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Concept Paper on Power Generation from Municipal Solid Waste

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CHAPTER 1 Introduction

1.1 Background

Indian municipalities (including Bangalore) have expanded rapidly in terms of population and economic growth. But in India it is evident that there is a lack of a robust municipal solid waste (MSW) management system to handle, monitor, coordinate, finance, plan and control the entire waste flow chain from generation, collection, transportation, disposal, treatment and re-use. Informal sectors whose activities are not coherent and as a result, waste is not appropriately managed and leads to environmental pollution.

In Karnataka over 50% of the municipal solid waste is generated in six municipal corporations. Bangalore city generates close to 4000 MTPD of solid waste, which is 10 times higher than its next municipal corporation in the state (like Mysuru, and Hubballi Dharwad). The per capita waste generation in Bangalore city is 0.4 kilograms per capita per day. Most of the municipal waste is generated in residential and market areas. In order to comply with MSW rules, the Bruhat Bangalore Mahanagara Palike (BBMP) has setup processing and disposal facilities on a public private partnership (PPP) model. As on date over 3000 MTPD processing and disposing facilities are in operational. The combination of technologies for processing MSW is an attempt for sustenance and viability as per the BBMP. Some of the existing installed treatment facilities are not operating to their full potential for various reasons which need to be analyzed.

The Electricity Act mandates the Electricity Regulatory Commissions to promote cogeneration and generation of electricity from renewable sources of energy which includes waste to energy and identify share of this in total sale energy in distribution licensee. The National Electricity Policy also encourages in setting up of waste to energy power generation projects for Urban Local Bodies (ULBs), with a view to reduce environmental pollution. Waste to energy (power generation) based plants are not coming up in the Karnataka, while in other parts of India such plants are already functional.

Karnataka Electricity Regulatory Commission (KERC) engaged a study to know the technical and financial viability of generating power using Municipal Solid Waste. Taking into account various subject experts (Regulatory, Technology, Environmental, and Financial) availability, the KERC assigned The Energy and Resource Institute (TERI) to take up the study in August 2015.

1.2 Objectives of Study

The objective of the study is to prepare a concept paper on power generation using MSW and suggest suitable technologies that could be adopted along with the technical and financial parameters required for determination of tariff for such projects.

1.3 Study area

The KERC was keen to understand current practices followed in collection / procurement of the MSW as well as the availability of MSW in terms of quantum and cost in BBMP and two major municipality corporations namely Mysuru and Hubballi-Dharwad.

1.4 Duration

The study duration was for 45 days and after completion of the field study the findings were shared with the commission. Following comments and suggestions on draft report has been prepared and submitted.

Chapter 2 Methodology

The study is based on review of secondary information available in the public domain and by direct interactions with technology suppliers including present waste to energy power producers in India. To understand the present scenario about MSW handling, discussions were held with Municipal Commissioners and officers responsible for MSW. During the study period visits were done to MSW handling site (in Bangalore, Mysuru, Hubballi-Dharwad) to understand the root cause problems/issues, preventing adoption of possible technological options for waste to energy power generation.

The study covers the following:

- Detailed survey of existing / operational waste to energy power plants (2-3 numbers) for assessment of their technical and financial parameters;
- Assessment of collection & segregation of the MSW along with quantity and cost of landed MSW with relevant data;
- Comprehensive analysis of technical and financial parameters for different types of waste to energy plants;
- Examination of appropriate waste to energy power generation technology suitable for the MSW;
- Evaluation of appropriate tariff to make waste to energy power generation financially viable.

During the survey a specific focus was made to collect technical reasons on why previously installed WtE power generation projects had failed. It is essential to understand capital investment cost of WtE projects compared to conventional biomass based power plants with regard to tariff perspective.

Few states have already derived tariffs for WtE projects, based on upcoming future projects in respective states. A component of the study also included understanding various parameters considered by different states and find gaps with investors (or technology suppliers) which were preventing WtE projects from taking off.

The findings of this study report are largely based on information provided by various technology suppliers, municipal authorities and through their discussions, meetings and presentations and field visit assessment.

Chapter 3 Treatment technologies of MSW

Various technologies are available for the potential recovery of energy or products from MSW. There are a number of factors to be considered for choosing a suitable technology for treating different components of wastes before their final disposal. The technology options available for processing the MSW are based on either bio-chemical conversion or thermal conversion. The types of processes in place for the both options are below:

Bio-Chemical Conversion	**Thermal conversion**
Compost (or) Biogas method	Incineration with or without heat recovery
• Aerobic	Pyrolysis and gasification
• Anaerobic Digester	Plasma pyrolysis
• Vermi-composting	Pelletization or Refuse Derived Fuel (RDF)

3.1 Aerobic Composting

It is a decomposition process in warm and moisture climate where the bacteria and other organisms act on the organic fraction of MSW that essentially consists of proteins, amino acids, lipids, carbohydrates, cellulose, lignin and ash in presence of oxygen. The reaction converts the organic matter, in its entirety, to compost, new cells, CO_2, water, NO_3, SO_4 and heat. The sorted organic fraction of MSW is an important parameter in aerobic composting process.

3.2 Anaerobic Digester (or) Biomethanation

It is a process based on anaerobic digestion of organic matter in which microorganisms break down biodegradable material in the absence of oxygen. It produces methane and carbon dioxide rich biogas suitable for energy production and hence, is a renewable energy source. The nutrient-rich solids left after digestion can be used as a fertilizer. Only the sorted organic fraction of MSW is suitable and shredded, minced and pulped particles to increase the surface area for the microbes to act and increase the speed of digestion.

3.3 Vermi compost

Vermi compost is a nutrient-rich, natural fertilizer and soil conditioner. It is a method of breaking down organic matter by earthworms (most often used are Eudrillus eugineae, Eisenia foetida or Lumbricus rubellus) and the excreta produced is utilized as a bio-fertilizer. Both small scale and large scale operations are available to handle MSW. The sorted organic waste which is free from excessive acidity and alkalinity is suitable for vermi compost process.

3.4 Incineration

Incineration of MSW essentially involves combustion of waste leading to volume reduction and the heat can recovered to produce steam that in turn produces power through steam turbines. It requires high temperature in the order of 800-1000 ^{o}C, and sufficient air and mixing of fuel stream. The minimum temperature for burning carbonaceous wastes to avoid release of smoke and prevent emissions of dioxins and furans is 850 ^{o}C. In order to ensure proper breakdown of organic toxins it is important to maintain a residence time (at least for 2 minutes). The MSW for incineration process should contain < 45% of moisture and Calorific value > 1200 k Cal/kg.

3.5 Pyrolysis and gasification

Gasification is a process that converts carbonaceous materials into carbon monoxide and hydrogen by reacting MSW at high temperatures with a controlled amount of oxygen. The output gas mixture is called synthesis gas or syngas and it can be used as fuel. To produce useful syngas, various cleaning processes are also involved. Due to higher moisture content in MSW, tar generation during gasification is a limitation to adopt the technology.

3.6 Plasma pyrolysis

Plasma pyrolysis is a waste treatment technology that gasifies matter in an oxygen-starved environment to decompose MSW material into its basic molecular structure. It uses high electrical energy and the high temperature is created by an electrical arc gasifier. The arc breaks down the waste primarily into elemental gas and solid waste (slag), in a device called a plasma converter. Based on the input quality of MSW, the gas from the plasma containment will be removed as syngas and the same gas undergoes various cleaning process before it is used as fuel. Processing MSW (as wet waste) as plasma power alone is uneconomical and the plasma container requires high quality liners to deal with elements in MSW (like chlorine).

3.7 Pelletization or Refuse Derived Fuel (RDF)

Pellets are produced by shredding municipal solid waste (MSW) or steam pressure treating in an autoclave. RDF consists largely of organic components of municipal waste such as plastics and biodegradable waste compressed into pellets and bricks. Production of RDF uses various mechanical separation stages. The yields of RDF depend on technology adoption. A four stage process gives RDF which is suitable as fuel for boilers (yield of such RDF is < 30% using input material as MSW).

Apart from these conventional WtE technologies, emerging technologies such as catalytic conversion and pyrolysis are also available for converting plastic waste into liquid fuel.

Chapter 4 Status of MSW based Power Generation Projects

4.1 Initial WtE Projects

Initial WtE power generation projects were commissioned during 2003 and operated in South Indian cities (Hyderabad and Vijayawada). The adopted process was conversion of MSW to RDF and then incineration technology. These initial projects were supported by the Ministry of New and Renewable Energy (MNRE) and Technology Information Forecasting Assessment Council (TIFAC), who extended technology assistance. The capacity of the initial projects was in the range of 6.6 MW. Strictly speaking the incineration technology appeared to be an improved version of a biomass boiler. The designed boilers were using upto 30% of bio material such as rice husk and wood chips along with MSW. It is important to understand that the cost of the biomass was very low in 2003, and during this period several bio-mass based power plants were taken up. The demand for biomass increased and so their cost also steeply increased. The WtE project in Vijayawada operated till 2007 and it sold power to APTANCO at Rs 3.50 per kWh. Following the increased cost of the biomass the approved tariff from regulator became impractical to run the WtE power generation plant. Another important factor was that these initial WtE projects were not equipped with pollution control equipment due to which they were criticized by the public and pollution control agencies.

