste mass by 70 percent and waste volume by 90 percent respectively. At the end of the process, it provides steam for electricity generation and co-generation. But due to high organic content (40-50 percent), high moisture content and low calorific value (<4.2 MJ/kg) of the waste generated, as per experts, this process is not best suited for India. Moreover, as compared to biomethanation, the global warming potential of incineration is higher. Since the plants in India handle vast quantity of mixed waste, housekeeping is a challenge leading to significant odour and visual pollution. Also, they must reject 30-40 percent of waste in landfills because they are either inert or too poor in quality to be combustible. Landfills emit by-products which, if left, untreated can leak into the soil resulting in contamination of water sources, plants, and food.

It is possible to combine organic material with other waste streams such as plastics and burn them in an incinerator, then recovery energy from the output. Whilst this might get rid of a problem, this makes little sense from an energy standpoint, as food waste typically consists of 70 percent water and 30 percent solids. Before the solids can be burnt to recover energy, you must evaporate the water from the material.

When used appropriately, biodegradable waste, such as food, sewage and farm residues, is a valuable resource. It can be converted into energy and to create compost, soil improver and fertiliser.

Moreover, as per an order passed by the National Green Tribunal on March 20, 2015, the compostable fraction cannot be used for burning and should be used for compost or biogas. The order also states that the recyclable portion has to be sent for recycling (some products have high calorific value but when burnt they release highly toxic gases) and only the non-recyclable, non-biodegradable waste (textiles, non-recyclable plastic, ceramic) can be sent to these WTE plants. This brings consideration of anaerobic digestion for segregated municipal solid waste within the country.

Anaerobic digestion is a biochemical process that utilises anaerobic bacteria to degrade organic fraction of waste in the absence of oxygen. This method is very useful for wastes containing a high percentage of moisture (>50 percent). After, digestion two end products are released namely biogas (mainly consisting of methane (55–60 percent) and carbon dioxide (30–45) percent having energy content of about 20-25 MJ/m3) and a bio-slurry that can be utilised as organic fertiliser.

Bio-methanation is a solution for processing biodegradable waste, which remains underexploited.

