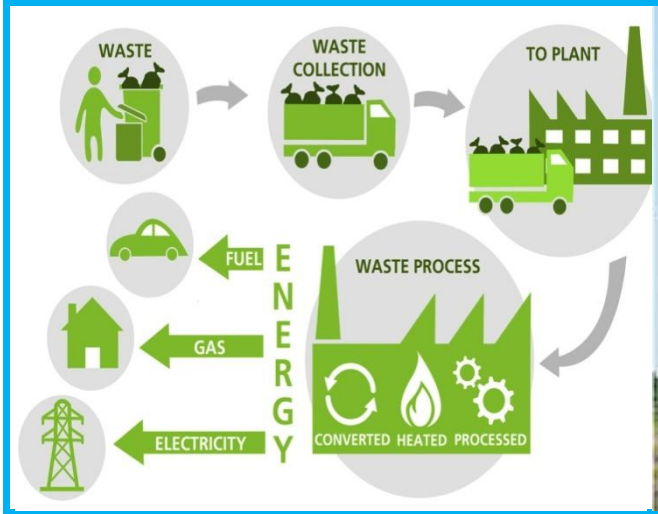
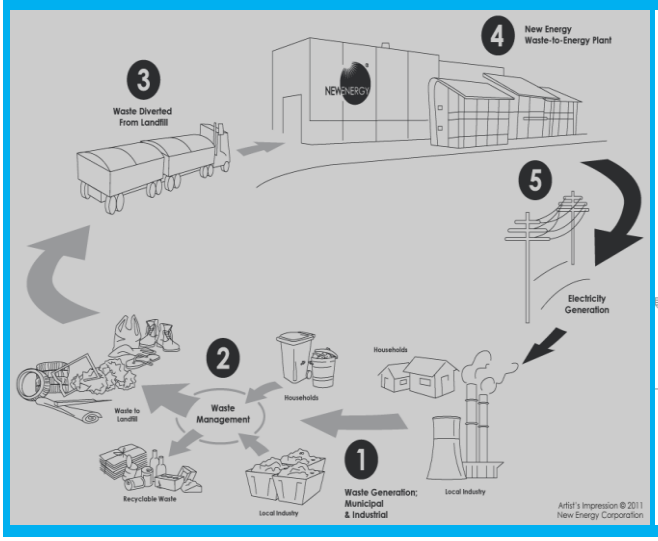
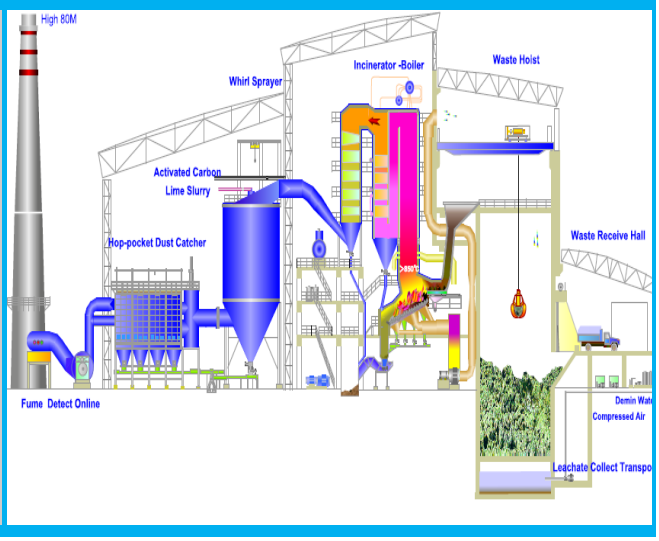
Report of the Task Force on Waste to Energy (Volume I)

(In the context of Integrated MSW Management)







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Planning Commission

May 12, 2014

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List of Abbreviations

Abbreviation	Full Form
ALM	Advanced Locality Management
B&T	Build and Transfer
BARC	Bhaba Atomic Research Centre
BOOT	Build Own Operate and Transfer
BOT	Build Operate and Transfer
C&D	Construction and Demolition
CBO	Community Building Organisation
CC	Conventional Composting
CFB	Circulating Fluidized Bed
CHP	Combined Heat and Power
CHP	Coversion to Heat and Power
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
CSLF	Common Sanitary Landfill
CSS	Centrally Sponsored Scheme
DAE	Department Of Atomic Energy
DBFOT	Design Build Finance Operate and Transfer
DBOOT	Design Build Own Operate and Transfer
DPR	Detailed Project Report
EI	Empowered Institution
EIA	Environment Impact Assessment
ELV	End of Life Vehicle
EO	Executive Officer
EOI	Expression Of Interest
EU	European Union
GHG	Greenhouse Gas
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GOI	Government Of India
GPRS	General Packet Radio Service
GSM	Global System For Mobile Communication
HOD	Head of Department
ICT	Information Communication Technology
IISC	Indian Institute of Science
ILFS	Infrastructure Leasing & Finance Services
IMSWM	Integrated Municipal Solid Waste Management
ISWA	International Solid Waste Association.
JnNURM	Jawaharlal Nehru Urban Renewal Mission
KW	Kilo Watt
MCA	Model Concession Agreement
MIS	Management Information System
MNRE	Ministry of New and Renewable Energy
MoA	Ministry of Agriculture
MoEF	Ministry of Environment and Forest
MoP	Ministry of Power
MoUD	Ministry of Urban Development
MSW	Municipal Solid Waste
MT	Metric Tonnes
MW	Mega Watt
NCV	Net Calorific Value
NEERI	National Environmental Engineering Research Institute

Abbreviation	Full Form
NEP	National Environment Policy
NGO	Non-Governmental Organisation
NIMBY	Not In My Backyard Syndrome
NRP	National Recycling Program
NTP	National Tariff Policy
O & M	Operation & Maintenance
PCC	Pollution Control Committee
PMO	Prime Minister's Office
PPP	Public Private Partnership
PPPAC	Public Private Partnership Appraisal Committee
PSP	Private Sector Participation
RDF	Refuse Derived Fuel
RET	Renewable Energy Target
RFP	Request For Proposal
RFQ	Request For Qualification
RWA	Residents Welfare Association
SERC	State Electricity Regulatory Commission
SJSRY	Swarna Jayanti Shahri Rozgar Yojana
SLF	Sanitary Landfill
SM-MSW	Smart Municipal Solid Waste Management
SPCB	State Pollution Control Board
SPV	Special Purpose Vehicle
SWM	Solid Waste Management
SWOT	Strength, Weakness, Opportunities And Threat
TAC	Technical Advisory Committee
TF	Task Force
TIFAC-DST	Technology Information, Forecasting & Assessment Council- Department Of Science & Technology
ToR	Terms of Reference
TPD	Tonnes Per Day
UIDSSMT	Urban Infrastructure Development Scheme for Small and Medium Towns
ULBS	Urban Local Bodies
VC	Vermi- Composting
VGF	Viability Gap Funding
W to E	Waste to Energy
WEEE	Electric and Electronic Equipment Waste
WHO	World Health Organisation
WPI	Wholesale Price Index

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Report of the Task Force on Waste to Energy

We, the Members of the Task Force constituted to study technological aspects of Waste to Energy (W to E) projects and propose potentially sustainable models of Municipal Solid Waste (MSW) processing including energy recovery through integrated MSW management in the country, have carefully looked at the current situation of MSW management and various technologies that can be supported at a Decentralized and Centralized level on Public Private Partnership (PPP) mode to enhance resource recovery and deriving energy and nutrients from waste, after due deliberations have adopted the Report for Submission.

Dr. K. Kasturirangan
Chairman

Members

1. Secretary, MoUD	**2. Secretary, DAE**	**3. Secretary, MoP**
4. Secretary, MNRE	**5. Secretary MoEF**	**6. Adviser to DCH, PC**
7. Dr. Indrani Chandrasekharan	**8. Prof. S. Dasappa**	**9. Prof. Emran Khan**

Expert Members

10. P. U. Asnani	**11. Prof. Shyam R. Asolekar**	**12. Amit Kumar**
13. Dr. Sharad P. Kale	**14. Dr. A. Akolkar**	**15. Vijay Chaurasia**

Dr.A.K.Dhussa

Peer Review

Dr. Isher Judge Ahluwalia	**Dr M. Ramachandran**
Dr R.K. Pachuari	**Dr Sunita Naraian**

Preface

The purpose of this report is to identify technically feasible, financially affordable and environmentally sound processing and disposal technologies for Municipal Solid Waste (MSW) and assess, evaluate and recommend systems, processes, technological options, financial mechanisms and institutional arrangements to enhance resource recovery and promote Waste to Energy (W to E) technologies while ensuring integrated management of MSW in India.

The report provides an overview of the enormous management challenge that municipal solid waste presents and also offers a basis for choosing from among the various options available.

Currently, of the estimated 62 million tonnes of MSW generated annually by 377 million people in urban areas, more than 80% is disposed of indiscriminately at dump yards in an unhygienic manner by the municipal authorities leading to problems of health and environmental degradation. The untapped waste has a potential of generating 439 MW of power from 32,890 TPD of combustible wastes including Refused Derived Fuel (RDF), 1.3 million cubic metre of biogas per day or 72 MW of electricity from biogas and 5.4 million metric tonnes of compost annually to support agriculture. The existing policies, programmes and management structure do not adequately address the imminent challenge of managing this waste which is projected to be 165 million tonnes by 2031 and 436 million tonnes by 2050.

Further, if the current 62 million tonnes annual generation of MSW continues to be dumped without treatment; it will need 3, 40,000 cubic meter of landfill space everyday (1240 hectare per year). Considering the projected waste generation of 165 million tonnes by 2031, the requirement of land for setting up landfill for 20 years (considering 10 meter high waste pile) could be as high as 66 thousand hectares of precious land, which our country cannot afford to waste. The Task Force (TF) has taken a serious view and considers it imperative to minimize the wastes going to landfill by at least 75% through processing of MSW using appropriate technologies.

The processing will not only generate revenue and new products from waste, but also improve public health and quality of life of people. World Health Organization (WHO) has observed that 22 types of diseases can be prevented/ controlled by improving the MSW management system. This will indirectly save huge financial resources currently spent on health and medical services.

The thrust of the task force is therefore to minimize the quantum of waste for disposal by optimal utilization of the potential of all components of MSW by adopting the “concept of 5-R” – Reduce, Reuse, Recover, Recycle and Remanufacture – and through integrated Municipal Solid Waste Management, derive energy and other useful products and ensure safe disposal of residual waste. The ultimate objective should be zero waste going to landfills.

While evaluating the technological options to treat all components of wastes, factors that have been considered by the TF include quantity and composition of MSW,

collection, segregation and transportation capabilities of Urban Local Bodies (ULBs), scale of operation (centralized vs decentralized), institutional & financial issues, conversion technology, estimation of energy, compost generation, capital and operational costs, financing options including outcome-based subsidy, levy of tipping fees and user charges and optimally exploring Public Private Partnership (PPP) and Private Sector Partnership (PSP) potential. These have been addressed with the core objectives of reduction in soil, water and air contamination, minimization of environment and health impacts, increasing the level of resource recovery and recycling and reduction in greenhouse gas (GHG) emissions.