4.2 Jindal power project, Okhla

The JITF, Timarpur - Okhla Waste Management Company (Private) Limited (TOWMCL) integrated Waste Management Complex Plant was set up at Okhla, Delhi by utilizing the Municipal Waste generated in Delhi city as a basic input. The waste is supplied by the Municipal Corporation of Delhi (MCD) and New Delhi Municipal Corporation (NDMC). The project has been conceptualized as an integrated project which is expected to offer a unique and integrated solution for management of both liquid and solid wastes of Delhi city.

The TOWMCL is a special purpose vehicle/company setup jointly by the Infrastructure Leasing & Financial Services (IL&FS) through Unique Waste Processing Company (UWPC) and Andhra Pradesh Technology Development Centre (APTDC). ILFS has incorporated New Delhi Waste Processing Company Private Limited, Okhla, New Delhi (NDWPCL) – a 100% subsidiary for developing commercially viable municipal waste projects through public private framework in various parts of the country.

The Integrated MSW Processing Complex consists of MSW processing plant, (*capable of processing around 2,050 tonnes per day*) to convert MSW to RDF and power plant in a 13.5 acres plot at Okhla. The RDF plant at Okhla was designed to process 1300 TPD of MSW and expected to generate around 450 TPD of Refuse Derived Fuel (RDF) from Okhla Plant and 225 TPD of RDF from Timarpur Plant in the form of fluff. The fluff is expected to have a Gross Calorific Value (GCV) of 2,500 kCal/kg to 3,000 kCal/kg of fluff and will be available for firing in specially designed boilers to generate high pressure / high temperature steam. The steam generated from the boilers is expected to generate about 20.9 MW of power.

The power plant consist of three Hangzhou (Chinese) make boilers of 26 TPH capacity with steam outlet parameters of 41 kg/cm^2 (g) & 410 ^{o}C steam outlet temperature and one 20.9 MW bleed cum condensing turbo generator generating power at 11 kV level.

The conversion process of MSW into RDF involves processes such as – Homogenization, Size reduction, Drying, Segregation and Densification (Optional). The RDF is fluffed into a uniform density by a variable speed inclined pan conveyor, which tumbles the RDF in the lower hopper.
The plant is provided with air cooled condenser for condensing the steam from the turbo generator TG. The condensate is pumped back from the condensate storage tank to the de-aerator of the boiler. The Rotary dryer in the RDF plant has a Hot Air Generator (HAG) in which biomass segregated from MSW will be combusted to generate hot air.

The plant has installed dust filtration system consisting of pollution control equipment - cyclones, dust settling chamber, bag filters, electrostatic precipitator and gas recirculation system. Apart from this, the dioxin and furans emissions are controlled in three stages in the entire project flow i.e., Extensive segregation techniques, Controlling the SPM levels, Furnace design with 2 sec retention and temperature of 850^{o}C.

The Okhla plant was intended to collect MSW from 14 Circles of NDMC, eight wards of the city zone and six wards of the SP zone. MCD & NDMC has agreed to supply the waste free of cost at the project site on entering into an agreement with the MCD for 25 years. In order to meet the regular requirements of fuel for the boiler, it is envisaged to have a main storage area for RDF. This storage capacity will meet the fuel requirements of the boiler for about 3 days. During rainy season the garbage has high moisture content and requires high energy to reduce the moisture content. Hence garbage is not been accepted during rainy season and MCD will dispose at their landfill site. The detailed Process description of the TOWMCL facility is given in **Appendix – 4/1**.

The plant has been designed for maximum moisture content of 50% and to be in operation for 330 days in a year with a plant load factor of 70% (*due to heterogeneous nature of the Municipal Solid Waste (MSW), the plant is prone to frequent unscheduled breakdowns*). The Auxiliary power consumption is @ 24 % for the integrated plant, which involves power plant (9%), fuel processing by way of an RDF plant (12%) including Sewage Treatment plant (3%).

The project will sell all the power generated from the project to BSES Rajdhani power limited (*approval from Delhi Power Corporation Ltd*) at a preferential tariff of Rs.2.83/Kwh approved by the Commission with provisions made in Section-6.4(1) of the National Tariff Policy.

4.3 Solapur Bioenergy Systems Pvt. Ltd

Organic Recycling Systems (India) Pvt. Ltd is a large scale technology supplier of biomethanation plants for municipal and industrial waste. The name of ORSPL waste to energy power generation plant is Solapur Bioenergy Systems Pvt Limited and the facility is set up in a 9 acres land. The Waste-to-energy plant in Solapur uses a process called Thermophilic biomethanation. The process involves generation of methane gas by breaking down biodegradable waste material with the help of microbes. Subsequently, the gas is burnt to generate power. Presently the plant processes around 300 TPD of municipal solid waste which is unsegregated. Inside the plant premises the recyclable material is separated and converted as RDF (15%). During segregation a reject quantity of 15% is used as a landfill. Close to 50% of the organic material is processed by biomethanation. At the end of the process the sludge of 20% is converted into bio- compost. The main process steps include segregation (manual), belt conveyors, pulverization (with water addition), hominization (sizing), digester (3500 m^3) and gas holder (2 X 1000 m^3).

The plant is designed as two steams of 200 TPD waste handling and is capable of generating power (< 4 MW). The plant is currently installed with 3 numbers of 945 kW (~ 1 MW) gas engines; the auxiliary power consumption to operate each stream is 0.5 MW. Based on the total generation capacity, the auxiliary power consumption is around 25%. The bio compost (sludge) generation is around 80TPD for its full capacity operation. The installed gas generators have been imported from M/s Guker, Spain, and these units are connected to the grid at 33 KV level; and this waste to energy plant is in operation from July 2013.

The present sale of power cost is Rs 4.88 per kWh; due to higher investment cost Rs 18 crores per MW and operational cost, the plant has filed a petition to the Maharashtra electricity regulatory commission and is expecting a revision of tariff to Rs 6 per kWh. ORSPL is ready to share the operational plant data, only after signing a non- disclosure agreement (NDA) and the shared plant data is provided in **Appendix – 4/2**.

The ORSPL technology has been well accepted by various municipalities after the Solapur plant's successful operation. It is proposed to set up similar plants across the country. Pune Municipal Corporation (PMC) has planned to set up 750 TPD capacity MSW handling in two phases (500 + 250 TPD). Earlier, BBMP had also allocated land for ORSPL at Mandur. However after the closure of Mandur dumping site, a new site has been allocated at S K Palya.

4.4 Rochem Green Energy Pvt. Ltd (RGEPL)

RGEPL has set up a waste to energy power generation project of 2.6 MW in Pune. The facility is designed to process MSW of 700 TPD, and as on date the maximum intake of waste from the municipality is less than 300 TPD. It is intending to use Pyrolysis – gasification technology to process the waste and the technology supplier is Concerd Blue, Germany. The technology provides cleanest and most efficient platform for managing waste disposal and creating sustainable green energy solution as per the suppliers. The facility has started the pyrolysis process in end of 2012. The investment cost declared for the Pune facility is Rs 130 crores.

The process involves automatic segregation (metal / non-metal /residue), pressing of separated material as RDF (50%), shredding to 300 mm size, drying through rotary drum from flue gases, again separation and secondary shredding (65 mm size) and pyrolysis (updraft gasifier), reformer which operates under nitrogen atmosphere. The produced syngas is passed on to a gas engine.

It is important to know that facility has installed two gas generators of 380 KVA and 2.6 MW capacity, but plant has never operated the 2.6 MW engine since it is not integrated to the grid. It has just laid a 12 km cable to connect to the 22 kV substation grid line. The syngas produced in the reformer is used across the drier and same is used for running a small generator of 380 kVA to meet its internal power consumption. For MSW processing of 700 TPD capacity, four numbers of pyrolysis towers have to be commissioned, whereas till date only a single tower has been installed. MERC has approved a tariff of Rs 5.86 per kWh to supply power to the state grid.

The facility is getting a tipping fee of Rs 350 per ton and is selling the recyclable materials by forming sized bales and dried as RDF to various industries. The bales are mainly purchased by biomass based power plants for Rs 1000 per ton. It appears that in the near future also the waste to energy power generation may not come up at this location.

4.5 Essel Infra Pvt. Ltd

Essel Infra has started construction of a new incineration based waste to energy power generation plant in Jabalpur. The technology supplier of the upcoming plant is Hitachi Zosen India Limited, who is global market leader (operating over 500 WtE plants) in the waste to energy power generation segment. The proposed plant is planned to handle 600 TPD mixed municipal solid waste (MSW). The proposed boiler design flow and pressure is 56 TPH and 65 bar respectively. The design thermal efficiency of the power generation unit is less than 24%. The power generation capacity is 11.5 MW and anticipated power export 9.7 MW to grid. The internal auxiliary power consumption could be 16% of the generation capacity.

The design features of the incineration plant are five days refuse storage bunker (3000 tons). The boiler is equipped with special alloy material, hydraulically operated ram feeder system, combustion control system and ash extraction system. The Pollution control equipment (which includes turbo reactor, fabric filter, and solids recirculation unit) is integrated to control SOx, HCL, Heavy metals and Dioxins & Furans. The MSW as a fuel is heterogeneous and corrosive due to its composition. To handle such fuel, high quality materials needs to be used. The investment cost for proposed project is close to Rs 200 crores. The on-going project information is provided in **Appendix – 4/3**.