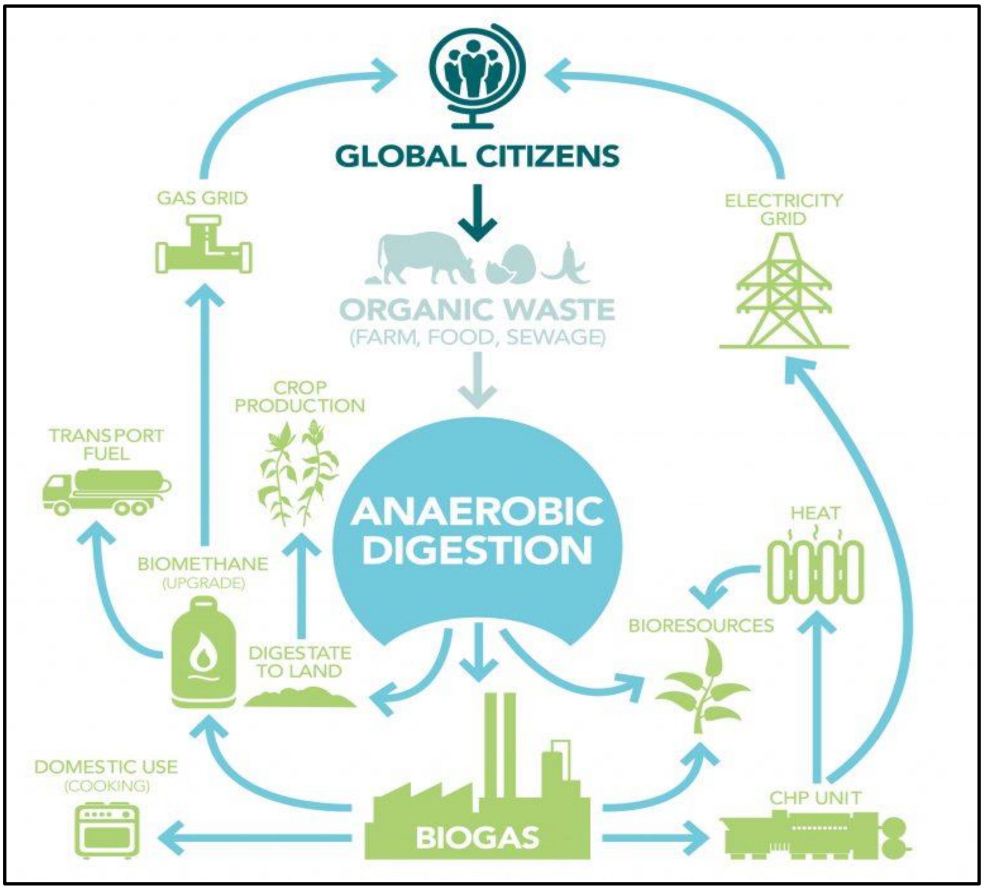


Fig 1: Biogas & anaerobic digestion (Source: World Biogas Association)

In addition to the anaerobic digestion process being a net energy producing process, wherein the renewable fuel can be used for electricity generation, heating purposes and/or biomethane, it also helps eliminates odour producing nutrient rich organic fertiliser, helps maximise recycling and reduces greenhouse gas emissions. The World Biogas Association recently published a report “the Global Potential of Biogas” which highlight the potential of anaerobic digestion technology to reduce global carbon dioxide emissions by 10-13 percent.

In comparison to composting, biomethanation requires less land and reduces disposed waste volume to landfill.

Biogas for electricity and heat (Cogeneration)

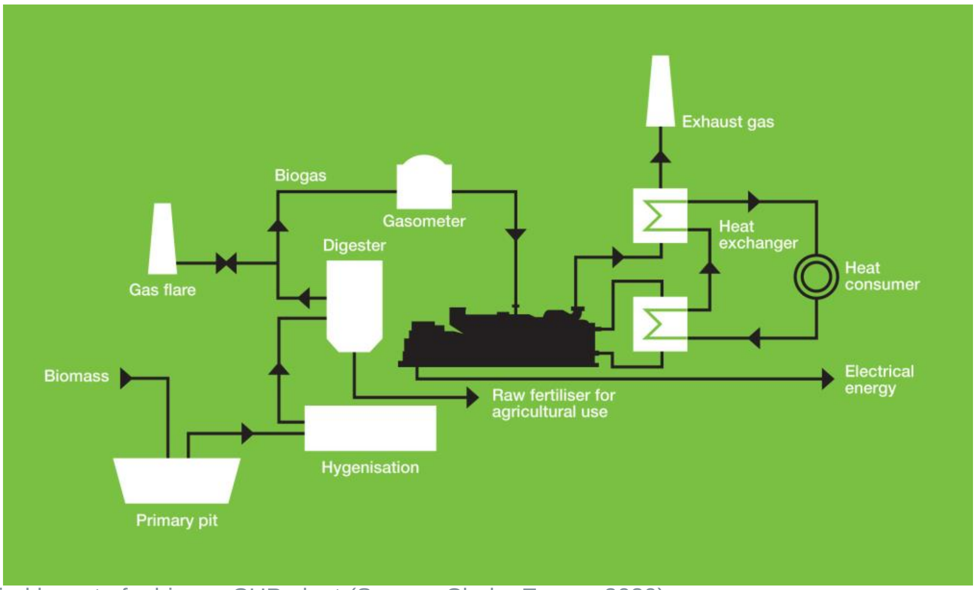


Figure 2: A simplified layout of a biogas CHP plant (Source: Clarke Energy 2020)

District cooling integration
In an Indian context there is growing recognition of the benefits of district energy, most notably district cooling through the United Nation's Environment Program – Cooling Smart Cities initiative. Surplus heat from combined heat and power (CHP) gas engines can be converted into cold water and has the potential to feed into a local cooling consumer, such as air conditioning or refrigeration systems, or could provide an input to a wider district cooling network.

Biogas for biomethane
Biogas upgrading is the process of the separation of methane from the carbon dioxide and other gases from biogas. The concentrated biogas – close to 100% methane is called 'biomethane' or 'renewable natural gas' (RNG). This gas can be used as a vehicle fuel ("bio-CNG") or injected into the gas distribution network.