It is strongly felt that citizens and municipal authorities need to change their attitude towards waste, make serious efforts to reduce the waste and recover recyclable materials, return nutrients to the ecosystem as well as derive energy from waste. Waste conversion technologies in vogue include a wide array of thermal, biological, chemical and mechanical technologies capable of converting MSW into useful products like compost and energy such as steam, electricity, natural gas and diesel/ ethanol.

While a large number of commercial scale plants based on conversion technologies are operational worldwide, very few plants are successfully operating in the country. Very limited and not very encouraging experience in the W to E area and age old composting technologies not finding adequate acceptance in the present form with the farming sector, have resulted in a crisis like situation, necessitating immediate identification of appropriate technologies and suggest mechanism for supporting such technologies to make them affordable and viable. It is recognized that any waste processing plant, small or big, which produces biogas, syngas, ethanol, electricity, liquid fuel or any other fuel is in fact a W to E plant and should be deemed eligible for support.

An attempt has been made in this report to guide Urban Local Bodies in adopting an integrated approach towards MSW management with a focus on W to E and to advise Government of India and the State Governments to extend financial and technical support to facilitate optimum utilization of municipal solid waste as a resource, tapping unutilized energy potential of the MSW and ensuring proper collection, transportation, processing and final disposal. This report will also guide the stakeholder in understanding the issues associated with processing options.

In presenting options, the report highlights preconditions required for different cities with varying composition of waste. It also emphasizes the need for a regulatory framework to ensure segregation at source and separate collection of various streams of waste and human resource capacities (technical, managerial and planning-oriented) at the level of the local government so that the Municipal Authority and the state government together can begin addressing this major challenge.

The report is structured as follows:

Chapter 1 describes the status of MSW and estimates of generation, processing facilities state wise, need for recovery and recycling, existing legal framework and

suggestions, the current status of financial support to the sector and the constitution of the Task Force. Chapter 2 deals with mandate and deliberations of the Task Force and provides an insight into the overall reasons for our unsuccessful attempt at scientific processing and disposal of MSW. The chapter also deals with gaps and constraints observed and suggestions made by experts.

Chapter 3 & 4 outlines the technological options for the treatment and disposal of MSW, discusses the two major groups of processing MSW namely, bio-chemical and thermo-chemical. It also details the three main technological options; incineration, gasification and pyrolysis as well as emerging plastic waste to liquid fuel. The energetics and economics of W to E and the issues in the operation of W to E technologies including significance of segregation, collection and transportation, centralized and decentralized approaches including choice and International experience is detailed in these chapters.

Proposed models for MSW management covering SWOT analysis of the treatment technologies and environmental implications, framework for appropriate technological options as well as the concept of integrated MSW management are detailed in Chapter 5. The chapter also recommends technological options for various classes of cities based on five criteria and illustrating these for easy implementation. Chapter 6 deals with the potential for Public Private Partnerships (PPPs) and Private Sector Participation (PSP) and the two frameworks, one on collection, segregation and transportation and the other for setting up waste processing and disposal facilities. It also clearly details PPP options available to municipal authority to discharge their functions effectively. Contract models, engagement of private partners and elements of concession agreements are also outlined.

Chapter 7 deals with modes of financing, existing financial support available and possible options for funding capital and Operation and Maintenance (O&M) costs. Institutional mechanism, management structure and the role of municipal authorities are detailed along with smart waste management in Chapter 8.

Chapter 9 highlights policy, strategy and regulatory framework required for the proposed models as well as capacity building and research and development. Summary and recommendations of the Task Force are given in Chapter 10.

As the problems of waste management are assuming serious proportions, the bottom line is that every citizen of this country should be sensitive to the implications of not dealing with the waste scientifically, with the attendant impact on environment and health. Proper attention to waste management should assume cultural dimensions and not restrict to merely procedural, legal or financial aspects. The discipline that the country displays in dealing with waste should be viewed in the broader context of the discipline that we need to bring to every national endeavour. To us, as Indians this should be a reflection of our pursuit for excellence and perfection in everything that we undertake at the level of institutions, community and society.

Acknowledgement

The Task Force would like to express their grateful thanks to the Planning Commission, particularly Deputy Chairman, as well as Prime Minister's Office (PMO) for entrusting this important task of examining the technological aspects of Waste to Energy projects in the context of contemporary municipal solid waste scenario in India, to explore various options of Waste to Energy and to recommend potentially sustainable models for MSW management.

In order to consolidate, assess and analyze inputs obtained through various deliberations, as well as taking stock of the experience in operating various MSW plants through visits, a Drafting Committee was constituted. Mr. P.U. Asnani , Chairman, UMC Global brought to bear his life long experience in the planning and implementation of MSW related activities both nationally and internationally, in creating a cogent framework for the document. Prof. Shyam R. Asolekar, Head, Centre for Environmental Science and Engineering at Indian Institute of Technology, Bombay provided vital support for the formulation of the document, especially in the context of assessment of different technologies based on rigorous scientific analytical methods. Prof. Asolekar's erudition and scholarship brought a new dimension to the discussions, enriching the value of the report. Dr. Sharad P. Kale, Senior Professor, BARC has been one of the recognized authorities in the area of bio-gas and has set up a number of plants to deal with bio-degradable/wet-waste. His contribution to the document has been based on his experience in setting up several plants across the country for low volume bio-waste processing and also dealing with several municipalities and other bodies. Dr. Avinash Akolkar, Member Secretary, Central Pollution Control Board (CPCB) has been associated with the organization for over several decades and helped the Drafting Committee with his vast experience and deep knowledge on matters of pollution control and waste disposal strategies. Dr. Anil Kumar Dhussa of MNRE prepared a detailed note on W-to-E technologies adopted globally and an assessment of advantages and disadvantages of these technologies in the Indian context. Mr. Vijay Chaurasia, Adviser, CPHEEO, MoUD provided valuable inputs to the Drafting Committee with factual data of the bottlenecks in the operation of W-to-E plants. The Task Force not only acknowledges with gratitude the Members of the Drafting Committee, but would like to take note of the several hours of deliberations and discussions they held.

Chairman of the Committee would particularly like to recognize the vital role of Dr. Indrani Chandrasekharan, Member of the Task Force, for her excellent organization of meetings of the Drafting Committee. In this process, she also brought to bear her own vast experience on the subject, thus enriching the debates and discussions.

The entire activity of the Task Force at the level of the Planning Commission was overseen by, Shri. Ravi Mittal, Adviser (Infrastructure). His experience in formulation and insight into the execution of Public Private Partnership Projects in highway and green airport projects resulted in a scheme on PPP in MSW management which was critical to the drafting of the chapter on PPP and finances.

In order to make an independent assessment of the subject matter reflected in the Report, for its integrity and authenticity, the Task Force requested four eminent professionals to peer review the report. Dr. Isher Judge Ahluwalia one of the peer review Members, presently the Chairperson, Board of Governors of Indian Council for Research and International Economic Relations (ICRIER) and Chairman of the High Power Expert Committee set up by the Ministry of Urban Development, has been involved in the broader issues of urban planning, urbanization, policy framework and other related issues linked to environment, health, finances and institutional mechanisms. Her in-depth knowledge, evident through extensive publications, on the subject of urbanization in general and Municipal Solid Waste Management in particular has been brought to bear in making a candid assessment of the report. All her comments and suggestions have been appropriately incorporated in the final version of the report. Dr. M. Ramachandran, former Secretary of Ministry of Urban Development, who spearheaded JNNURM & UIDSSMT, also agreed to serve as a Member of peer review Committee. His exhaustive suggestions on each of the chapters based on his own vast experience helped the Task Force to sharpen its approach to the different issues addressed in the report. Dr. R.K. Pachauri DG TERI with his deep involvement on matters of energy sustainability and environment also studied this Report and highlighted certain specific Waste to Energy strategies that have been appropriately reflected in this report. Finally, as a peer reviewer, Dr. Sunita Narain, Director-General of Centre for Science Environment assessed the Report of the Committee in the context of her vast knowledge on environment and health for its grass root level applicability and related institutional framework. The Task Force would like to acknowledge and thank the Members of the Peer Review Committee for the vital inputs provided by them.

In consonance with the broader view of the Task Force the peer review Members were of the opinion that the entire Waste to Energy Management Strategy for the country should be one of an integrated approach with emphasis on waste reduction, resource recovery including Waste to Energy as a part of the overall MSW management. The Task Force has appropriately incorporated the comments and suggestions of Peer Review Members.

The Task Force especially would like to acknowledge Dr. Saumitra Chaudhuri, Member, Planning Commission who provided very useful inputs on the global scenario and helped to map some of the useful aspects of MSW endeavor elsewhere in the context of national scene. Dr. N.B. Mazumdar, formerly with HUDCO, provided an interesting analysis of the core problems and also suggested certain directions for solutions to the same. This was very valuable in the formulation of the Task Force strategy. Dr. Srinivas Chary, Director at the Administrative Staff College of India, (ASCI), Hyderabad made valuable analysis of different options for PPP which in the view of the Committee are of considerable importance to the issues of management and institutional mechanisms for MSW. Dr. Mukund Rao, special consultant on GIS, provided new concepts in the context of bringing ICT that could be a potential tool for better management of MSW programmes in the country. Dr S.R Maley and

Dr P.D. Grover provided vital information which greatly enabled computing of financial resource. Dr. Rahul Pandit of Janwani, Pune provided an insight into successful local endeavours for MSW management which could be replicated. To all these individuals, the Task Force would like to express special gratitude.

Several companies, organizations, institutions presented detailed account of their own experience of running specific programmes on MSW in the country. These include M/s Jindal Urban Infrastructure Limited, M/s A2Z Infrastructure-Kanpur, M/s SELCO International Limited-Hyderabad, M/s RAMKY Pvt. Limited-Hyderabad, M/s EXCEL, Delhi in the category of Public Private Partnership and decentralized models. Dr. Shivprasad of M/s Blended Fuels Limited- Bangalore highlighted and detailed solutions for ensuring successful Waste to Energy projects in the country. Officials of Steel Authority of India (SAIL)-New Delhi made a presentation on the current status on MSW in their colonies. Senior Officials of M/s Bharat Heavy Electric Limited (BHEL)-Haridwar in an exclusive meeting confirmed the possibility of manufacturing furnaces, steam turbines and pollution control equipment by them in the country and arrest the need to import such equipment. Dr Amiya Kumar Sahu of the National Solid Waste Association of India provided an independent analysis of the national Solid waste management scenario in the country. Dr. Kale of BARC also provided very exhaustive inputs on the bio-methanation technology based on successful operation on a number of plants in the country.

The Task Force also greatly benefited from presentations made by a few municipal corporations namely, Chandigarh, Ahmedabad, Kolkata and Nagpur who provided their own experience in the context of transitioning to a new approach to MSW management. These presentations provided the Task Force with a comprehensive picture of the issues of waste generation, collection, transportation, processing and disposal as well as an insight into the institutional mechanisms and financial resources.