The Essel Infra has made an agreement with a Distribution Company for sale of power for Rs 6.30 per kWh. More details on the type of agreement is not available. At the same time long term tipping fee arrangement is carried with the municipal council. The project is designed to handle higher capacity of MSW taking into account the future population growth.

4.6 Small Scale Biomethanation

The Bruhat Bangalore Mahanagara Palike (BBMP) has made it mandatory to segregate waste and citizens who follow the rule complain that the contractors aggregate the segregated waste. Hence BBMP has initiated 16 biomethanation projects across the various wards of city, as one of the steps for effectively tackling the waste management crisis that has been prevailing in Bangalore since many years.

According to the BBMP scope, each plant would convert biodegradable waste into energy (biogas powered engines), and process five tonnes of wet waste a day. Furthermore the power generated by these plants will be used locally for lighting purposes. The technology suppliers ere Mailhem Engineers, Pune and Ashoka Biogreen plants. The companies have signed an agreement with the BBMP for the construction of 16 plants on build, own, operate, transfer (BOOT) basis, some of which are complete and some are under construction and yet to be commissioned. The total cost of the biogas plant was found to be in the range of Rs 80 - 120 lakhs. It was known that firm will maintain the plants for three years with maintenance cost for each plant would be around Rs. 23 - 25 lakhs for three years.

During our study, a few plants operating in Kuvempu nagara, Kudlu and Mathikere were visited. These plants are getting 5 TPD (in Kuvempu Nagar & Mathikere) and 3 TPD (kudlu) of segregated wet waste, which is subjected for biomethanation after manual segregation (pre-feed). Biomethanation of organic wastes is accomplished by a series of biochemical transformations - hydrolysis, acidification and liquefaction followed by methane transformation. The process generates biogas with high content of methane (55–70%) which after proper pre-treatment are directly used as fuel by employing gas engines to generate electricity. This technology has dual benefits. It gives biogas as well as manure as end product.

Mailhem engineers had shared the operating parameters (power generation) of Kuvempu nagar biomethanation project and the same is given below.

MIPL/R&D/53

MAILHEM IKOS
ENVIRONMENT

5 TPD MAILHEM BIOMETHANTION PLANT (1st July to 31st July 2015) - KVMP, BANGALORE

	Only for July 2015	Cumulative from March 2015 till date
Total Waste received at site (tons)	121.7	606.4
Total Organic waste fed to the plant (tons)	119.5	594.5
Total Biogas generation (cum)	8277	38,872
Power supplied to the grid (Electric units)	5496.4	28,560.3
Total Manure Generated (tons)	10.7	42.05
Total C02 emissions curbed (tons)	69.31	344.8

MAILHEM BIOMETHANTION PLANT PERFORMANCE (1st July to 31st July 2015):

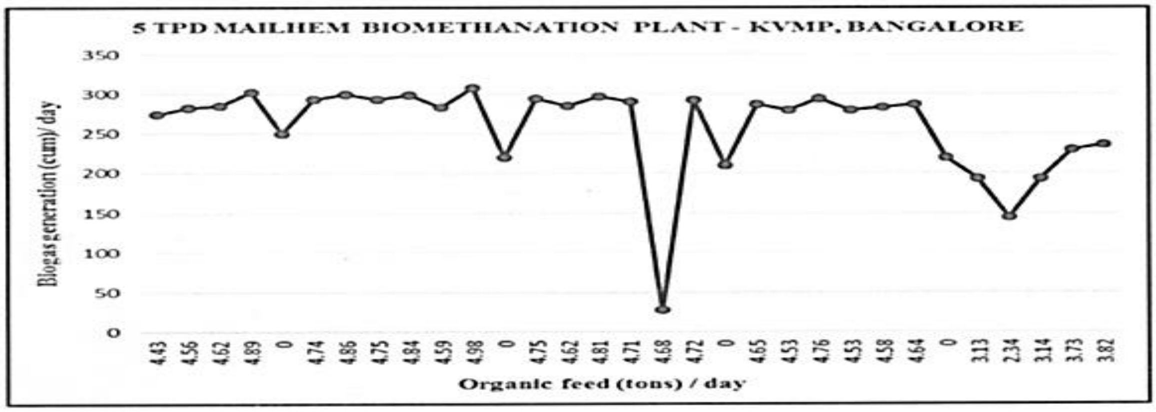


Fig 1 Graphical representation of Biogas generation for the organic waste fed to the Mailhem Biomethanation plant for the month of July 2015

The list of biomethanation plants (for generation of energy from bio-degradable waste of 5 MTPD) which have been setup or planned in various wards of BBMP in Bangalore is given in **Appendix – 4/4**.

Many municipal authorities across India have considered the utilization of bio-degradable components of waste at a decentralized level to minimize the cost of collection and transportation to centralized processing facilities. Currently, this technology has been successfully employed in many cities in India ranging from 100kg/day to 10 TPD in a decentralized manner for biodegradation of segregated organic wet wastes such as wastes from kitchens, canteens, institutions, hotels, and slaughter houses and vegetables markets, about 40 of which are operated by private sector. The cost of setting up one 1TPD plant is estimated at Rs 17-20 lakh and for 5 TPD Rs 70 lakh. One TPD plant generates 80 to 100 m^3 gas and 50 kg of manure. The typical biogas composition is 70% methane (CH_4) and 30% carbon dioxide (CO_2).

4.7 Failure of Waste to Energy Projects.

Some of the prime reasons for waste to energy plants which could not successfully operate for a longer time are given below.

- Project developers have used alternate fuel apart from MSW to supplement the generation;

  Hyderabad / Vijayawada : Rice husk
  Navi Mumbai : CNG (proposed)

- Project developers are more interested in land acquisition in municipal limits and obtaining loans from banks;

- Adopted technology / equipment have a minor adjustment of biomass based power plants;

- Use of low cost technology led to adopting minimum pollution control equipment;

- Pyrolysis and Gasification: High tar generation (one reason moisture content). However promoters are more interested in getting paid through tipping fees and sale of MSW & derived products.

- Plants which were commissioned or operated earlier could not get reliable supply of waste to operate at maximum capacity. In particular, biogas units are also on the verge of shutting down due to non-availability of segregated waste.

Chapter 5 MSW handling in Karnataka municipalities (Bengaluru, Mysuru, Hubballi-Dharwad)

5.1 Policy & Legislation

The State governing laws and also the 74th Constitutional amendment of 1992 clearly stipulates that solid waste management as the primary or obligatory function of municipal authorities. Significant strategies for solid waste management were formulated by the Ministry of Environment and Forests (MoEF) in the Municipal Solid Wastes (Management and Handling) Rules, 2000. These rules, notified after the direction of Honourable Supreme Court of India to municipal authorities for scientific handling of MSW from generation to final disposal with source segregation, composting, and other techniques such as refuse-driven fuel and waste-to-energy conversion to be implemented as early as 2003.

Despite constitutional and legal mandate, due to lack of infrastructural, financial, and human resources, these rules were largely unimplemented in many urban local bodies. Hence, these rules were followed up by a set of additional rules and policies for MSW management.

- National Environment Policy (NEP) in 2006;
- Plastic waste (Management and Handling) Rules, 2011 notified under the Environmental (Protection) Act, 1986 to regulate littering and manufacturing of plastic carry bags;
- National urban sanitation policy.

5.1.1 Proposed MSW Rules 2013

With a view to expeditiously improve solid waste management in the country, the Ministry of Environment and Forests (MoEF), Vide S.O No. 1978(E) dated 2nd July, 2013 notified the draft MSW Rules, 2013 in supersession of the MSW Rules 2000, inviting objections and suggestions from citizens. The Karnataka High Court observed that the Union Ministry of Environment and Forests (MoEF)'s move to comprehensively amend the existing law governing municipal solid waste management would promote a regressive approach of collecting waste without segregation at source. The court noted that the proposed amendments (*particularly harm the progressive waste management initiatives going on in Bengaluru for the past one year under the direct supervision of the High Court)* would undo all the efforts taken up in the past decade in implementing the rules of MSW 2000.

Hence in a significant ruling, the Honourable High Court directed the MoEF not to notify its proposed controversial amendments to the Municipal Solid Waste (Management and Handling) Rules of 2000 and ordered MoEF to consider all the objections filed against the amendments and then prepare new draft rules and place them before the court.

5.1.2 Proposed MSW Rules 2015

Following the public comments and observations of the National Green Tribunal and Karnataka High Court on the draft of the 2013 Rules, the MoEF, GoI has proposed to amend the existing regulatory framework for environmentally sound management of the waste being generated in the country. The draft Solid Waste Management Rules, 2015 have been placed on the ministry's website for public comments & also National Consultation Programmes were conducted across the country. The major features of the Draft Rules of above policies are given below.

- Segregate and store the waste generated by waste generators in three separate streams namely bio-degradable or wet waste, non-bio-degradable or dry waste and domestic hazardous wastes in suitable bins and handover segregated wastes to waste collectors as per the direction by the urban local body from time to time;
- Store the below mentioned waste separately (each) and dispose as per their rules,

    i. Sanitary waste,
    ii. Construction and demolition,
    iii. Horticulture waste and garden.