Biogas upgrading technology can be easily applied to anaerobic digesters, wastewater treatment facilities and landfill sites. Biogas upgrading can be used as a substitute technology to gas engines or can be used in parallel where power and heat are required on site.

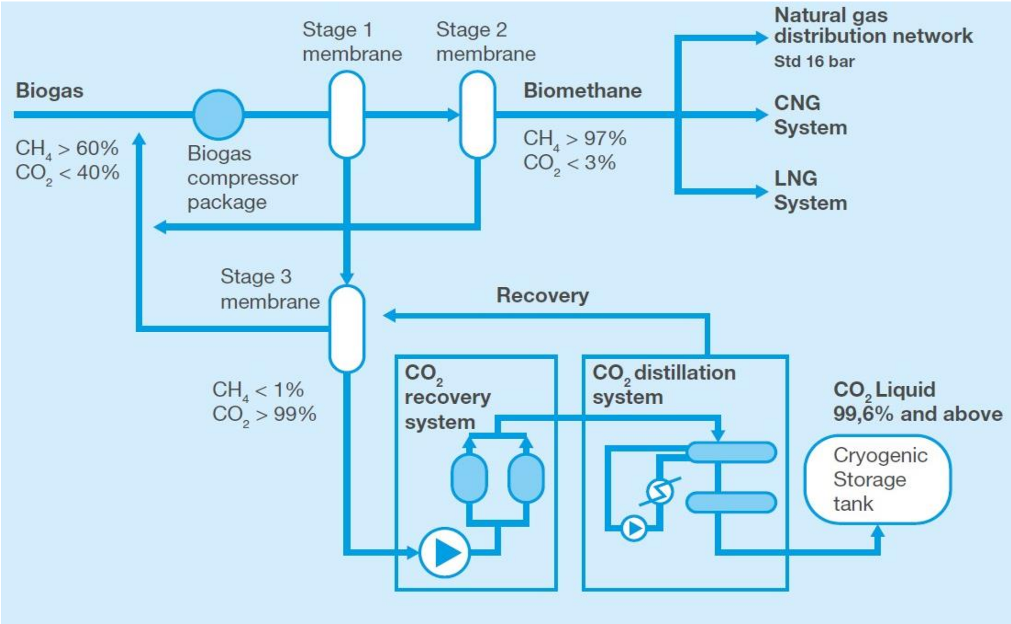


Fig 3: TPI' Italy membrane-based biogas upgrading technology

Digestate options

The beneficial residue from anaerobic digestion consists of a solid and a liquid. The solid is high in carbon and can be composted and used as a soil improver. It is rich in stable carbon that can be used to improve soil health. The liquid residue has value as a sustainable fertilizer with an NPK (nitrogen: phosphorous: potassium of ~ 2-4 : 0.2-1.5 : 1.3-5.2).

The fertiliser manufacturing industry is a key sector in India but is a high energy consumer. Much of this energy is derived from imported fossil fuels. The recovery and use of digestate from solid waste can reduce dependence on energy intensive manufactured fertiliser.

It is possible to combined both the liquid and solid digestates to make beneficial use of both materials for crops.

Composting

Composting is the process by which naturally occurring aerobic decomposition is harnessed. The output of composting is compost, if derived from clean input materials such as green waste or source-segregated food waste can produce high quality material. Composting requires energy, by way of turning compost piles, or in a closed system by agitation. Composting therefore is a net energy consumer. If composting occurs in open windrows there may be Odour problems. The solid digestate from anaerobic digestion can undergo an additional composting phase as anaerobic digestion is less able to breakdown lignin and cellulose than with an anaerobic system.

A summary of features of different biowaste technology types.

Technology type	Electricity	Heat	Biomethane	Compost / soil improver	Ash / tar
Anaerobic digestion	++	++	++	++	
Composting				+++	
Incineration	+1	+			++
Gasification	+	+	+ (BioSNG)		++

(Source:https://www.longdom.org/open-access/comparison-of-technologies-to-serve-waste-to-energy-conversion-47549.html)

India faces major environmental challenges associated with waste generation and inadequate waste collection, transport, treatment, and disposal. Current systems in India cannot cope with the volumes of waste generated by an increasing urban population, and this impacts on the environment and public health.