As part of assessing the actual operational experience of some processing facilities in the country, a few of the Members of the Committee visited different plants, both operational and those that have ceased to function. These included M/s Jindal Urban Infrastructure Limited, M/s A2Z Infrastructure-Kanpur and M/s SELCO International Limited-Hyderabad. Members of the Committee were briefed by the plant operators on the intricacies of interface with municipalities and state governments as well as issues of finance and sustainability.

Last but not the least, the Task Force would like to put on record sincere thanks to individuals in the Planning Commission and research scholars of IIT, Bombay who continuously toiled to facilitate organization of meetings and discussions, timely documentation, creating agenda, recording minutes and so on. Special mention should be made of the role of Mr. Partha Sarathy Reddy, Director and Ms. Gayatri Nair, Joint Director and Mr. Anand M. Hiremath, Research Scholar, IIT Bombay for his untiring technical support.

Chairman of the Task Force would like to express his deep gratitude to each and every Member of the Task Force for their very vital contributions during different meetings and providing timely guidance to carry the discussions forward in an effective and directed manner. As an example the Task Force received detailed comments on the early draft version of the report from Secretary, MoUD which steered many aspects of further discussions on the Task Force.

Executive Summary

Municipal Solid Waste (MSW) has to be managed by technologies and methods that enable keeping our cities clean, prevent pollution and protect the environment and at the same time minimize the cost through recovery of resources and energy. As per CPCB report 2012-13 municipal areas in the country generate 1, 33,760 metric tonnes per day of MSW, of which only 91,152 TPD waste is collected and 25,884 TPD treated. The MSW, therefore, dumped in low lying urban areas is a whopping 1,07,876 TPD, which needs 2,12,752 cubic meter space every day and 776 hectare of precious land per year.

As per 2011 census, the 377 million people living in 7,935 urban centres (with 4,041 statutory municipal authorities and 3,894 town with more than 5,000 people of which 75% are male involved in non-agricultural activity), generate 1, 70,000 TPD and 62 million tonnes of MSW per year which is based on an average per capita generation of 450gm per person per day. It needs to be noted that 62 million tonnes of waste generation reported, annually, does not include wastes picked up by kabadiwalas from households and from the streets by rag pickers. As per MoUD, 70 million tonnes of waste is generated currently in urban centres. There are thus conflicting data about the quantum of waste actually generated in urban areas in the country, principally because there is no system of periodically collecting and updating country wide data base on quantity and composition of waste.

As per information available for 2012, compiled by CPCB, municipal authorities have so far only set up 279 compost plants, 172 biomethanation plants, 29 RDF plants and eight Waste to Energy (W to E) plants in the country. World Health Organization (WHO) has observed that 22 types of diseases can be prevented/ controlled in India by improving Municipal Solid Waste Management (MSWM) system. Scientific management of MSW will save, huge financial resources currently spent on medical services and the health of our young population.

Principal reasons for the prevailing unhygienic conditions in our cities is the casual attitude of the citizens as well as the municipal authorities towards managing solid waste, lack of priority to this essential service, inadequate and inappropriate institutional structure, lack of technical knowhow and paucity of financial resources.

The Task Force critically looked at failure/under performance of the processing facilities setup and observed that 1) lack of due diligence on the part of investors as well as public sector , 2) non supply of committed quantity / quality of waste to the plant by the municipal authority, 3) presence of inerts - dust & C and D waste in MSW delivered for processing, making the operations difficult and very expensive, 4) Inadequate market for sale of compost/RDF, 5) public outcry against the location of a plant, and 6) lack of financial viability of projects, were found to be the major reasons. It has been reported that quite a few of the processing plants set up as mentioned earlier (in para 3) are currently non- operational.

This report provides an insight into the various stages of MSWM such as, segregated storage at source ,collection, segregation, transportation, processing and disposal of wastes. It also details the integrated waste management approach, decentralized and centralized systems, feasible technological options, framework for MSWM including PPP and financial feasibility for various classes of cities, regulatory changes, use of Information Communication Technology (ICT) and the financial support in the form of capital and O&M that needs to be extended to the sector.

1. Appropriate Approaches, Systems and Technological options

After careful considerations of the views expressed by the subject experts, municipal authorities, technology providers, other stakeholders and the observations made during the field visits, the task force recommends: :

A. Integrated approach towards management

In contrast to the current fragmented approach to management of MSW, an Integrated Municipal Solid Waste Management (IMSWM) system that addresses all essential activities namely, segregation and storage of waste at source, door-to-door collection, secondary storage, transportation, transfer stations, processing and disposal of MSW simultaneously in a coordinated manner is recommended as a way forward to transforming MSWM practices in the country. Such an integrated approach will make towns and cities clean and liveable and optimize tapping the potential of MSW through recovery of recyclables, generation of energy, compost and Refuse Derived Fuel (RDF) from the waste and minimize the wastes going to landfills.

i. **Segregation of waste for efficient utilization of resources:** A campaign should be launched to create awareness on the importance of reducing the waste generation. It is strongly felt that the principle of Reduce, Reuse, Recover , Recycle and Remanufacture (5Rs) should be adopted and after making serious efforts to minimize waste , all components of MSW be utilized in a manner, that the full potential of the waste is tapped. Appropriate segregation at source/secondary storages is essential to achieve this object. The waste that can be recycled should be recycled to manufacture new products saving natural resources, the wet wastes that can produce biogas or compost, should be processed and the wastes that are non recyclable and yet have high calorific value should be used for W to E projects.

ii. **Participation of civil society**

Municipal Authorities should make concerted efforts to involve civil society in managing their waste and motivate Resident Welfare Associations (RWA), CBO / NGO's to take up work of community awareness and door to door collection to facilitate resource recovery and waste minimization.

iii. **Integration of kabadiwalas and rag pickers into MSWM system:** For efficient utilization of untapped resources, source segregation of MSW, recycling enabled through the informal institution of kabadiwalas and ragpickers be appropriately integrated into the system through recognition and strengthening of this sector. The municipal authorities may support association of rag pickers or NGOs in setting up

Recyclable Waste Collection Centres (RWC) on municipal land where the rag pickers can sell for a price the recyclable materials (not otherwise purchased by kabadiwalas) collected by them. The municipal authority may also involve the rag pickers (there are an estimated 1 million rag pickers in the country) through NGOs or private sector for picking plastic and other recyclable materials from the streets in a designated area for making the cities "litter free" and preventing the useful material going to landfills. Such rag pickers could be paid incentive money for carrying out the task satisfactorily. While protecting the interest of rag pickers care needs to be taken to prevent child labour.

To facilitate sorting of recyclable materials collected by informal sector and supporting recycling industry, the municipal authorities should set up waste sorting facilities at suitable locations and permit the informal sector to use the facility for segregation of recyclables.

iv. **Common regional sanitary landfills- an essential component of IMSWM:** Sanitary landfill is an essential component of waste management chain where municipal authorities are required to dispose of inert wastes such as street sweepings, silt from the surface drains and residual waste from the processing plants. The percentage of inerts and residual waste currently required to be disposed off in sanitary landfills in the country forms about 25% of the MSW generation – which will progressively reduce with improvement in waste management system. Landfill requires professional management and heavy machinery to compact the waste and regular monitoring to safeguard the environment.

Considering, the need for 60,000 acres of land (@15 acre per 1 lakh population) for a period of 25 years to dispose 42,500 TPD of inerts and residual wastes, it is essential to set up Common Regional Sanitary Landfill Facility, to reduce the land requirement. Cities above a population of one million should set-up their own landfill and permit all cities and towns within 50km periphery of the city to use the facility for disposal of their waste. Common regional facilities may be constructed for rest of the cities, towns and urban centres by forming clusters within 50km radius with a population of at least one million. Only in special cases, where, the distances between the cities are large, the cluster size may be brought down suitably to handle at least 50 TPD of residual waste. It is not viable to have standalone landfills for small towns/cities. The construction of common landfills may be facilitated by state agencies in close co-ordination with metropolitan area planning committee/ district planning committee and town planning department of the state governments.

B. Centralized and Decentralized processing of waste

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. Centralized plants may be setup only when suitable land or small entrepreneurs for setting up decentralized facilities are not available or where the neighbourhood is opposed to setting up facilities in its area. In situations where setting

up of centralized processing becomes inevitable, such facilities should be sufficiently large and private sector should be encouraged to design, construct, finance, operate and maintain such facilities.

In order to have a clear understanding on the preference of centralized or decentralized facilities for technologies, their advantages, limitations and applications; a survey was conducted wherein opinion of experts was recorded in the form of scores. Fifteen experts responded to the survey.

Decentralized v/s centralized processing of MSW:

i. Experts were of the opinion that decentralized approach is appropriate for segregation at source, transportation, pre-processing of wastes, biomethanation, conventional and vermi composting. Centralized approach is recommended for technologies such as incineration, pyrolysis, gasification, RDF production, mechanical composting C&D waste processing and managing sanitary landfills.

ii. Decentralized processing was preferred in case of bio-degradable waste.

iii. Municipal authorities should therefore consider utilizing bio-degradable components of waste at a decentralized level and minimize the cost of collection and transportation to centralized processing facilities. Centralized compost or bio-methanation plants may however be set up where suitable land or small entrepreneurs for setting up decentralized facilities are not available.

iv. For utilizing combustible waste, centralized W to E project facilities should be sufficiently large to handle at least 300 TPD of combustible waste and private sector should be encouraged to invest in such projects on Design, Build, Finance, Operate and Transfer (DBFOT) basis.

The central and state governments may jointly demonstrate how decentralized approach can work by setting up at least one decentralized processing facility in each state at full government cost and technical assistance. This may be utilized as a training ground and opportunity for other local bodies to follow.

C. Selection of appropriate technologies for processing of MSW waste

Learning from past experience, it was considered essential to identify suitable technology or combination of technologies for processing all treatable components of MSW. It was observed that there are several technologies currently being advocated for processing of waste world over. These technologies can be classified into two broad categories namely:

1. Bio-chemical conversion of biodegradable MSW
2. Thermal processing of MSW

Group one covers technologies such as composting and biomethanation, whereas Group 2, include technologies like gasification, pyrolysis, incineration and mass burning. Refuse Derived Fuel (RDF) can also be prepared from combustible MSW and

used as a feedstock for W to E plants. Technology for production of syngas also merits consideration.