- No waste generator shall throw the waste on the street, open spaces, drain or water bodies. All waste generators shall pay such user fee or charge or fines as may be specified in the bye-laws of the urban local bodies for the sustainability of the solid waste management systems.
- Provide easy access to waste pickers and recyclers for collection of segregated recyclable waste such as paper, plastic, metal, glass, textile from the source of generation or from material recovery facilities;
- Facilitate construction, operation and maintenance of solid waste processing facilities and associated infrastructure in house or with private sector participation or through any agency for optimum utilization of various components of solid waste adopting any of the following technologies and adhering to the guidelines issued by the ministry of urban development and central pollution control board from time to time and standards prescribed by central pollution control board and preference shall be given to decentralise processing to minimise cost and environmental impacts:

i. Biomethanation, microbial composting facility, vermi composting, anaerobic digestion or any other appropriate processing for bio-stabilisation of wet biodegradable wastes;
ii. Waste to energy processes for conversion of dry non recyclable combustible fraction of waste into energy or supply as feedstock to solid waste or refused derived fuel based power plants or cement kilns or like;
iii. Construction and demolition waste processing facility for optimum utilization of construction and demolition waste making aggregates, bricks, paver blocks or any other useful product.

- Metropolitan and district planning committees or town and country planning department of the state and urban local bodies has to ensure identification and allocation of suitable land, (*i.e, separate space for segregation, storage and decentralised processing of Solid Waste is demarcated in the development plan for group housing or commercial, institutional or any other non-residential complex exceeding 200 dwelling or having a plot area more than 10,000 square meter)*; and facilitate establishment of common regional sanitary landfill for a group of cities and towns falling within a radial distance of 50 Km.
- Department of Fertilisers through appropriate mechanisms may incentivize the sale of city compost & ensure promotion of co-marketing of compost with chemical fertilizers.

With Government's special impetus on *Clean India Mission in Consonance, Make in India & ease of Doing Business amendments* are timely endeavour towards meeting these initiatives of the government.

From the existing policies and legislation, it is clear that segregation of waste and recycling of valuable (plastic) materials are mandatory. Hence the rules & guidelines defined should be implemented at all the hierarchy level of municipal administration.

5.1.3 MSW Policy in Karnataka

Municipal solid waste is defined distinctively in each state based on the Municipal Solid Waste State Policy. In Karnataka, the urban local self-governing bodies (*commonly called Municipalities*) are functioning since more than 100 years by provisions contained in the Karnataka Municipalities Act, 1964. Later, the Government of Karnataka reconstituted the municipalities based on population and other criteria as Town panchayat, Town Municipal Councils & City Municipal Councils and City Corporations and made MSW management, one among the obligatory responsibilities of the city corporations as per the Municipal

Corporation Act, 1976 [1]. Based on the above classification, at present there are 10 City Corporations, 41 City Municipal Councils, 68 Town Municipal Councils and 94 Town Panchayats in the state.

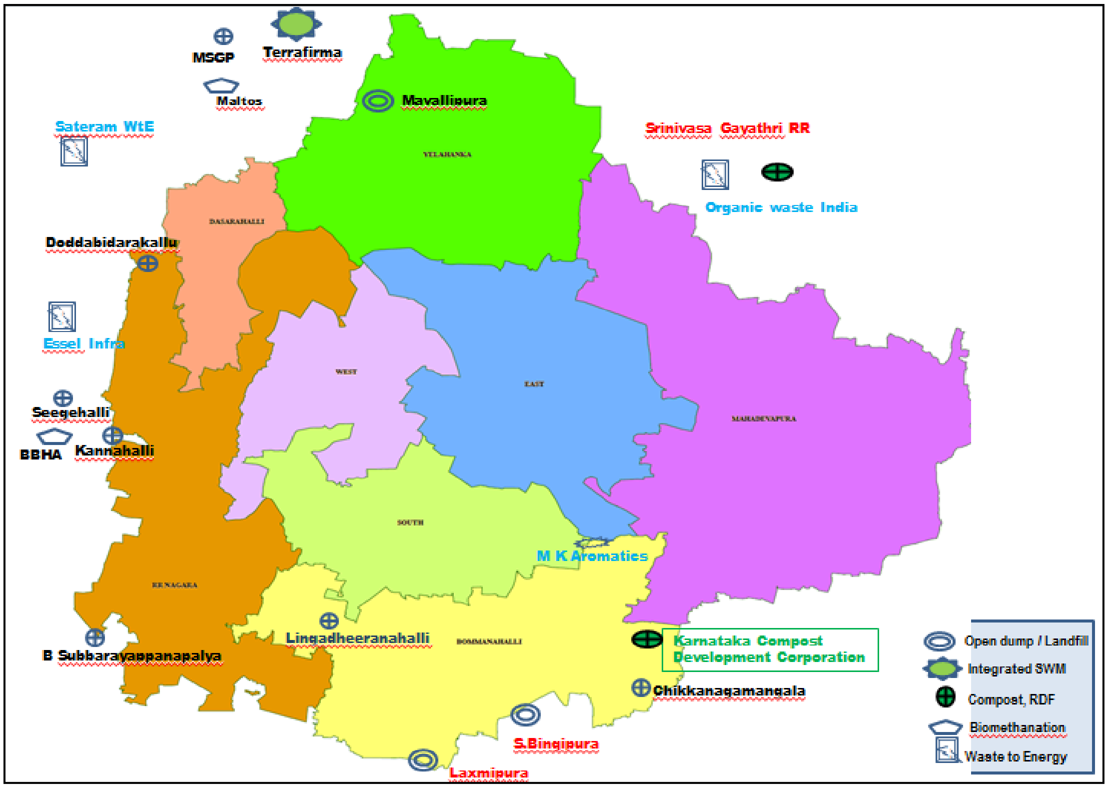
Karnataka State Pollution Control Board (KSPCB) has constituted a MSW Committee as per Rule 6(2) of the MSW Rules, 2000 and further delegated the powers to the Chairman and Member Secretary to issue authorizations. The Committee examines proposals submitted by Municipal Authorities or an operator of a facility and takes decisions on issue of authorization under MSW Rules for setting up of waste processing and disposal facility including landfill and to comply with Schedule of said Rules.

According to the 2011 census, Karnataka's population is 61,095,297 spread over an area of about 1,90,000 km^2. As per discussions with KSPCB and ULBs, an estimated amount of ~9500 MT of MSW is generated from all the urban local bodies in Karnataka state. Out of which, BBMP generation share ~4000 MTPD with collection efficiency of 80-85% and rest of ULBs in Karnataka generates ~5500 MTPD with collection efficiency of 80-90%. Many of the ULBs in do not even have reliable MSW generation estimates.

Most of the ULB's in Karnataka are carrying out primary (door to door) collection, street sweeping, secondary collection, transportation and disposal (processing is only in few places) at their designated places. Few of the ULB's also initiated source segregation and made it mandatory for waste generator to separate organic and non-organic waste at their source. Due to lack of provision for separate carriers in most of the transportation vehicles (auto tippers/tractors/trucks), there may be mixing of segregated waste with others during the transportation to MSW disposal sites.

5.2 MSW management in Bengaluru

Bengaluru has a population of about 8.52 million (2011 census) by covering an area of ~800 km^2. Earlier, Bengaluru Mahanagara Palike (BMP) was in charge of the civic administration of the city *(7-CMC, 1-TMC, 110 villages*). BBMP was formed from the BMP through notification under Karnataka Government on January 16, 2007. Later in the year 2009, the Government through an amendment to KMC Act, 1976 increased the number of wards from 100 to 198 to cover a vast and growing Bangalore, which increased the stress of BBMP for MSW management. The MSW handling in BBMP premises is schematically depicted in the below figure (map).



At present, it is estimated that around 4000 MT of MSW is generated per day in Bengaluru and BBMP has spent amount Rs.447 to 459 crores in their previous FY 2013-14 & FY 2014-15 towards solid waste management expenses. Some of the salient features and observations of MSW handling in BBMP are listed below.

- Major portion ~1200 MTPD of the city's garbage is treated in Terra Firma (*Integrated waste management facility*) and 200 MTPD in MSGP Infra Tech, respectively. These two plants at Doddaballapura are processing mixed waste after segregating at their site;

- Karnataka Compost Development Corporation (KCDC), at present processing 200 MTPD segregated MSW and it is intended to increase to 500 MTPD, after expansion;

- High court of Karnataka ordered Mavallipura landfill to be closed in 2012 and later in 2014 directed M/s Ramky to processed 300 MTD of wet waste, to be supplied by BBMP;

- For effective tackling of MSW and recovery of various recyclable materials, BBMP has set up Dry Waste Collection Center (DWCC)s in 170 wards, which have a receiving capacity of 1.5 tonnes of garbage per center;

- Notification has been sent by BBMP to bulk waste generators like Hotels, Restaurants, Kalyan Mantaps, Apartments etc., for establishing the separate system to scientifically manage the MSW generated in their premises or through any empanelled service providers. Two plants for converting food waste to Compressed Bio Gas (CBG) at Kannahalli (250 TPD) and Huskur (100 TPD) has been established by Bruhath Bengaluru Hotels Association (*Noble Exchange Environment Solutions*) and Maltose Agri Products Ltd respectively;