The challenges and barriers are significant, but so are the opportunities.

Challenges associated with use of Anaerobic Digestion in treating municipal solid waste

The process of anaerobic digestion appears to be a more reliable and promising technology as it not only aims to solve the problem of organic solid waste, but also provides sustainable energy in the form of biogas. Moreover, it eco-friendly and less labour intensive.

In India, the process of anaerobic digestion is still unpopular due to lack of due consideration by the government. Of late, composition of the urban solid waste used as a feedstock is the most important determining factor in the process of anaerobic digestion. The most significant types of solid wastes with considerable anaerobic digestion potential are municipal solid waste (MSW), kitchen waste, garden waste, leave aside energy crops (maize, grass, sugarcane, etc.) as it brings in discussions of food security over energy security.

Investors, policy makers, and the public could benefit from gaining a deeper understanding of the value of investing in biogas systems and a biogas industry. Greater public support for the adoption of biogas systems could result in more opportunity for biogas development. In addition to lack of awareness of biogas benefits, we share few of the other challenges:

Policy and regulatory challenges

In most Indian cities, MSW collection, segregation, transportation, processing, and disposal is carried out by respective municipal corporations and state governments enforce regulatory policies. In some cities, like Mumbai, Chennai, Delhi, Bengaluru, Hyderabad, and Ahmedabad, garbage disposal is done by Public Private Partnerships (PPPs). The private sector has been involved in door-to-door collection of solid waste, street sweeping (in a limited way), secondary storage and transportation and for

treatment and disposal of waste. However, the regulatory framework for the sector has not been updated and equipped with the necessary and execution plans or clauses which mandate effective implementation.

Some of the regulatory challenges which are present in the sector are:

1. Though Solid Waste Management Rules 2016 clearly specifies the duties of all the stakeholders involved, it does not take into consideration any financial implication for non-compliance or non-performance by an urban local body. However, in the recent updates support the sale of compost and RDF and purchase of power from waste energy plants by Discoms. Yet, the cost of electricity produced from biomethanation plants are more expensive (after considering appropriate subsidy as being offered by Ministry of New & Renewable Energy) in comparison to Rs 3-4 per kilowatt hour (kWh) from coal and solar plants. Hence, discoms are not interested to buy such expensive electricity when cheaper ones are available.

2. According to SWM Rules 2016, it is the duty of every waste generator to segregate and store the waste in three different bags for biodegradable, non-biodegradable, and hazardous waste, respectively and hand it over for proper disposal. However, despite several efforts and heavily spending on municipal solid waste management, it remains one of the most neglected areas of urban development leading to failure in tapping the resource value of waste.

3. The SWM Rules 2016 mention user fee to be charged by urban local bodies for solid waste management. Charges, if being levied are not helping to meet the objective of waste segregation at source nor helping municipalities offset the operational costs of the service. Those who use the service should contribute towards it.

4. India’s pollution thresholds – as mentioned in the SWM Rule 2016 are already significantly more relaxed than, say, most European countries. But the impact of pollution would be much higher in a densely populated country like India than in Europe. The Solid Waste Management Rules 2016 has limited directives stated towards the implementation of incineration technology. In India, due to lack of proper management and resource availability, waste is mainly burnt in many instances.

5. Though the SWM Rules 2016 state that it is the duty of Secretary–in charge, Urban Development in the States to ensure identification and allocation of suitable land for setting up processing and disposal of solid waste, lack of coordination amongst stakeholders (in specific to municipalities, state government and central government) leads to poor strategy for implementation at every step in the process.

Financial challenges

1. Heavy reliance on government subsidies. Also, Central Finance Assistance for municipal solid waste (n segregated form) biogas power plant is Rs. 3.0 Cr./MW ($397K per MW) whereas that using incineration or any other thermal technology is Rs. 5.0Cr./MW ($662K per MW)

2. Lukewarm response of banks and financial institutions including weak supply chain.

3. Low level of private sector participation due to lack of market and debt finance for the projects.

4. Difficulties in obtaining long-term Power Purchase Agreement (PPAs) and reasonable tariff from state Discoms.

5. Government's heavy focus on solar and wind has impacted development of waste-to-energy sector, though WtE projects aims to reduce the colossal amount of solid waste accumulating in cities and towns all over India.