Besides conventional W to E technologies, new technologies are emerging in India for converting polymeric wastes to liquid fuel called "catalytic conversion of waste plastic to liquid fuel" and blending chopped plastic waste with molten bitumen for enhancing the strength of roads. These technologies can also be used for profitably utilizing plastic wastes which are not currently recycled.

i. **Strength, Weakness, Opportunities, Threat (SWOT) analysis and environmental footprint analysis of existing W to E technologies**: In order to select appropriate technologies, SWOT analysis as well as environmental footprint analysis have been carried out in respect of each technology; its relative strengths and weaknesses have been examined in detail and a framework for appropriate technological options has been worked out for adoption by various cities depending on their population, quantity and quality of waste generated.

ii. **Appropriate Technological Options:** In the Indian context, the following technologies are identified for processing of MSW:-

   a. Biomethanation for wet biodegradable wastes

   b. Conventional microbial windrow/mechanized/ vermi composting for wet biodegradable wastes

   c. Preparation of briquette/ pellets/ fluff as Refuse Derived Fuel (RDF) from dry high-calorific value combustible wastes

   d. Incineration / Gasification / Pyrolysis for dry high-calorific value combustible wastes

   e. Plastic wastes to fuel oil

A combination of aforesaid technologies has been identified based on the range of population and quantity and quality (percentage of biodegradable) of wastes generated. In addition, the cost of setting up of processing plants along with the expected quantities of value added products and by-products have also been considered. Choice of suitable technologies for various classes of cities as per 2011 census is given below.

a. Cities with population of 2 million and above, which generate more than 1100 TPD of MSW thermal route are suitable for setting up standalone waste to energy plants. These cities should also setup a combination of biomethanation, and composting (VC/CC) plants besides setting up of W to E plants to optimally utilize biodegradable wastes. Conversion of waste plastic to fuel oil which is an emerging technology is also suggested as an option.

b. Cities with population of one to two million, which generate more than 550 TPD of MSW are suitable for setting up a waste to energy plant based on thermal route only -- with the support of adjoining cities supplying RDF to make the W to E plant viable. These cities should also setup a combination of biomethanation,

and composting (VC/CC) plants to optimally utilize biodegradable wastes. Conversion of waste plastic to fuel oil has also been suggested as an option.

c. In respect of the 415 Class I cities which have a population range of 1 lakh to 1 million generating 30 to 550 TPD of MSW, the technological options are a combination of biomethanation and composting (VC/CC) plants to optimally utilize biodegradable wastes. However, these cities may set up a common /regional W to E plant after ensuring adequate availability of RDF on a regular basis from participating cities. Conversion of waste plastic to fuel oil is also suggested. Hill stations are also included in this set of cities and local bodies will have to ensure that recommendations made for hill cities in respect of technological options be used for ensuring proper disposal of MSW.

d. For towns with population below 100,000 including peri-urban areas (although known as villages but declared as census towns and included in urban population), which generate less than 30 TPD waste and have 30 to 65% of biodegradable fraction of MSW, a combination of biomethanation, composting (VC/CC) and RDF preparation is considered the most suitable technological option for management of MSW. These cities should segregate dry waste, prepare RDF and supply RDF prepared as fuel to W to E plants established in cities with over a population of 1 million.

The biogas generated from biomethanation plants can be utilized for direct supply through pipelines or converted to power. In case of plants with 10 TPD and above capacity, biogas can be commercially bottled and marketed.

iii. Process flow diagram: Looking at the size of the cities and volume of the wastes generated, process flow diagrams have been drawn to enable local authorities to integrate waste management as well as processing and disposal of waste. A typical process flow diagram for cities above 2 million which have potential of setting up waste to energy plants is given in **Figure A**.

iv. Viability of W to E plants: As W to E plants are viable only when the plant has a capacity to process 300 TPD or more segregated waste, it should only be set up in large cities with population above 2 million or for a group of cities exceeding that population. The combustible waste generated in small towns and cities should therefore be utilized for preparing RDF and used as feed stock for power plants or cement or metallurgical plants

v. Potential of waste to energy projects: As per realistic estimates, India can produce 32,890 tonnes of RDF each day which can currently support 88 power plants of 5 MW each in a foreseeable future of 5-7 years based on incineration, gasification or pyrolysis technologies. The number of power plants can increase to 215 plants by 2031 and 556 power plants by 2050 generating 2,780 MW power.

2. Public private partnership- as a mode of service delivery

Public private partnerships (PPP) may be encouraged in Solid Waste Management sector by the state governments through a policy framework on PPP and development of standard Request for Proposal (RFP) documents including concession agreements clearly outlining the roles and responsibilities of private sector and the municipal authorities. A simple workable mechanism to resolve the disputes that may arise between the concessionaire and the municipal authority during the concession period may be provided by the state to avoid long drawn litigations. PPP may be encouraged in providing services that are not currently provided by the municipal authorities and for setting up waste processing and disposal facilities. PPP projects will facilitate, putting private money into public projects (Ahluwalia, 2014) and pave way for infrastructure development. Through this mode of procurement, the government/municipal authority will be able to tackle serious problems of municipal waste management by combining the respective strengths of the public and the private sector. The municipal authorities may be fully apprised of the concept of PPP and the benefits they can derive through PPP mode of service delivery.

Keeping in view the current status of MSW management, three types of MSW management models are envisaged:

i. The functions that could be best performed by the municipal authority only.

ii. The functions that could be performed by the municipal authority and / or private sector.

iii. The functions that could be best performed by the private sector only.

In all the three scenarios the municipal authority shall remain accountable for efficient delivery of service. The municipal authorities are advised to follow recommended models (**Figure B**) on a PPP mode as detailed in the report.

PPP scheme to avail viability gap funding- Municipal authorities with population above 2 million where large W to E projects have been recommended, should consider adopting the PPP scheme drafted by the planning commission and detailed in Chapter 6.

3. Financial support for the sustainability of MSW management & processing and disposal facilities:

A. Viability gap funding

Viability of waste processing technologies on PPP mode is a matter of great concern. It is considered essential to bridge the viability gap through financial support from government of India, state government and municipal authorities. After carefully examining the viability gap, it is felt that private sector may be given viability gap funding to the extent of 40% towards capital expenditure by the central government upfront or 20% viability gap funding each for capital investments and O&M costs linked to performance and another 10% by the state governments for the sustainability of such projects.

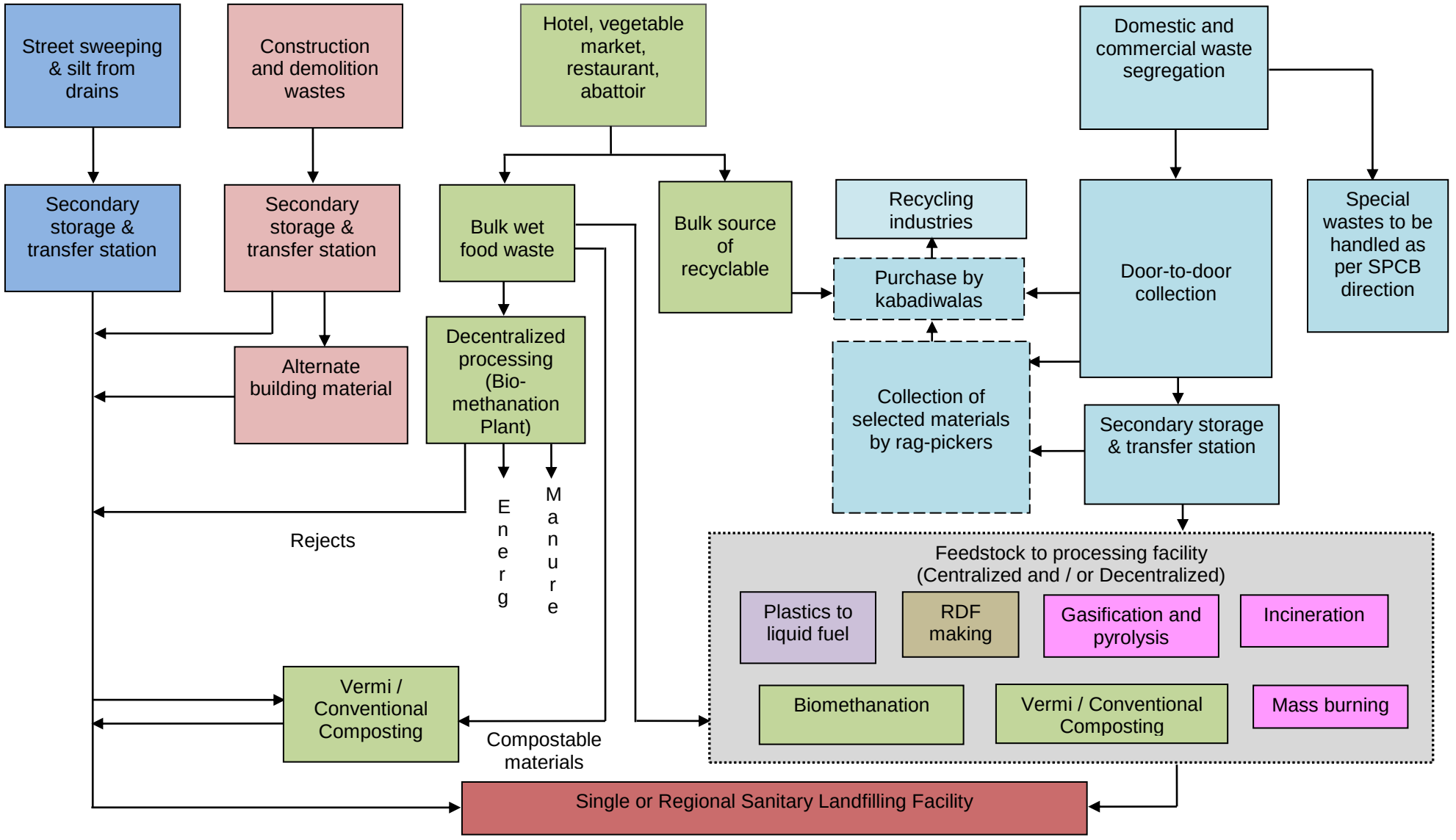


Figure A: Integrated MSW Management System for the Population of more than 2 Million