- After the High Court ordered BBMP not to dump any more garbage the way it has been and inadequate operations of earlier MSW processing units, has forced BBMP to set up six new MSW processing plants at Lingadheernahalli, Doddabidrakallu, Subbrayanapalya, Seegehalli, Kannenahalli and Chikka-nagamangala. Detailed project report along with Environmental Impact Assessment and public hearing has been carried out for all these plants at an investment of Rs. 440 crore. Although the BBMP has commissioned six new plants, it was observed that not all units are operating at their maximum potential. Around 200, 50, 80, 70 MTPD of Mixed MSW are processed in Kannenahalli, Seegehalli, Doddabidarakallu and Subbarayappanapalya respectively. The Chikkanagamangala plant is yet to start functioning and temporary stay order has been issued for Lingadeernahalli, following the protest of the local people. BBMP has shared an abstract for the EIA studies carried out for the new plants and the same has been given in **Appendix – 5/1;**

- Biomethanation power plants — BBMP has constructed 16 biomethanation plants across the various wards of the Bengaluru city, out of which 8-10 plants are operating and rest of them are under commissioning. Each plant has the capacity to process 5 tonnes of wet waste a day into biogas and generate around 50 KW power;

- About 1200 tonnes are open dumped at landfills in S.Bingipura and Lakshmipura (*This was said to be closed recently, due to non-compliance of MSW rules);*

- Apart from these, approvals have been given to waste to energy plants for M/s Satarem Enterprises (1000 TPD to 14 MW), M/s Organic Waste India – (600 TPD to 8.6 MW) and M/s Essel Infra (600 TPD). BBMP has signed an agreement with these franchises on PPP framework;

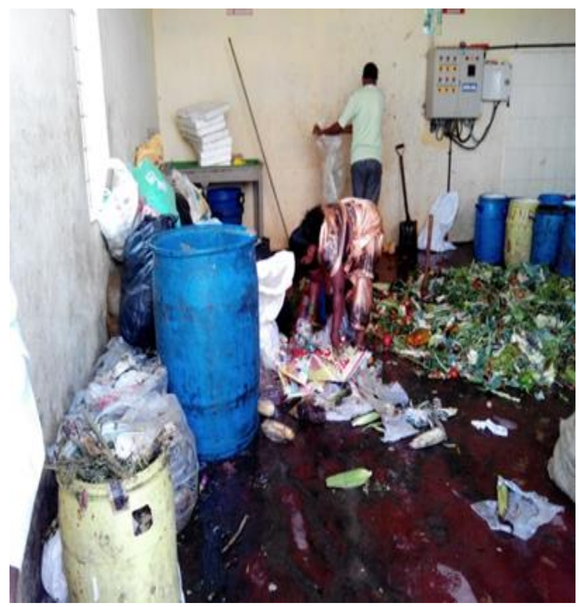
- Srinivasa Gayathri Resource Recovery Limited (SGRRL) was expected to set up an integrated MSW to energy plant at Mandur and generate 8 MW of power by processing 1000 MTPD of MSW. However SGRRL

  had failed to do so, except few power plant machineries erected until now since the year 2005. BBMP has terminated their contract with SGRRL, who is facing charges after huge sum of loan was raised pledging Mandur landfill;

- Quantity of recyclable waste diverted by Scrap dealers, waste pickers, itinerant buyers, sorters and other workers in the informal sector was not available;

- Construction and demolition waste are disposed exclusively in separate identified sites;

- Few gated communities, layouts and apartment complexes have already put source reduction, decentralized waste management systems in place.



Detailed information of each MSW processing sites in BBMP premises are given in **Appendix – 5/2** and the brief summary is given in the below table 5.1.

Table 5.1 Detailed information of each MSW processing sites in BBMP premises

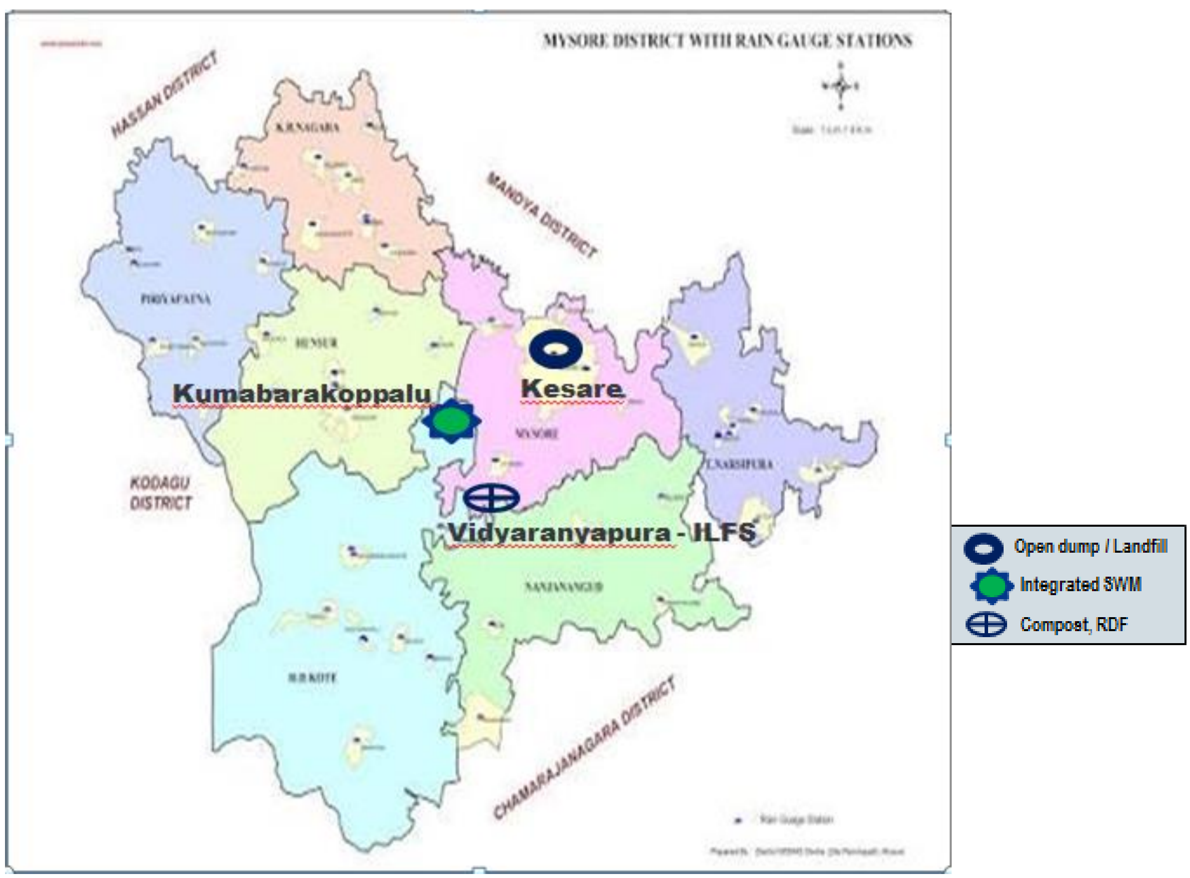
Sl. No	Firm – MSW Site	Firm – O & M	Capacity, TPD	Operating, TPD	Technology
			Existing Operational- BBMP units		
1	Gundlahalli – Doddaballapur	Terrafirma Biotechnologies	1000	1200	Compost, RDF & value added products
2	S Bingipura	BBMP	500	1000	Open dump - Land filling
3	Hosapalya – Haralur	KCDC	500	200	Compost – Windrow (WR), Vermi,
4	Chigeranahalli	MSGP Infra	500	200	Compost – WR, vermi & RDF
5	Mavallipura	BBMP / Ramky	300	200	Compost
			Newly commissioned - BBMP units		
6	*Kannenahalli*	*ILFS*	*500*	*200*	*Compost – WR, vermi & RDF*
7	*Seegehalli*	*ILFS*	*150*	*50*	*Compost – WR, vermi & RDF*
8	*Doddabidarikallu*	*UPL Environ. Engg Ltd*	*200*	*80*	*Compost – WR, vermi & RDF*
9	*B Subbarayappanapalya*	*JP Morgan*	*200*	*70*	*Compost – WR, vermi & RDF*
10	Kannenahalli - BBHA	Noble Exchange soln	250	8	Bio-gas – CNG bottling
11	Doddaballapur	Maltos	100	30	Bio-gas – CNG bottling
12	Ward wise decentralized units	Mailhem ikos ltd, Asoka Bio-green ltd.	5 x 16	5 x 8	Bio-methanation power generation
	Sub- total		***4280***	***~3300***	
			MSW units not in operation / proposed		
13	*Chikkanagamangala - BBMP*	*ILFS*	*500*	*Under const.*	*Compost – WR, vermi & RDF*
14	Gorur halli	M/s Sateram	1200	Mob protest	Waste to Energy power plant
14	Giddenahalli	M/s Essel Infra	600	Land acquisition process	Waste to Energy power plant
16	Mandur - North	Organic waste India	1000	Land substitution	Compost, Waste to Energy plant
17	Mahadevapura	M K Aromatics	10	LOI issued	Pyrolysis – Plastic to Oil.
18	Mandur - South	SGRRL	1000	Terminated	Compost, RDF fired Power Plant
18	Lakshmipura	BBMP	250	Closed	Landfill
19	*Lingadheeranahalli - BBMP*	*ILFS*	*200*	*Court – stay*	*Compost – WR, vermi & RDF*
	Sub- total		***4760***		
	Grand total		**9040**	**3300**	

Source: BBMP, KSPCB and KUIFDC reports.