Project and structural challenges

1. Lack of technical and financial feasibility of the projects – primarily due to improper revenue estimations, waste generator charge collection and estimating contingencies. For example, resistance from locals (all waste-to-energy technologies are not clean and green), antisocial elements creating hurdles in waste collection and transportation and availability of realistic risk assessment models.

2. The scale of the problem is unclear, as there is no authentic and reliable data available for waste generation quantities and disposal. In unison, India lacks adequate environmental, technical, and economic performance data related to biogas-system production of energy, co-products, greenhouse gas and other emissions, and water quality benefits, required market analysis standpoint.

3. Poor town planning and spatial framework to facilitate appropriate distributed waste treatment and energy generation facilities in urban areas.

4. Scarcity of land.

5. Quality of waste - The fundamental reason for the inefficiency of WtE plants is the quality and composition of waste. MSW (municipal solid waste) in India has low calorific value and high moisture content. As most wastes sent to the WtE plants are unsegregated, they also have high inert content. These wastes are just not suitable for burning in the incineration technology driven plants. To burn them additional fuel is required which makes these plants expensive to run.

6. Non-integration of informal sector – one of the largest and most significant stakeholders in waste treatment is the informal or the unorganised sector involving waste pickers, informal rag pickers. They are also the first point of contact responsible for collection and segregation of waste as well. Low levels of awareness within this segment effects the quality of waste generated. Unfortunately, this sector is not managed or controlled by the ULBs or State or Central government, hence it becomes challenging to monitor and manage their activities.

7. Although many people are involved in this sector, SWM has a lower priority than sanitation, health, and other issues.

8. In India, WtE projects are extremely complicated and expensive to build. In addition to other economic streams, waste-to-energy projects usually require high tipping fees. A tipping fee is what the trash hauler must pay to dump the trash at the facility. With WTE projects, the tipping fee can end up being 50-60 percent of the overall revenue stack and this money needs to come from municipalities, all of which are not financially self-sufficient.

Technology challenges

1. Appropriate technology solutions which are environmentally friendly and can treat the quality of mixed waste generated in India is not economical. The treatment technologies which are available require mechanical separation using trommels, screens air density separators or else manual separation in smaller plants. This adds to project costs.

2. The technology options for waste to energy are not yet established thus leading to uncertainty with the implementing agencies about the suitability of technologies and preparedness of urban local bodies (ULBs) for managing these projects.

3. There has been a failure in the incineration plants due to their inability to handle mixed waste. The WtE plants have also triggered widespread criticism among citizens on account of the environmental impact it has.

4. The public private partnership which can sustain such technology solutions is insufficient to due lack of funds.

Conclusion: Failure of waste-to-energy projects is mainly attributed to non-economic feasibility, lack of sustainable planning, high cost technologies, non-availability of the required segregated waste and lack of coordination between the stakeholders.

Recommendations

Central Government

Central government should evaluate the potential of a tax on the dumping of waste to make sustainable waste treatment technologies more commercially viable.

States

All states should have a solid waste management authority with experts on various aspects of MSW, including selection of appropriate waste to energy technology suitable for the different type of waste composition, contracting, financial management along with the overall long-term carbon emission reduction potential of a given scheme. This authority may be made responsible for the following:

- Document the status of SWM and create a mechanism for continuous update of the status.
- Assess the correct situation of MSW in the municipal areas within a state and identify the gaps that need to be bridged.

- Prepare norms for assessing the requirement of tools, equipment, vehicle, manpower for collection and transportation of waste and for setting up processing and disposal facilities as per guidelines outlined.

Urban Local Bodies:

- All municipal corporations should have MSW Management Department alongside minimum technical and supervisory staff to ensure efficient MSW service delivery and strengthen urban local bodies to enter contracts.
- Efforts should be made to educate the waste generators to minimize the waste and segregate the waste at source.
- Informal and unorganised sector should be assimilated in this process and awareness amongst them should be created on proper waste collection and segregation methodology. They play an important role in solid waste management within the country.
- Separate arrangements for collection, transportation of domestic, trade, institutional and market should be made to ensure that such waste is directly delivered at the waste processing facility meant for biodegradable and recyclable waste.
- Improvements to be made to town planning. Suitable sites should be earmarked at local level for the development of sustainable waste treatment infrastructure.