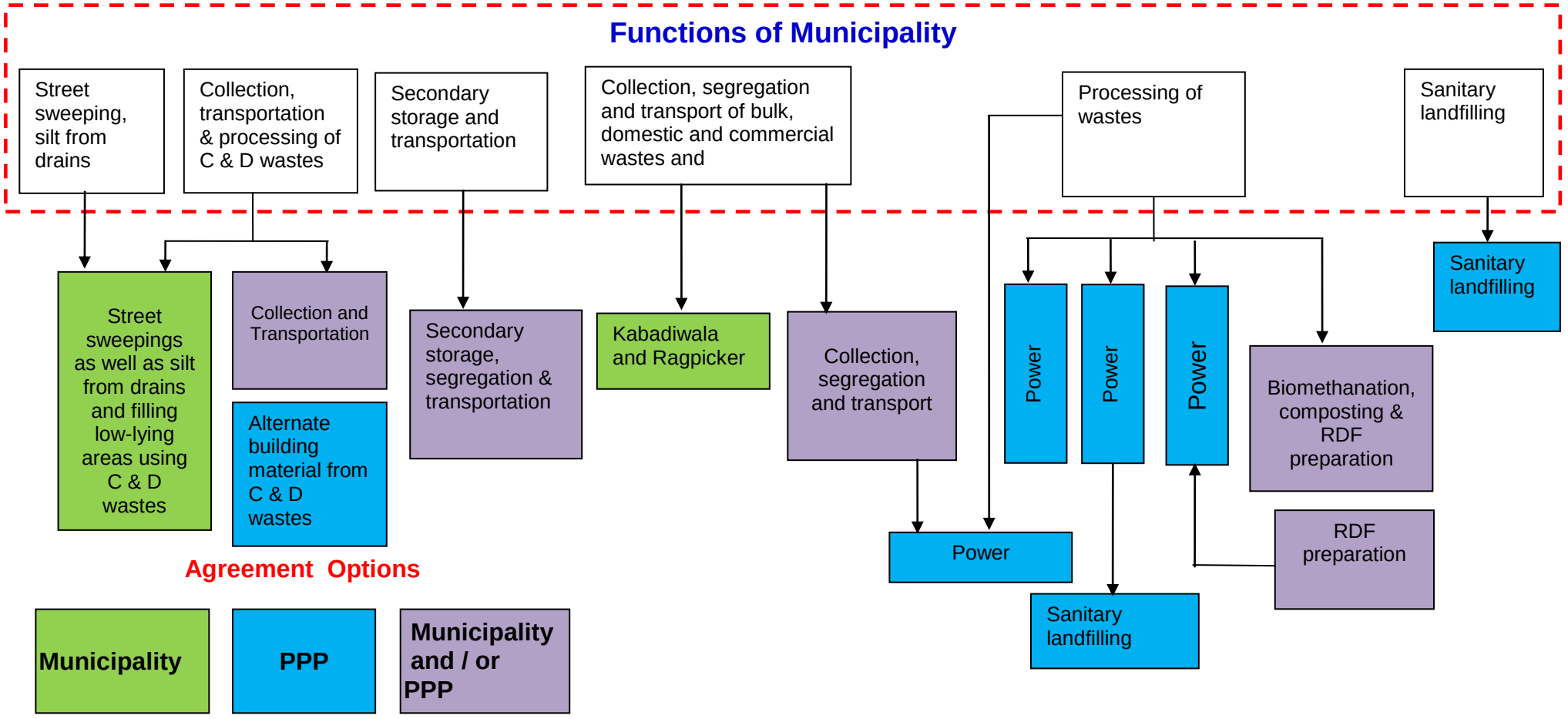


Figure B: PPP Agreement options for Integrated MSW management available to municipal authority

The total Viability Gap Funding should be the bidding parameter and should be determined by competitive bidding. The private entity which seeks lowest viability fund should be selected to execute the project

Such support when linked to performance of the plant -- viability gap funding may be given per unit of electricity produced or per tonne of compost produced for a fixed period of 3-5 years. Support may also be extended in setting up common regional sanitary landfill for cluster of cities, remediation/capping of dumpsites as well as for supporting door to door collection, secondary storage and transportation of waste to ensure that the processing plants get committed quantity and quality of waste. The municipal authorities should facilitate private sector in availing viability gap funding and avail themselves the support for improving collection and transportation on the lines recommended in the chapter on public private partnership (PPP).

B. Cost estimates

With a view to facilitate the GoI in determining the financial support to the ULBs a cost estimate has been prepared for setting up waste processing plants including W to E plants, preparation of RDF, biomethanation, composting and vermi composting facilities. The estimated capital investment works out to approximately Rs. 11,951 crore as shown in **Table A.**

Support may also be extended to all municipal authorities to revive existing non-functional/partially functional waste processing plants funded earlier under various schemes of Government of India or State Governments.

Besides financial support to waste processing facilities, it is essential to support the municipal authorities in putting the entire system of door to door collection, secondary storage, transportation and disposal of residual waste at regional landfills so that appropriate quality and quantity of segregated waste reach the processing facility for treatment and inerts reach the disposal facility directly without mingling with waste to be processed.

The ball-park cost estimates for procurement of tools, equipments and vehicles for meeting the capital costs for collection and transportation of MSW as well as for setting up of engineered sanitary landfills have been estimated. The preliminary estimates indicate that the capital costs for collection and transportation of MSW and for setting up of approximately 500 engineered Sanitary Landfill Facilities (SLF) works out to approximately Rs. 10,740 crore (**Table B**). This includes provision of mechanized sweeping as advised by MoUD in one million plus cities at a cost of Rs. 208 crore. This amount may have to be spent over a period of three years at the rate of Rs 3,580 crores per year. The Central Government and State Government could support this cost by giving grants as recommended in the report. The report also estimates the total investment required for the sector and the share of Government of India, State Government and private partner for the various activities to be undertaken in a PPP mode including revitalizing the defunct MSW processing plants set-up through

government grants, remediation and capping of dumpsites and C&D waste processing. Total investment required is Rs. 23,240 crore. Assuming availability of assets worth 20% with the municipal authorities, the total investment works out to be Rs.20, 153 crores. As detailed earlier and as depicted in the **Table C**, the cost share of GoI, State and the private partners vary and works out as under:

I. Government of India share Rs. 7670
II. State Government share Rs. 4,302
III. Public partner share Rs. 8,181

Besides the above, Rs 600 crore is proposed for Centre of Excellence to be set up in IIT's in the four regions of the country for R & D in technology for MSW management and recycling.

The Government of India and the state governments should play a major role in dissemination of information on the outcomes of R&D conducted by centres of excellence, on the recommendations contained in this report as well as other relevant reports and provide adequate training support to the municipal authorities in achieving the desired objectives

With a view to facilitate smooth disbursement of funds, MoUD should be designated the single point of support. The support of Ministry of Agriculture, Ministry of New and Renewable Energy, CPCB etc could be channelized through MoUD in a well coordinated manner.

4. Proposed support for capital investments and O&M costs

Under JnNURM all cities and towns are eligible for Grants, under UIG component or under UIDSSMT schemes. The current UIG support covers only 65 cities, it is proposed that efforts should be made to widen the coverage and to extend financial support to at least 468 class 1 cities which will cover over 70% of the urban population. It would not be difficult for the Central Government to look at the needs of these cities critically and even monitoring their performance. The remaining 7,467 small local authorities including 3894 census towns (urban centres) not covered under such schemes may also be given financial support through state agencies to put their MSW management systems in place to ensure that MSW systems improve in all small towns and large cities simultaneously. The support to census towns other than municipalities can be rooted through respective state agencies.

A. Segregation, Collection and Transportation

The capital investment required for these activities may be shared as under:

i. 35% grant from central government
ii. 35% grant from state government
iii. 30% investment from the municipal authority from its internal sources and / or through equity from private sector.

Table A: Tentative Capital cost estimates for processing various fractions of MSW

Sr. No.	Classif-ication of Cities	No of Cities	Population, % of Total Urban population & GPCD*	Quantity of waste Generated TPD	Waste to be treated (65%)** TPD	I Waste for W to E		II Waste for Bio-Methanation		III Waste to Compost		Cost I (10/12** *Cr per 75 TPD)	Cost II (15 Cr per 100 TPD)	Cost III Rs 5 Cr per 100 TPD)
						TPD	in %	TPD	in %	TPD	in %			
1	More than 1 M	53	160 M, 42.4% & 550 gm	88,000	57,200	22,880	40	5,720	10	28,600	50	3,050	858	1,430
2	0.1 to 1 M	415	105 M, 27.9% & 450 gm	48,000	31,200	7,800	25	6,240	20	17,160	55	1,248	936	855
3	Below 1 Lakh	7467	112 M, 29.7%, 300 gm	34,000	22,100	2,210	10	6,630	30	13,260	60	354	995	665
	Total		377 M, Average 450 gm	1,70,000	1,10,500	32,890		18,590		59,020		4,652	2,790	2,950
												# Grand Total approx. Rs 10,392 Cr		
Add 15% on account of likely price rise during procurement over a period of 3-5 years												**1,559 crore**		
TOTAL												**11,951 crores**		

Note: The total cost can be reduced by about 15-20% by deducting the cost of existing operational plants

The cost figures are tentative and hence the estimates could be ± 15% .

* GPCD is grams per capita per day

** This does not include 17,000 TPD (10%) recyclable wastes collected by rag pickers and 42,500 TPD (25%) of inert waste

*** 2 crore per 100 TPD addition amount is proposed for segregating RDF in smaller towns

Table B: Cost estimates for procurement of vehicles, tools and equipments for MSWM and SLF

Item	Numbers Required	Unit cost (in Rs.)	Total cost (in Rs.)
Door to door collection vehicles @ 1 vehicle per 10,000 population	37,700	5.5 lakh	2,073 crore
Containerized Tricycles for door to door collection from narrow lanes and low income settlements (20% areas)	75,400	16,000	121 crore
Handcarts for street sweepings @ 2 per 1000 population	7,54,000	8,000	603 crore
Mechanical road sweepers @ 2 for One Million plus cities	320	65 lakh	208 crore
Secondary Storage containers (1.1 m^3) for street sweepings and inerts only (30% waste)	1,80,000	20,000	360 crore
Compactors for transportation	4,875	31 lakh	1,511 crore
Transfer stations for 50% waste	250	4 crore	1,000 crore
Common Sanitary Landfills for 25% waste for 5 years capacity	about 500 for disposal of 42,500 TPD	500 per tonne/day for 5 years	3878 crore
TOTAL			9754 crore Or 9760 crore
10% increased on account of likely price rise during procurement over a period of 3 years			10736 Or 10,740 Crore

Note: The total cost can be reduced by about 15-20% by deducting the cost of existing vehicles tools, and equipments

Table C: Recommended cost sharing for MSWM activities

Sr. No.	MSWM Activity	Total Investments (Rs in Crores)	Required Investment (80%) (Rs in Crores)	GoI Share (%) (Rs in Crores)	State Share (Rs in Crores)	PPP Share (%) (Rs in Crores)
1	Collection, Storage and Transportation *etc*	6,862	5,490	1,922 (35%)	1,922 (35%)	1647 (30%)
2	MSW processing such biomethanation, composting, gasification etc.	11,951	9,561	3824 (40%)	956 (10%)	4,780 (50%)
3	C&D Waste Processing	500	500*	150 (30%)	100 (20%)	250 (50%)
4	Support to Non-Functional Plants	500	500*	250 (50%)	100 (20%)	150 (30%)
5	Support to Regional Common Sanitary Landfills	3,878	3,102	1,024 (33%)	1,024 (33%)	1,054 (34%)
6	Remediation of Dump Sites /Capping	1,000	1,000*	500 (50%)	200 (20%)	300 (30%)
	Total	24,691	20,153	7,670	4,302	8,181

Note: * Budget provision suggested

The operation and maintenance cost of primary collection and transportation of waste in an efficient manner may be met with by ULBs by levy of user fees as per paying

capacity and waste generation rates of the users as recommended in this report and ensuring its recovery by timely billing and efficient collection. Municipality may meet the gap in the O&M cost by levy of sanitation tax. The basic principles to be considered by Local Bodies while prescribing norms for levying user/service fee for MSW services include: polluter pays principle, proportionality and capacity to pay.