After implementing the above initiatives, around ~2,300 MTPD of MSW are processed with concept of tipping fee and support fee paid by BBMP. It is estimated that about 30% of the processed MSW is recovered as RDF, 12-15% yield of compost products and rest of the MSW comprising moisture and inert materials. The present techniques of BBMP continue to lack the resilience to implement and sustain their waste management; therefore it justifies for the strong necessity of establishing centralized WtE projects in the Bengaluru.

5.3 MSW management in Mysuru

Mysuru is the third-largest city in the state of Karnataka, India. According to the 2011 national census of India, the population of Mysuru is 887,446 spread across an area of 128.42 km². Mysuru City Corporation (MCC) is responsible for the civic administration of the city and 65 wards are covered by the MSW management program. The MSW handling in MCC premises is schematically depicted in the below figure (map).



5.3.1 Salient Observations of MSW handling in Mysuru

Mysuru generates around 402 tonnes of MSW every day and outsourced operations which MCC's coverage in garbage collection is above 80%. Some of the salient features and observations of MSW handling in MCC are listed below.

- On an average 200 MT of MSW is transported everyday by MCC to centralized processing plant at Vidyaranyapuram, scientifically processed by composting method. Presently MCC has outsourced the operation and maintenance of compost Plant to M/s IL & FS. Plant personnel had shared the detailed procedures of the processing of MSW in their plant and the same is given in **Appendix – 5/3**.

- Under JnNURM scheme, MCC has adopted following activities for self-sustained management of MSW in city.

  - Established nine Zero-Waste Management (ZWM) centres in different zones of the MCC. Though MCC claims, about 10-20 MTPD of MSW is processed at eight out of the nine centres, but it was observed that only Kumbarakoppal ZWM centre is operating at its maximum potential.

  - With investment of Rs 29 crore , sanitary landfill facility was established over 34.5 acres of land at the sewage farm in Vidyaranyapuram. Residual waste or rejects from the compost plant and zero waste management plants are sent to the sanitary landfill site, operated and maintained by M/s JUSCO.

  - In 2015, MCC had distributed two (red and green) dustbins to 1.5 lakh households & planned to extend the programme for all houses coming under MCC limits. The total cost of the project is Rs 2.94 crore.

  - NGOs such as Self-help groups (SHG) and Stree Shakthi Sanghas were hired by MCC to educate residents about MSW management & promote segregating waste at source.

- At present the animal waste is buried under the ground, however MCC is planning for establishing a facility for disposal of animal carcass (waste) from slaughter houses.

All these implemented measures contributed to help Mysuru to earn the first place in Swacch Bharath Abhiyaan rankings, National Level Campaign for Urban Development. Brief details of MSW handled in MCC premises is summarized in the below table 5.2.

Table 5.2 MSW handling in Mysuru City Corporation

Sl. No	Firm – MSW Site	Firm – O & M	Capacity, TPD	Operating, TPD	Technology
1	Vidyaranyapura , Mysuru	IL & FS	200	200	Compost – WR, vermi
2	Zero waste Management Sites	NGOs	90	50	Segregation of dry & wet waste for recycling
3	Non vegetarian waste	MCC	-	6	De-burial
4	Vidyaranyapura	JUSCO	-	90	Scientific landfill
5	Kesare	MCC	-	200	Open dump – land fill

Source: MCC, KSPCB and KUIFDC reports.

Nearly half of the city's waste going to landfill untreated and also to effectively handle additional generation of garbage in future, MCC has proposed an action plan to construct additional compost plants at Rayanakere & Old Kesare – 200 TPD each. It was known from discussion that, MCC wants to extend their zero waste management to other wards too and proposed for 6 new bio gas plants – 1 TPD each.

5.4 MSW management in Hubballi – Dharwad.

The twin cities of Hubballi-Dharwad are located at about 20 Kms from each other and Hubballi is regarded as one of the commercial centres and business hubs of north Karnataka. The city is governed by Hubballi Dharwad Municipal Corporation (HDMC). The quantity of waste generated in HDMC is about 400 TPD. Currently the HDMC transports waste from various collection units and dumps openly in dumpyards (22 acres in Hubballi and 16 acres in Dharwad). The MSW handled in the HDMC premises is schematically depicted in the below figure (map).

The per capita generation of waste is 367 g/capita/day. The major contributors for waste are Household (55%) and commercial (16%). Currently there is no segregation happening at the source. The rag-pickers collect the recyclable items from industrial area bins and street level dumping site. Earlier, farmers used to take the remaining of the landfill to their fertilizer requirement, at present due to complex nature of waste, the practise has been stopped. At present, a rudimentary vermicomposting of 10 TPD is practiced which is not at all effective. Though the HDMC claims, there is separate processing of medical and hazardous waste but it was observed that medical waste are reaching the

Brief details of MSW handled in HDMC premises is summarized in the below table 5.3.

Table 5.3 Brief details of MSW handled in HDMC premises

Sl. No	Firm – MSW Site	Firm – O & M	Capacity, TPD	Operating, TPD	Technology
1	Kempigere– Hubballi	HDMC	20 acres	280	Open dump – land fill
2	Hosa yellapur – Dharwad	HDMC	16 acres	120	Open dump – land fill
Proposed plan : Compost plants with RDF processing facility at Shivalli & Hunasekatta halla – 500 TPD					

It is known that Hubballi-Dharwad Municipal Corporation has planning for integrated waste management to their MSW generated in the twin cities.. The proposed site for integrated MSW processing and disposal facility (67 acres and 20 guntas) is located 1 Km east of Shivalli, which is situated about 20 Kms north of Hubbali city center and 18 Kms east of Dharwad. The Hunshikatta Halla stream is located about 4.0 Kms away from the site. The proposed MSW facility comprising of the following:

1. Windrow composting
2. RDF processing facility
3. Sanitary landfill

Considering the present operations in HDMC, can consider the waste to energy (power generation) using biomethanation technology similar to Sholapur model.

Chapter 6 Appropriate Technology Options

6.1 WtE Power Generation Projects Concerns

The primary concern of WtE power generation projects is that it should be developed where municipal population is above two million, it is viable only when adequate quantity and quality (percentage of biodegradable) of wastes is generated. While estimating waste availability, present segregation methods and intermediate process (like composting) have to be accounted. It is economical to operate WtE power generation with combustible waste of at least 300 TPD quantity.

6.2 Operational WtE Power Generation

Based on reliable operation and implementation of new projects two technologies were identified for the Indian context. Both these technologies meet environmental compliance applicable to WtE power generation. They are

1. Incineration (or) Combustion technology with energy recovery;
2. Biomethanation process

The other WtE power generation technology like gasification, pyrolysis have not been yet demonstrated on a large scale.

6.3 Incineration Technology

Incineration is the complete combustion of waste with the recovery of heat, to produce steam, which in turn produces power through steam turbines. Typically, the feedstock could be segregated or un-segregated MSW or refuse derived fuel. Mixed MSW containing alkalies normally of Potassium & Sodium Oxides which lowers ash fusion temperature to 950 $^{\circ}$C. MSW contains predominately Silica. Silica with alkalies creates agglomeration and fouling on heating surfaces. Silica in fly ash causes erosion of Heating Surfaces. Chloride compounds of MSW cause corrosion of heating surfaces. MSW combustion products contain SO_2/SO_3 that cause acid dew point corrosion on metal surfaces. The components to handle MSW and Boiler parts are specially designed and different from normal biomass boilers. The design of Grate & Boiler calls for a special metallurgy and a special configuration. The type of equipment used in incineration technology are listed in the following table:

Incineration of MSW based power plant	Biomass based Power Plant
Total Heating surface area is 9950 m^2	Total Heating surface area is ~3000 m^2
Refuse storage bunker with RCC Construction (5 days storage)	Open storage
Fuel feeding System :	Fuel feeding System :
Fully automatic Grab crane system	Simple inclined Belt conveyor
Hydraulically operated automatic RAM feeder	Conventional screw feeder with VFD
Combustion grate:	Conventional grate
Reciprocating grate Moving bars with holes	fixed bars
grate area : 97.5 sqm (each grate bar 20 kgs)	grate area : 30 sqm (each grate bar 2 kgs)
Imported alloy steel grate bars	Local Cast Iron bars
Auxiliary fan size	
Excess air requirement 60% for MSW	Excess air requirement 25%
(If required oxygen lanced)	
Supply air fan size 60% bigger in capacity	
Air Preheating system :	
Steam Coiled Air Pre Heater (SCAPH)	Conventional flue gas to air pre heating
Refractory lining	About 25 to 50 tons of Refractory in the first pass
230 Tons of special Refractory	depending on Boiler configuration
Requires additional burner arrangement	No additional burner
Bottom Ash Extractor	
Designed for taking load of 500 kgs single object dropping	Simple belt conveyor in water bath
Combustion control system	
fully automated imported combustion control system	Simple DCS based combustion Control
Emission control	
Flue gas treatment system (Dioxins & Furans destruction system)	Electrostatic precipitator (ESP)
Total Weight	525 Tons without auxiliaries
1500 Tons without auxiliaries	