Technology

- Different technologies for treating different kind of waste are available in the market. Applying all the possible technologies in an integrated way can help to reach the goals of sustainability. Therefore, open dumping and unsanitary landfilling are not sustainable options and cannot be recommended for treating waste.
- Increase in quantum and complexity of waste with increase in population, economy of the country and fluctuations in crude prices have demanded serious consideration of biomethanation technology implementation wherein high calorific value biogas generated can be used for electricity and/or as transportation fuel.

With proper municipal solid waste management facilities, the Government of India, other ministries and nodal agencies involved in this sector have the opportunity to improve the living condition of urban and rural people, improve public health, conserve resources, mitigate GHG emissions and generate energy by adopting appropriate technology.

Also, rapid depletion of non-renewable energy resources and the threat of global climate change have forced the energy sector in India to look for alternative sources of energy to generate enough energy and preserve the environment at the same time. Unfortunately, the technology for utilisation of green energy remains very expensive or unable to satisfy India’s need for energy, or both. There is, however, one alternative source of energy which has great potential when it comes to efficient power generation at acceptable cost – biogas.

Utilisation of biogas for electricity and/or biomethane will bring in various other stakeholders into consideration and other challenges, an aspect not covered under this study.

References

1. PwC Report on Waste management in India: Shifting Gears
2. Niti Aayog
3. https://mnre.gov.in/waste-to-energy/current-status
4. https://www.deccanherald.com/city/life-in-bengaluru/five-new-waste-to-energy-plants-to-handle-mixed-trash-761627.html
5. https://powermin.nic.in/en/content/power-sector-glance-all-india
6. Revised guidelines of waste to energy program dated 28-02-2020
7. www.seas.columbia.edu/earth/wtert/sofos/MSWM_India_-Choice_of_Technology_recommendations.pdf 15)https://www.thehindu.com/news/national/wasted-effort-half-of-indias-waste-to-energy-plants-defunct/article26273068.ece
8. India Infrastructure Research Report, 2017
9. https://mnre.gov.in/waste-to-energy/current-status
10. https://economictimes.indiatimes.com/news/economy/policy/niti-aayog-suggests-waste-to-energy-plants-to-clean-up-solid-waste/articleshow/60244081.cms
11. https://www.downtoearth.org.in/news/waste/burn-it-all-58827
12. https://powermin.nic.in/en/content/power-sector-glance-all-india
13. https://www.livemint.com/news/india/india-plans-to-set-up-500gw-of-renewable-energy-capacity-by-2030-1561474737868.html
14. https://economictimes.indiatimes.com/industry/energy/power/renewables-to-account-for-55-of-total-installed-capacity-by-2030-rk-singh/articleshow/64737298.cms?from=mdr
15. http://www.cea.nic.in/reports/monthly/installedcapacity/2019/installed_capacity-03.pdf
16. https://energy.economictimes.indiatimes.com/news/power/india-has-installed-96-waste-to-energy-projects-so-far-power-minister-r-k-singh/72874213
17. https://www.worldometers.info/world-population/india-population/
18. https://www.indiatoday.in/business/story/india-becomes-world-fifth-largest-economy-overtakes-uk-france-report-1647446-2020-02-18
19. https://www.worldometers.info/world-population/india-population/
20. https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/energy-outlook/bp-energy-outlook-2019-country-insight-india.pdf
21. Presentation by Abhinav Chandra, then Municipal Commissioner of Agartala
22. Waste to Energy in India, Sharda Aswani, Energetica India
23. Waste – to – Energy Plants – Drishti
24. Status and Challenges of Municipal solid waste management in India: A Review by Rajkumar Joshi and Sirajuddin Ahmed, Cogent Environmental Science
25. State Renewable Energy Capacity Addition Roadmap – Niti Aayog
26. Requirement of government support for sustainable Waste-to-energy Projects in India – Gyan Prakash Misra and Priyanka Kaushal – energy Technology and Ecological Concerns: A Contemporary Approach