B. Processing of Wastes

i. Centralized Plants

i. 40% viability gap funding for capital investment from the Government of India or 20% viability gap funding each for capital investments and O & M costs linked to performance.

ii. 10% support from the State Government towards O&M expenditure.

iii. Minimum 50% to be invested by private sector.

ii. Decentralized Plants

i. 40% from the Central Government towards capital investment or 20% viability gap funding each for capital investments and O&M costs linked to performance

ii. 20% from state and/or ULB's as a viability gap for O&M Costs based on performance.

iii. 40% investments from private sector

C. Support to existing Defunct/Partially Functional Processing Plants

The municipal authority may consider inviting private sector to operationalize defunct plants earlier funded by Central or State grants/schemes. Funding support (capital subsidy) may be extended as under:

i. 50 % from government of India

ii. 20% state government

iii. 30% investment by private operator

D. Construction & Demolition Waste Plants

i. 30% grant from central government

ii. 20% grant from state government

iii. 50% to be borne by private sector

E. Common regional Sanitary Landfill Facility (SLF) for Disposal of Inerts

The inert wastes from the municipal areas and residual waste from the processing plants need to be disposed off in a sanitary landfill. SLFs need to be sufficiently large so

that they can be properly equipped and professionally managed, planned for a minimum period of 25-30 years and constructed under the strict supervision of municipality. The initial cell shall have a capacity to handle inerts and residual waste typically for a period of five years.

Fifty three cities with a million plus population can set up their own landfill facilities economically, and permit all cities and towns within 50km periphery of the city to use that facility for disposal of their waste. Common regional facilities may be constructed for rest of the 7,882 cities, towns and urban centres by forming clusters within 50 km radius with population of at least one million. Only in special cases, where, the distances between the cities are large the cluster size may be brought down suitably to handle at least 50 TPD of residual waste.. For smaller cities common / regional facilities are recommended as individual facilities are both neither economically viable nor can be managed sustainably.

Construction of SLF's and common SLFs covering a population of 10 lakh can be financially supported as under:

i. 33% grant from Central Government of India limited to Rs 2 Crore
ii. 33% from the State Government authority limited to Rs 2 Crore.

The Government grants for SLF's and CSLF may be 33% limited to 2 crores of the cost per 1 million population. If the landfill covers a larger population, the support could be proportionately increased. As a pre-condition to aforesaid grant, suitable land for SLF should be made available by the ULB/State Government to the concessionaire with all necessary clearances.

F. Rehabilitation and Capping of Dumpsites

Rehabilitation and remediation of abandoned landfills including capping of dumpsites should be initiated on priority in the cities where water table is generally high and the amount of waste being deposited is large. Scientific assessment of contamination of soil and groundwater should be undertaken and extent of damage and possibilities of remediation may be ascertained. Based on the outcome and cost implications, a strategic decision regarding remediation and or capping should be taken. Capping should be planned to minimize further damage and release of the part of the land by scraping and accumulating scattered waste and using it for sanitary landfills or putting it to a profitable use. Remediation to release precious land is therefore strongly recommended.

Financial support to the extent of 50% of the cost by the Central Government and 20% cost by the State Government may be considered.

G. Tipping Fee

Tipping fee is a charge which municipal authorities are required to pay to a private operator, who undertakes the responsibility of processing the waste aimed at minimizing the waste going to the landfills and in the process derive some useful

products to meet part of the cost. The Tipping fee is meant to bridge the gap between the amount spent by the concessionaire on processing the waste and the income derived from the products. The municipal authorities therefore need to provide for tipping fee to sustainability of the projects undertaken on PPP mode. The gap is generally in the range of 30-50%. This gap should be partly bridged by payment of tipping fee by the Municipal Authorities and the rest by VGF. Internationally all projects are viable because of payment of adequate tipping to bridge the gap. The proposed state MSW Mission should determine the gap percentage to be bridged by Tipping fee depending on the financial status of the municipality authorities.

5. Institutional Strengthening

To facilitate the municipal authorities improving solid waste management practices and the construction of waste processing and disposal facilities, an institutional support mechanism is recommended at national and state level which envisages having an Authority or Mission at the National level and a special technical cell under it , designated as the reference point, to guide and support the states and municipal authorities in problem solving and facilitation including advise on appropriate technologies for processing and disposal of waste, allocate funds to improve MSW management, support the programmes of training and capacity building of municipal authorities, *etc*. Similarly it is recommended that state governments may set up solid waste management authority / mission at state level which may assess the situation of MSWM in the local authorities, prescribe norms for having various types of tools, equipment, vehicles, manpower, *etc.*, assess the need of fund for putting an appropriate MSM management system in place and extend financial and technical support to municipal authorities in procurement of tools, equipment and vehicles and setting up processing and disposal facilities. It may further help in identifying suitable waste land for setting up regional/common facilities and facilitate their construction, operation and maintenance etc. in close coordination with town planning department of the state. The states may seriously consider professionalizing the MSW department by creation of cadres, training opportunities for all the staff, induction of professionals as have been recommended in the report. This may be linked with performance grants being given to municipal authorities. The municipal authorities are advised to have MSW department or cell in each ULB, introduce door to door collection, transportation of bio degradable and recyclable as well as high calorific value of waste directly to processing facility and separately collect inert waste such as street sweepings, silt from the drains, construction & demolition waste for their further treatment and/or disposal without mixing this waste with doorstep collected waste to facilitate cost effective processing of waste.

6. Research and Development in MSW sector

Research and Development in MSW sector is not a priority area in the country. Vendors bring in technologies, vehicles and equipment from developed countries and try to market them to municipalities, which have no means to ascertain appropriateness of the technologies and suitability of tools and equipment. It is recognized that, the cities

and state MSWM cells need expert advice while selecting technology as well as deciding on tools, vehicles and equipment needed. Research and Development in this sector to identify appropriate technologies and tools and equipment for use in various levels of city with different quality and quantity of waste generated is therefore considered essential. It is recommended that Indian Institute of Technologies (IITs) and leading scientific institutions be encouraged to take up research projects and programmes in this sector, including recycling processes. At least four institutions be identified each in north, south, east and west where Centre of Excellence can be set up with government of India support. This support may be extended for a period of 10 years and budgetary provisions of Rs.150 crore per institutions (total Rs 600 Crore) could be made to support research and development. These institutions may also undertake R & D activities on the various processing technologies in vogue, their suitability in Indian conditions in addition to developing new technologies, products, and management practices.

7. Smart Waste Management

Keeping in view the advancement in science and technology application of "smart municipal solid waste management" concepts may be introduced by the municipal authorities to keep a complete track on the operation of MSW management.

i. The use of Information Communication Technology (ICT) in MSW management will reduce the manual effort and enhance the efficiency of collection, transportation, and identification of dumping site, manpower management, resource management and addressing citizen's complaints.

ii. Use of technology in synchronization of waste vehicle tracking and quality monitoring should help to ensure better performance of the system.

iii. A Pilot SM-WMS project be initiated and systems /equipment be standardized enabling cost reduction and easy replication.

8. Policies & legislation

Following national policies be framed for the implementation of action plan.

A. Policy

i. The MoUD should come out with national policy outlining the country's intentions about handling waste of all types and clearly demarcating the role of central government, states and local authorities. The national goal should be clearly stated, specifically indicating what will be achieved by the end of each Plan.

ii. A National Policy on "Recycling, Resource Conservation and Preventive Environmental Management" notified.

iii. A performance based viability gap funding for waste processing projects.

iv. A performance based incentives in the field of environment and waste management for rewarding excellence be initiated and implemented.

v. An action plan to implement specific recommendations made regarding this sector in the NEP actively pursued. Details are in chapter-1.

B. Strategy

i. There should be a national strategy as to how the problems of municipal solid waste management will be handled including what type of funding and support will become available.

ii. Each state should come out with its own policy and strategy keeping in view the national policy and strategy as envisaged in the draft MSW rules, 2013.

iii. There should be a national standing task force/committee of eminent persons and experts to oversee the progress and report independently on the progress made by the states and the shortcomings that need to be addressed.

iv. Small landfills are not technically feasible and economically viable. An option to have a common regional facility at a reasonable distance (to avoid high cost of transportation) for disposal of waste for group of cities contiguous to each other need to be encouraged to save land, operational cost and facilitate scientific management of landfills.

v. Separate guidelines may be issued for management of municipal solid waste (MSW) in Hill towns.

vi. National Recycling Programme (NRP): The NRP will be an overarching framework to create and mainstream the organized waste management and recycling industry. Under the NRP structured frameworks and guidelines for recycling industry should be developed to integrate it with the existing waste management rules & guidelines. Industry and sector specific recycling standards , including recycled product standards be developed under the NRP

vii. Preparation of “model DPR”, RFPs including concession agreements for PPP contracts, guidelines on setting up common and regional Sanitary Landfill Facility (SLF) and waste management in hill towns and north east region should be undertaken by MoUD with the help of appropriate expert consultation.

viii. Evolve a mechanism at state level for capacity building and handholding, where necessary, of municipal authorities and make sure that all the local bodies implement the rules in a given time frame and achieve the service level benchmarks prescribed by MoUD and adhere to national sanitation policy in place

C. Legislation

i. MoEF should consider re-introducing a reasonable time frame for the implementation MSW Rules and Plastic Waste (Management and Handling) Rules 2011, by all the local bodies in the country.

ii. The State governments should be mandated to identify suitable lands to set up MSW processing facilities and for construction of sanitary landfills for large cities and regional landfills for group of small cities/towns, in cases where suitable land is not available with the urban local bodies.

iii. The town planning departments of respective states should be directed and authorized to reserve from time-to-time suitable parcels of land for setting up MSW storage, processing and disposal facilities while preparing development plans/ land use plans for cities and towns.

iv. In 1 million plus cities metropolitan planning authorities should have at least two experts on municipal waste management who could advise on reservation and selection of appropriate land for setting up waste processing and disposal facilities for large cities from time to time and also for setting up waste storage and transfer station facilities within large cities. Similar arrangement need to be made in district planning committee for addressing the issues of solid waste management in municipal authorities with population below 1 million.

v. Mandate citizens/waste generators to segregate the three major components of wastes namely biodegradable waste, non-biodegradable waste and domestic hazardous waste at source.

vi. Make it mandatory for municipal authorities to have at least three streams of waste collection namely

   a. Biodegradable and combustible wastes stored at households, shops and establishments and collected from the doorstep to be directly delivered at the processing facility.

   b. Inert waste such as street sweeping and silt from the drain to be collected and transported separately and taken directly to waste disposal site without mixing with waste collected from the doorstep.

   c. Construction and demolition waste to be collected separately and utilized for making bricks, paver blocks, aggregate or any other useful product and for filling in low lying areas, bio-engineering works for mosquito breeding prevention *etc*.

vii. Mandate preparation of an action plan at state level to ensure municipal authorities implement the rules in a given time frame.

viii. Specify most appropriate and viable waste processing technologies for small, medium and large cities in the country.

ix. In respect of sanitary landfills the rules should specify the minimum size of the sanitary landfill and encourage setting up of regional landfills for small cities and towns.

x. Separate provisions be made for management of municipal solid waste (MSW) in hilly areas.

Chapter 1

Introduction

Urbanization is an outcome of the changes in the pattern of livelihood and the consequent change in the nature of habitation. From its earliest days urban economy in most parts of the world has been dominated by trade and commerce, supported by artisanal and other specialized activities. As industrialization gained pace, economic activity increasingly shifted away from farming to factories and to the service industries causing rapid increase in urbanization.