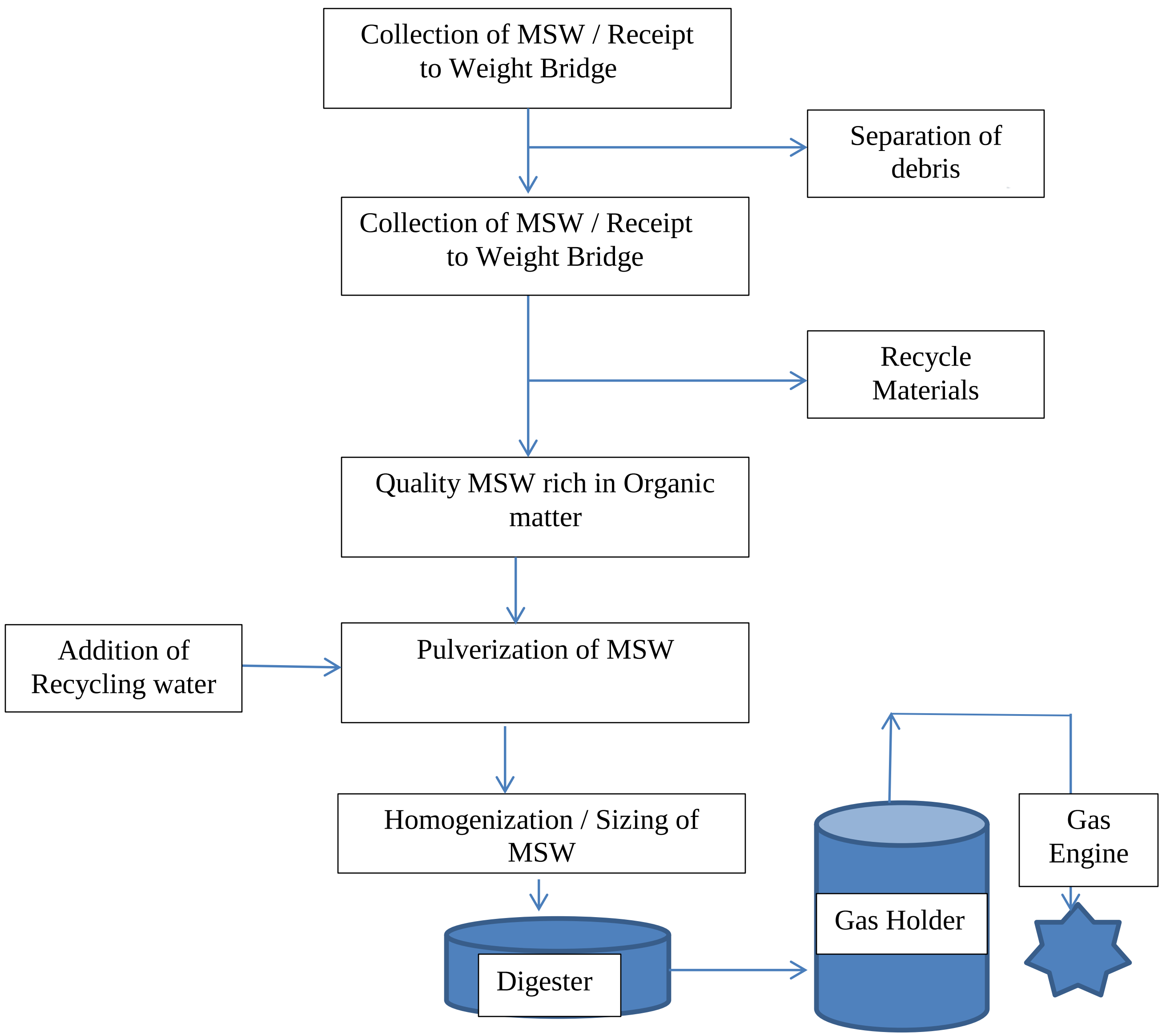
Plants can operate without use of auxiliary fuel and thermal efficiency in the range of 24%. An additive for flue gas treatment is an additional cost and its share is close to 25% O & M expenses. WtE power generation plant also consists of leachate treatment and residue handling as well as landfill is an addition feature. The environmental standards can met with proposed treatment facilities which are given in **Appendix – 6/1.** Considering all of the above factors, the cost of incineration technology MSW power plant initial investment works out to be Rs 18 crores per MW.

6.4 Biomethanation process

This technology is suitable for only organic biodegradable fraction of MSW. Heat released in less, resulting in lower and less effective destruction of pathogenic organisms than anaerobic composting. It requires waste segregation for improving digestion efficiency (biogas yield) and improving quality of residual sludge. The anaerobic digestion process leading to generation of biogas, which is used in gas engine for power generation. The liquid sludge can be used as rich organic manure.

The commercial operation of large scale biomethanation has been demonstrated in Sholapur. The details of the equipment and plant operations of Sholapur plant are given in Section 4.3. The technology is most appropriate for smaller municipalities and capacity enhancement of individual units can be carried by adding up capacity in modules (like multiples of 1 MW).

The main process steps include segregation (manual), belt conveyors, pulverization (with water addition), hominization (sizing), digester (3500 m^3) and gas holder (2 X 1000 m^3).



Chapter 7 Applicable Tariffs for MSW as fuel

7.1 Initiatives by the States

Some State Governments in India have announced policy measures pertaining to allotment of land; supply of garbage; and facilities for evacuation, sale, and purchase of power to encourage the setting up of waste-to-energy projects.

Land for the facilities is provided by the ULB at a nominal rent. The tariff for power purchase generally agreed upon according to the general guidelines issued by the Ministry of Non-Conventional Energy Sources and the decision is left to the regulatory authority.

However, in the wake of de-regulation of the power sector and in the absence of clear policy directions, delays often occur in finalization of actual contract terms with the entrepreneur, especially with regard to the power tariff.

7.2 Norms determined by Madhya Pradesh State Electricity Commission

The Madhya Pradesh State Electric Commission in 2013 has published general norms for the purpose of tariff determination of MSW based power projects. The details of the same are given below;

Capital Cost	:	Rs.600 Lakh per MW
PLF	:	60% - 1st year, 80% - 2nd year onwards
O & M expenses	:	5% of Capital cost – 1st year 5.72% of Capital cost –2nd year onwards
Plant Life	:	20 Years
Depreciation	:	7% for 1st 10 years and 20% for balance 10 years
Return on equity	:	20% pre tax
Interest on Debt	:	13%
Debt-Equity Ratio	:	70:30
Interest on working Capital	:	13.5%
Station Heat Rate	:	4000 kCal/kWh
Auxiliary Consumption	:	11.5%
GCV of MSW	:	2250 kCal/kg
Fuel Cost	:	Rs. 1320 per MT
Fuel Cost Escalation	:	5% per annum

7.3 Tariff order by different state electricity regulatory commissions

The tariff orders issued by different State Electricity Regulatory Commissions (SERC) over the past 10 years were studied. The following SERCs have passed tariff orders on municipal solid waste based power projects;

- Maharashtra Electricity Regulatory Commission (MERC)
- Gujarat Electricity Regulatory Commission (GERC)
- Delhi Electricity Regulatory Commission (DERC)
- MP Electricity Regulatory Commission (MPERC)

A comparison of the tariff by SERCs is given in Table 7.1.

Table 7.1: Details of Tariff orders by MERC, GERC, DERC

Tariff Order	Rochem Green Energy Pvt.Ltd.	Hanjer Green power Private Limited	ILFS	Okhla
State	Maharashtra	Gujarat	Delhi	Delhi
City	Pune		Gazhipur	Timarpur - Okhla
Year	Jun-14	Jul-11	Jul-08	Aug-07
Technology	Pyrolysis -Gasification	Incineration	Incineration	Incineration & Biomethanation
Fuel	MSW	MSW	MSW	MSW
Waste Processing Capacity	700 TPD		1300TPD	1300TPD
Power Generation Capacity	8.97 MW (3 x 2.99)		10MW	16MW
Cost of fuel considered for tariff calculation	Rs.300 /tonne	Rs.1320/tonne	No	No
Cost of tipping fee considered for tariff calculation	Rs.498 & Rs.574 lakhs per year	No	No	Paid by NDMC
Cost of bi-product considered for tariff calculation	Rs.58.5 & Rs.67.5 lakhs per year	No	No	No
Cost of transportation of fuel considered	No	Yes (included in landed cost of fuel as mentioned above)	No	No
Tariff (Rs/kWh)	Rs.5.86/kWh	Rs.6.80/kWh	Rs.6.87/kWh	Rs.2.32/kWh
Ownership	BOOT	Private Ownership	Private Ownership	
Auxiliary Power	15%	11.50%		
Remarks	Pune Municipal Corporation to supply 700TPD at plant site		Delhi Municipal Council to supply MSW at plant site	100 tonnes for bio-methanation
GCV Considered	2517 kCal/kg	2250 kCal/kg		

The above mentioned tariff orders were passed over the last 10 years and the investment cost considered to arrive at the above tariff orders are based on the biomass based power plants which are modified to use MSW as fuel along with certain percentage of biomass mix.

The following are the orders issued by various Regulatory Commissions towards WtE power generation projects. The details of the orders are available in public domain.