Levels of urbanization in Brazil and Malaysia can be compared with western Europe and North America and by 2025, even China and Indonesia are likely to have two thirds of their population residing in urban areas. Slower pace of urbanization over past six decades is case of India is the result of slow pace of economic growth and slower growth of employment opportunities in non agriculture sector .However, it is estimated that by 2025 37% of the population of India i.e., 450 million will live in urban areas.

Urban occupations generally fetch higher incomes -whether in factories or in the service sector or in petty businesses. Higher incomes enable higher levels of consumption. The impact on waste generation in the urban areas is a compounded effect of the proportionate increase in urban population, improved levels of income and change in the pattern of consumption.

The institutional response to the issues of urban waste management has only mirrored citizens' apathy. Outdated and unhygienic systems of waste collection, transportation and disposal continue in most of the cities and towns even though it has been more than a decade since Municipal Solid Waste (Management and Handling) Rules 2000 was notified. It is therefore, imperative to think afresh on the problem of dealing with urban waste.

Urban solid and liquid waste has two principal components. One is the municipal solid waste (MSW) which includes commercial and residential waste generated in municipal or notified areas in either solid or semi-solid form excluding industrial hazardous waste, e-waste and including treated bio-medical waste as defined in the MSW Rules, 2000. The other is the liquid waste, that is, sewerage. This Task Force is focused on MSW and hence the discussion that follows is exclusively on MSW.

The management of MSW is an organizational, technological and economic challenge. The primary objective of urban waste management must be outcomes that are acceptable from the perspective of public health and the environment. In the hierarchy of objectives, public health has to necessarily have the first priority. The choice of technology has also to pass the filter of public health responsibility. Needless to say, the solution has to pass the test of financial viability and fit into the institutional system that exists. Policy changes that can be helpful in closing out gaps and act as enablers for the

solutions to operate need to be identified and flagged as part of the policy reform that may be required.

The accumulation of garbage in various stages of decomposition, along with other representations of the squalor of unsanitary conditions in India and other parts of the developing world, has unfortunately become the identifiers of our progress- badges of shame so to say. That is, however, an unconstructive dialogue. Cleaning up of our cities and towns is not an aesthetic pursuit but a necessary one for responsible public health management. Squalor has been in evidence elsewhere in the past and has been successfully dealt with and there are no signs of it today to be seen. The technology and human endeavour that makes modern life possible also permits us to maintain cleanliness in our urban habitations and recover resource and Energy from waste. The Task Force views its mandate in respect to MSW in this particular light.

1.1. Current status of MSW and estimates of generation in the country

The Central Pollution Control Board (CPCB) has reported that 1,33,760 metric tonnes of waste is generated (Table 1) daily in urban areas in the country (SPCB response 2012-13). There are several deficiencies in the current system and they do vary across states and cities. In general, there is;

i. Little primary collection at the doorstep;

ii. Little storage and segregation of recyclables;

iii. Poor Secondary storage , mostly by the road side in open spaces or in derelict concrete of bricked in containment areas;

iv. No regular sweeping of streets;

v. Transportation of waste in open tractors /trucks;

vi. Little processing of waste; and

vii. Unscientific disposal of MSW at dump sites.

Uncontrolled dumping of wastes on precious land resource in and around towns and cities has created huge piles of waste, some running into millions of tonnes and are a source of contamination of ground water and air pollution posing a risk to public health. These dumping yards are breeding grounds for many infectious agents causing diseases like cholera, dysentery, jaundice, typhoid and diarrhoea .

Table 1: Estimated* waste generation in the country state-wise

Sr. No.	Name of the State / UT	MSW MT/ day 1999-2000			MSW MT/ day (2012)
		Class – I cities	Class – II Towns	Total	
1	Andaman & Nicobar	-	-	-	70
2	Andhra Pradesh	3943	433	4376	11500
3	Arunachal Pradesh	-	-	-	180.83
4	Assam	196	89	285	650
5	Bihar	1479	340	1819	1670

Sr. No.	Name of the State / UT	MSW MT/ day 1999-2000			MSW MT/ day (2012)
		Class – I cities	Class – II Towns	Total	
6	Chandigarh	200	-	200	340
7	Chhattisgarh	-	-	-	1896
8	Daman Diu & Dadra	-	-	-	85
9	Delhi	4000	-	4000	7500
10	Goa	-	-	-	183
11	Gujarat	-	-	-	8336
12	Haryana	3805	427	4232	3490
13	Himachal Pradesh	623	102	725	1370
14	Jammu & Kashmir	35	-	35	1792
15	Jharkhand	-	-	-	4450
16	Karnataka	3118	160	3278	6500
17	Kerala	1220	78	1298	1576
18	Lakshadweep	-	-	-	21
19	Madhya Pradesh	2286	398	2684	5079
20	Maharashtra	8589	510	9099	17000
21	Manipur	40	-	40	176
22	Meghalaya	35	-	35	268
23	Mizoram	46	-	46	552
24	Nagaland	-	-	-	270
25	Orissa	646	9	655	2383
26	Puducherry	60	9	69	495
27	Punjab	1001	265	1266	3853
28	Rajasthan	1768	198	1966	5037
29	Sikkim	-	-	-	40
30	Tamil Nadu	5021	382	5403	14532
31	Tripura	33	-	33	360
32	Uttar Pradesh	5515	445	5960	19180
33	Uttaranchal	-	-	-	1251
34	West Bengal	4475	146	4621	8674
	Total	48134	3991	52125	133760

Source: CPCB, Annual Report, 2013

* Does not include waste picked up by Kabadiwala at the doorstep and the ragpickers.

In comparison to the levels of the developed world, of 1-2.5 kg capita/day, our per capita average generation of 450 gm/day of MSW is of course, lower. The per capita municipal solid waste generation rate reported for small towns is 200-300 gm/capita, 300-400 gms/capita for medium cities and between 400-600 gms/capita for large cities. The total quantity of waste currently handled each day in the urban areas in the country is estimated to be 1, 70,000 metric tonnes *i.e.* about 62 million tonne per year. As per 2011 census, 31.16 % population of India *i.e.* 377 million people live in 7,935 urban areas with 4041 municipal authorities. It is estimated that by 2050, 50% of the population will be living in urban areas.

Considering that the volume of waste is expected to increase @ of 5% per year on account of increase in the population and change in lifestyle of the people, it is assumed that urban India will generate 2,76,342 TPD by 2021, 4,50,132 TPD by 2031 and 11,95,000 TPD by 2050.

The CPCB report also reveals that only 68% of the MSW generated in the country is collected of which, 28% is treated by the municipal authorities. Thus, merely 19% of the total waste generated is currently treated. The remaining waste is disposed off at dump sites / landfill sites untreated (**Figure 1 and Text Box 1**). The State wise details regarding waste generation, collection and treatment are in **Annexure I-A**. The enormous quantity of MSW (62 million tonnes per year), generated if successfully managed will dramatically reduce the potential of disease burden and provide a huge public benefit. This in itself justifies the public cost of collection and acceptable standards of treatment.

The status as on 2011, of processing and disposal facilities set up by the states/ UT's is detailed in **Table-2.** Only 22 States/UTs have set up processing and disposal facilities and the rest of the States/UTs have made no effort till 2013. Of the 279 Conventional composting and 138 vermi composting facilities, 172 biomethanation, 29 Refuse Derived fuel (RDF) and 8 Waste to Energy (W to E) plants reported to have been established many are either closed or underperforming.

1.2. Waste Recovery and Recycling

Various components of MSW have an economic value and can be recovered, reused or recycled cost effectively. Currently, the informal sector picks up part of the resources from the streets and bins to earn their living. However, a sizeable portion of organic waste as well as recyclable material goes to landfills untreated. Over 81% of MSW annually is disposed at open dump sites without any treatment. With planned efforts to Reduce, Reuse, Recover , Recycle and Remanufacture (5Rs) and appropriate choice of technology, the country can profitably utilize about 65% of the waste in producing energy and/or compost and another 10 to 15% to promote recycling industry and bring down the quantity of wastes going to landfills/ dumps under 20%.

As a strategy, it would be prudent to make efforts to motivate the waste generators to reduce generation in the first place and reuse the waste to the extent possible, guide and enable industry and commerce to enhance recovery of materials and intermediates during manufacturing, promote segregation of recyclables at source and re-use the material in re-manufacturing of products and intermediates, transitioning towards achieving the goal of optimum utilization of recyclable material.

The percentage of wet biodegradable waste is high in Indian waste and is a source of contamination of soil, water and air, if disposed indiscriminately

Figure 1: State wise details regarding waste generation, collection and treatment (2012-13)

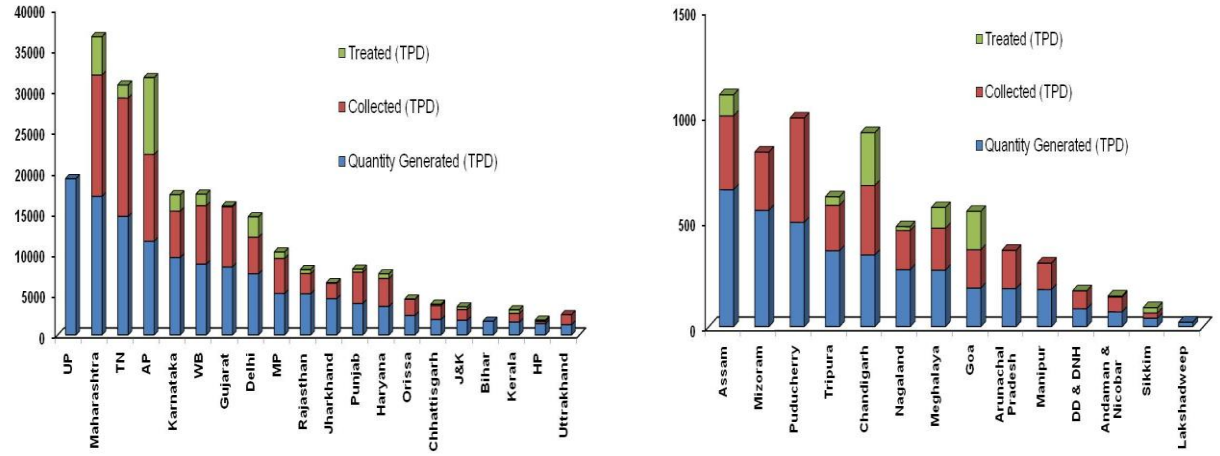


Figure 1: State wise details regarding waste generation, collection and treatment (2012-13)

Text Box-1
MSW Generation and Treatment Facilities

Generation in TPD	:	1,33,760
Collection Efficiency	:	68%
Total Waste Collected	:	90,957
Waste lost/littered	:	42,803*
Composition of MSW		
Organic Waste (51%)	:	68,218
Inert& non-organic (32%)	:	42,803
Recyclable (17%)	:	22,739
MSW Treatment Facilities		
MSW Treated/ Processed in TPD	:	25,884
No. of ULBs having treatment/ processing Facilities	:	626
1. Composting	:	279
2. Vermi-compost	:	138
3. Biogas Plant	:	172**
4. Palletization (RDF)	:	29
5. Waste to Energy	:	8
Landfilling		
Landfilled	:	65,489
Total waste to be landfilled	:	1, 08,292

Table 2
State-wise* Status of MSW Processing Facilities in India (2011)

State	Composting	Vermi-composting	Bio-methanation	Palletization (RDF)	Waste to Energy
A & Nicobar	1	-	-	-	-
Andhra Pradesh	24	-	-	11	2
Assam	1	-	-	-	
Chandigarh	Nil	Nil	Nil	1	Nil
Chattisgarh	6	Nil	Nil	Nil	Nil
Delhi	3	-	-	-	3
Goa	14	-	-	-	-
Gujarat	3	93	Nil	6	Nil
Himachal Pradesh	10	-	-	-	-
Jammu & Kashmir	1	-	-	--	-
Jharkhand	4	-	-	-	-
Kerala	21	7	10	1	1
Madhya Pradesh	7	-	-	2	-
Maharashtra	6	2	5	5	2
Meghalaya	1	1	-	-	-
Nagaland	1	1	-	-	-
Orissa	1	-	-	-	-
Punjab	1	3	-	-	-
Sikkim	1	-	-	-	-
Tamil Nadu	162	24	-	3	
Tripura	1	-	-	-	-
West Bengal	13	7			
Total	**279**	**138**	**172**	**29**	**8**

* All other States and UTs currently have no processing facilities

Biodegradable waste has a good potential for generating biogas, which can serve as fuel, can also be converted to energy as well as to compost which can improve soil health and lead to increased agriculture production. This wet waste must therefore be processed either through biomethanation or composting technology for generating biogas, electricity or compost for use as nutrient and prevent such wastes reaching the landfill.