State Commission	WtE Power Producer	Order No	Date of order
DERC	Timarpur Okhla Waste Management	F 3 (164)	14.08.2007
DERC	East Delhi waste Processing Co	F 3 (204)	11.07.2008
MERC	Sholapur Bioenergy Systems Pvt Ltd	Case No 65 of 2009	03.09.2010
GERC	Hanjer Green Power Pvt Ltd	Petition No.1052/2010	03.02.2011
MERC	Rochem Green energy Pvt Ltd	Case No 7 of 2012	23.08.2013
MERC	Rochem Green energy Pvt Ltd	Case No 77 of 2014	25.06.2014
MPERC	Power Company, Jabalpur	SMP-36/2013	01.10.2013

Chapter 8 Evaluation of Appropriate Tariff

State regulatory commissions have issued various tariff orders for municipal waste based power generation projects from 2004 making assumptions from time to time. CERC in its renewable energy tariff regulations of 2012, provided guidelines for determination of specific tariff on a case to case basis for municipal solid waste projects. Each technology has its inherent cost factors and the location of the project determines its capacity.

8.1 Factors in Tariff determination - WtE

Cost plus approach is one method followed for tariff determination of WtE projects. The parameters taken into account in this method Capital cost, Fuel cost, O & M, Auxiliary power consumption etc., these parameters varies based on technology as well as size of the WtE plant.

It is important to note that WtE project sites can also generate recyclables, RDF of high value, Compost /manure. Sometimes these value additions may yield some quick amounts rather than power generation. In tariff calculation accounting these parameters will be difficult. The WtE project developers must have long term agreement with municipal authorities for waste management, where developers are already getting tipping fee for MSW handling.

There are no operational data of specific projects available to consider as a base to determine the tariff.

Another option, where waste to energy projects can be treated as special case (where investment cost is high as per MNRE approved technology over Rs 15 crores per MW) and allow project developers to sell power under open access to third party. Once developers are making revenues from sale of power and at the same time, cost of fuel is determined, then it can lead to MSW shortage as fuel availability is under the control of Municipal authorities.

8.2 Technology based Tariff Evaluation

Based on interactions with technology suppliers and operational history of waste to energy running plants, two technologies were identified for implementation.

- Biomethanation plants where power generation capacity is lower but generates manure and is well suitable for many municipalities taking into account the type of waste segregation in place. *Example : Operational plant of Sholapur*
- MNRE approved combustion or incineration with energy recovery by using reverse reciprocating grate technology. This technology handles mixed waste and comes with pollution control equipment, and is well accepted globally to handle MSW. *Example: New coming up plant of Jabalpur*

It is important to account capacity / size of WtE plants for respective technology. Biomethanation plants can be multiples of 100 / 200 TPD, whereas incineration plants are economical above 300TPD as minimum capacity. It is also suggested that waste to energy power generation projects to be considered, when the MSW availability is over and above 300 TPD (as per planning commission report 2014).

The present tariff calculation for both approved technologies works out for 600 TPD handling of MSW. The parameters considered for calculations are taken from operational power plants data as well as technology suppliers and the working details are given in Table 8.1.

Table 8.1 Computation of Tariffs – WtE projects

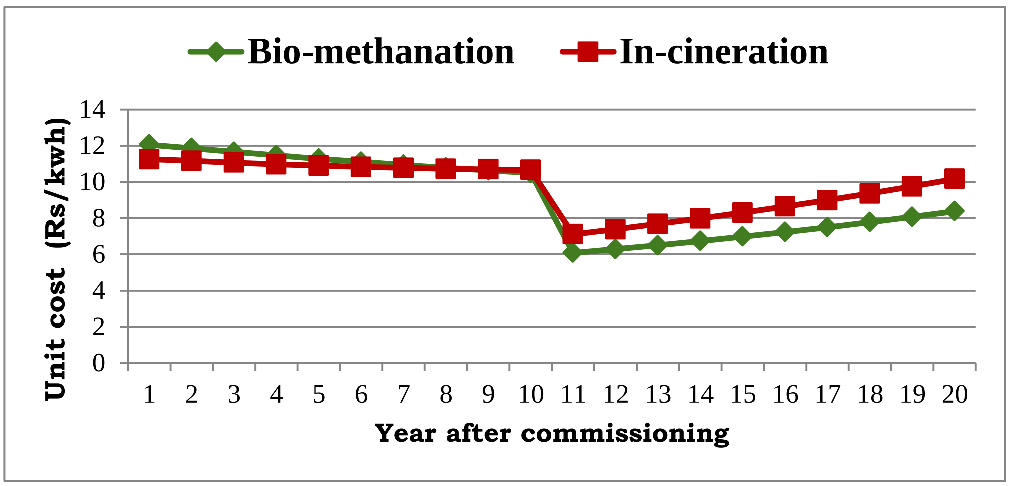
MSW for WtE project : 600 TPD				
Sl. No	**Parameters**	***Units***	**Biomethanation**	**Incineration**
1	Plant size	*MW*	6	12
2	Cost per MW	*Rs Crores*	18	16.7
3	Plant Load Factor	%	70	70
4	Auxiliary power cons	%	25	16
5	Interest on Working Capital	%	12	12
6	O & M	%	5	6
7	Debt -Equity Ratio		70 :30	70 :30
8	Debt Interest Rate	%	12	12
9	Debt Interest period	*Year*	10	10
10	Return on Equity	%	16	16

The average and levelised tariff based on 20 years of work is given in Table 8.2. It is important to note there is input fuel cost (MSW) accounted in the tariff calculations and break-up cost of other heads is listed down.

Table 8.2 Break-up of tariff components

Particulars	Biomethanation	Incineration
Average Tariff, Rs per kWh	9.19	9.72
Levelised Tariff, Rs per kWh	10.17	10.32
Break - up (Rs per kWh)		
O & M Expenses	2.91	2.89
Depreciation	2.73	2.26
Interest on term loan	1.34	1.11
Interest on Working Capital	0.97	2.21
ROE	2.22	1.84

The tariff working year wise potted in graph form and is given below. The details of tariff workings provided in **Appendix 8/1 (a & b).**



8.3 Suggested Tariff Implementation

As per the MSW policy there is an emphasis on *source segregation* of MSW and this is also in place in many ULB's. Due to various actions and situations there are many incidents where by segregation process is affected. Municipal corporations have also invested significant amount of funds in *decentralised waste segregation* and in composting process units. The quality of MSW availability varies from time to time in the same municipality and after decentralised waste segregation different type of RDF is available for waste to energy power generation plants.

It is important to note that various value chains do exist in MSW handling, which begins from door to door collection centres. Local agitations / walkouts of various agencies with in municipal areas in relation to MSW are impulsive. It is also important to consider seasonal variations on quality / quantity of waste availability.

Based on the present MSW system handling, when there is a price for MSW there could be demand and it can create short fall in availability. The new project developers many not got sufficient quantities as expected and WtE power generation projects can get into complications for continuous operations.

Municipal waste handling and disposal is sole responsibility of municipal authorities and it should be considered as income generation source. To meet other municipal services like lighting, Water pumping (in smaller ULB's), office buildings, schools etc., a substantial amount of funding is spent for power. It is a win-win situation for municipal utilities to set up (or invest) their own WtE power generation plants. The generated power can be connected to the grid and net power consumption, differential excess can be banked or allowed for third party sale. Even higher tariff of power generation, will really account because of net consumption accounting for municipal services. Ideally WtE power generation plants act like captive power generation unit for meeting municipal demand, in such cases there is no need to consider fuel costs in the tariff calculations. In this method the supply of MSW and its quality (caloric value) will be in the hands of municipal authorities and running WtE plants profitably is of prime importance.

Another appropriate approach is to look into existing MSW handling sites and long terms contacting firms, where WtE energy plants can be easily set up.

Chapter 9 Conclusion

Efficient and environmental friendly disposal of wastes is the responsibility of Municipal Corporations. The existing policy also strongly supports source segregation and installation of decentralised processing unit. Municipal authorities should consider utilizing all components of waste at a decentralized level and minimize the cost of collection and transportation to centralized processing facilities. The processing can reduce waste disposal by 80% and there-by reduce pressure on scarce land. Our study indicates that while the municipal corporations of Bengaluru and Mysuru have mandated the source segregation, it is not adopted 100%. In case of Hubballi-Dharwad, source segregation is not in place.

As per the Supreme Court direction without segregation burning of waste is not allowed, whereas the RDF produced from the processing units can be incinerated. Waste to Energy power generation plants can be best centralised units to process higher calorific value RDF from decentralised processing units. Collection/Segregation/transportation of MSW for disposal has various glitches. In all practical purposes the adopted technology should be suitable for heterogeneous waste. It was observed during our visit to bio methanation power plant at Solapur, segregation of waste is in place along with power generation. It is a proven technology to adopt for smaller Indian municipalities (eg. Solapur Bioenergy Systems Ltd). The upcoming WtE plant at Jabalpur (ESSEL Infra) is of incineration technology with heat recovery, which can handle mixed waste as fuel. However this technology is more economical to handle over 300 TPD municipal waste with RDF. The operational plant load factor of waste to energy plants is 70%.

Based on our assessment, BBMP can establish 600 TPD waste to energy plant with power generation potential of ~12 MW. In case of HDMC, where waste segregation is not in place, multiples of 200 TPD waste to energy power generation plants can be established and the same can yield ~2 MW. The above recommended technologies are approved by MNRE and meeting the environmental compliances. Our recommendations are on identical lines.

The evaluated tariffs are much higher compared to the prevailing renewable energy generation tariffs, due to higher initial capital investments. Tipping fee is prompting the WtE developers upto processing of waste and not to risk with high investment power generation. It is recommended that Municipal authorities may treat WtE power generation as their captive power unit, as it results significant amount of cost savings to the Municipalities.

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