Considering that reusable and recyclable wastes form 20-25% of the actual waste generated (which does not include the wastes collected by the kabadiwalas from source of generation). Plastics, paper and glass constitute 17% of the recyclable wastes. Plastic wastes including composites are high calorific value material and crucial ingredient for MSW based W to E plants. This material also needs to be fully recovered and profitably utilized.

The next step should be to strengthen segregation of the non-recyclable dry combustible MSW at secondary storage depots/transfer stations and optimally utilize this material in

the form of RDF which can be fed to W to E power plants and as auxiliary fuel in cement and metallurgical industry. Setting up of small to large plastic waste to liquid fuel plants, thereby utilizing the plastic not picked up by kabadiwalas and rag pickers, also needs to be encouraged.

1.3. Legal and Policy framework for MSW Management

The 12th schedule of the Constitution (The 74th constitutional amendment of 1992) clearly assigns solid waste management as the primary function of municipal authorities. State laws governing the municipal authorities also stipulate management of solid waste as an obligatory function of the municipal authorities. Despite constitutional and legal mandate no serious efforts have been made, by municipal authorities towards scientific processing and disposal of MSW. It was only after the direction issued by Hon. Supreme Court of India in a public interest litigation spl CA No 888 of 1996, the Municipal Solid Waste (Management and Handling) Rules was finalized by the Ministry of Environment and Forests (MoEF and notified in 2000). These rules define MSW, mandate that all municipal authorities in the country shall manage MSW in a time bound manner and the State Government ensure implementation of the rules. These rules were followed up by the National Environment Policy (NEP) in 2006. A set of rules on plastic waste management were notified under the E(P) Act, 1986 to regulate littering and manufacturing of plastic carry bags. The following paragraphs summarize the rules notified.

A. Municipal Solid Waste (Management and Handling) Rules 2000

The MSW Rules of 2000 principally mandates collection, storage, segregation, transportation, processing, and disposal of municipal solid wastes as outlined in **Annex (Volume 2)**. A deadline of 31 December 2003 was laid down for implementation of these rules.

A study, of the status of implementation of the MSW Rules 2000 by the mandated deadline by the States, was carried out in class 1 cities of the country. It revealed that in 128 cities except for street sweeping and transportation, compliance was less than 50% and in respect of disposal compliance was a dismal 1.4 %. **Figure 2** displays the status of implementation as on 1 April 2004 and that for the period 2011-12 in respect of primary collection, processing and disposal in the country. It is quite evident from the data that very little effort towards compliance was made by most municipal authorities in the country.

B. National Environment Policy, 2006

The National Environment Policy, (NEP), 2006 is intended to be a guide to action: in regulatory reform, programmes and projects for environmental conservation; and review the enactment of legislation by agencies of the Central, State, and Local Governments. The policy also seeks to stimulate partnerships of different stakeholders, i.e. public agencies, local communities, academic and scientific institutions, investors, and

international development partners, in harnessing their respective resources and strengths for environmental management.

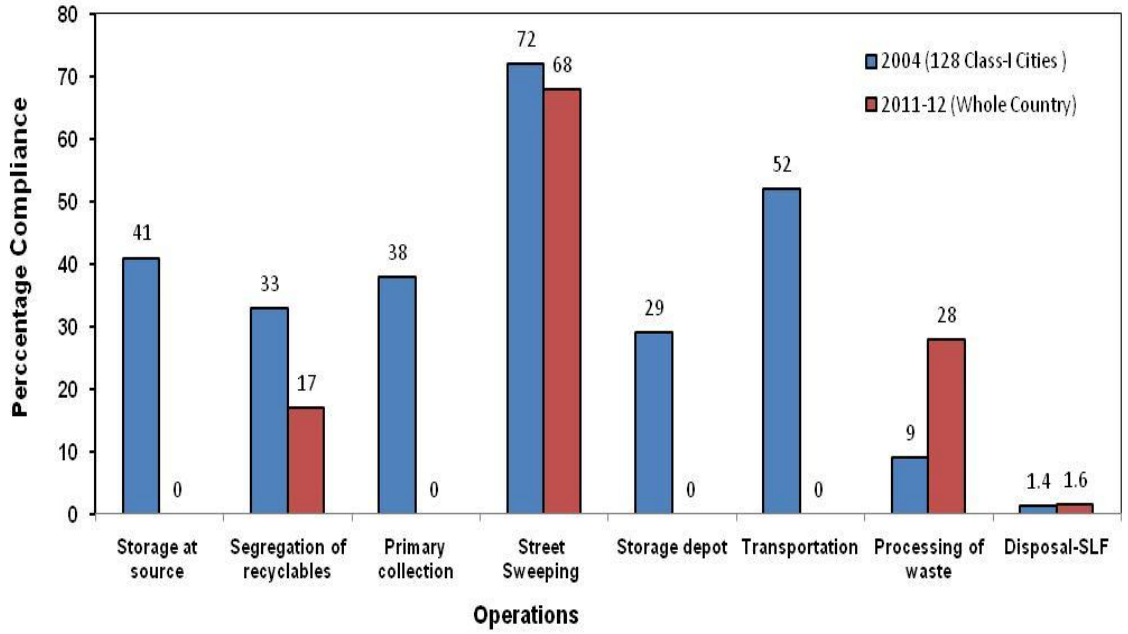


Figure 2: Status of implementation of MSW Rules 2000 as on 2004 and 2011-12

Source: P.U. Asnani, 2004, CPCB, 2012**.**

An action plan for solid Waste Management is stated on page 39 of the National Environment Policy, (NEP), 2006. **Text Box -2** indicates the specific issues that need to be addressed.

Text Box-2:- Action plan for MSW Management- specific issues as per NEP, 2006

1. Develop and implement viable models of public-private partnerships for setting up and operating secure landfills, incinerators, and other appropriate techniques for the treatment and disposal of toxic and hazardous waste, both industrial and biomedical, on payment by users, taking the concerns of local communities into account. The concerned local communities and State Governments must have clear entitlements to specified benefits from hosting such sites, if access is given to non-local users.

2. Strengthen the capacities of local bodies for segregation, recycling, and reuse of municipal solid wastes- recognizing inter-alia the positive impacts it may have on the welfare of safai-karamcharis, and setting up and operating sanitary landfills, in particular through competitive outsourcing of solid waste management services.

3. Give legal recognition to, and strengthen the informal sector systems of collection and recycling of various materials. In particular enhance their access to institutional finance and relevant technologies.

4. Promote biodegradable and recyclable substitutes for non-biodegradable materials, and develop

C. The Plastic Waste (Management and Handling) Rules, 2011

The plastic Waste (Management and Handling) Rules 2011 were issued in supersession of the "Recycled plastic manufacture and Usage rules, 1999" notified under the Environment (Protection) Act 1986. Rule 6 of the said rules mandates that a plastic waste management system be put in place and identifies municipal authority as the agency responsible for implementation of the said rules within their jurisdiction. The major provisions of the rules are in **Annex (Vol.2)**

D. National Urban Sanitation Policy, 2011

The National Urban Sanitation Policy pertains to management of human excreta and associated public health and environmental impacts. It is however recognized that integral solutions need to take account of other elements of environmental sanitation, i.e. solid waste management; generation of industrial and other specialized / hazardous wastes; drainage; as also the management of drinking water supply. The NUSP thus seeks to create fully sanitized cities through awareness generation, State sanitation strategies and integrated city sanitation.

E. Framing of MSW Rules 2013

With a view to expeditiously improve solid waste management in the country, the 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 new rules after due consideration of comments /suggestions received, will be notified

by the Ministry of Environment and Forests and would help improving the level of MSW services in the country. The major features of the Draft Rules of 2013 are outlined in **Annex (Volume 2)**. The rules specify two important statutory requirements; approval of technology and obtaining Clearance and Consent for setting up waste processing and disposal facilities as under:

i. **Technology Approval**

In the proposed MSW Rules 2013, standards have been laid down for composting, incineration and leachate treatment. In respect of waste to energy technology, the rules prescribe that the State Pollution Control Board shall notify ambient air quality standards around such facilities on a case to case basis. However, emission standards prescribed for incineration and for disposal of treated leachate shall apply. Powers have been delegated to the State Pollution Control Board to approve new technologies. The rules further provide that the Central Pollution Control Board shall review the use of any new technology for processing, recycling and treatment of municipal solid waste, prescribe standards and publish requisite guidelines. This would facilitate approval of any new technology at the state level.

ii. **Clearances, Consents and Standards**

The draft rules mandates that the municipal authority or operator of a facility shall seek authorization for setting up waste processing and disposal facility including landfills and ensure compliance with specified standards. It also mandates seeking environmental clearance for setting up processing and disposal facility as per the Environment Impact Assessment notification dated 14th September, 2006. The rules mandate that construction and demolition waste, parks and garden waste and dairy waste shall be collected separately and shall not be mixed with MSW.

D. Construction & Demolition (C & D) Waste

C&D waste is one of the major components of MSW and is a major hindrance in waste processing when mixed with MSW and delivered at the processing facility. C&D waste finds a brief mention in Schedule III of the Municipal Solid Waste (Management and Handling) Rules, 2000 and the ‘‘Manual on Municipal Solid Waste Management’’ of the MoUD, 2000 has a chapter on C&D waste which lays down basic guideline on its handling.

The expert committee on C&D waste, constituted in January, 2014 by the MoEF to draft rules on C&D waste, has undertaken detailed study and prepared the draft rules encompassing segregation at source, institutional mechanisms for waste collection, reuse and reprocessing, imposing charges on C&D waste generators, formulation of standards for C&D waste *etc*., to address the C&D waste collection, utilization and safe disposal.

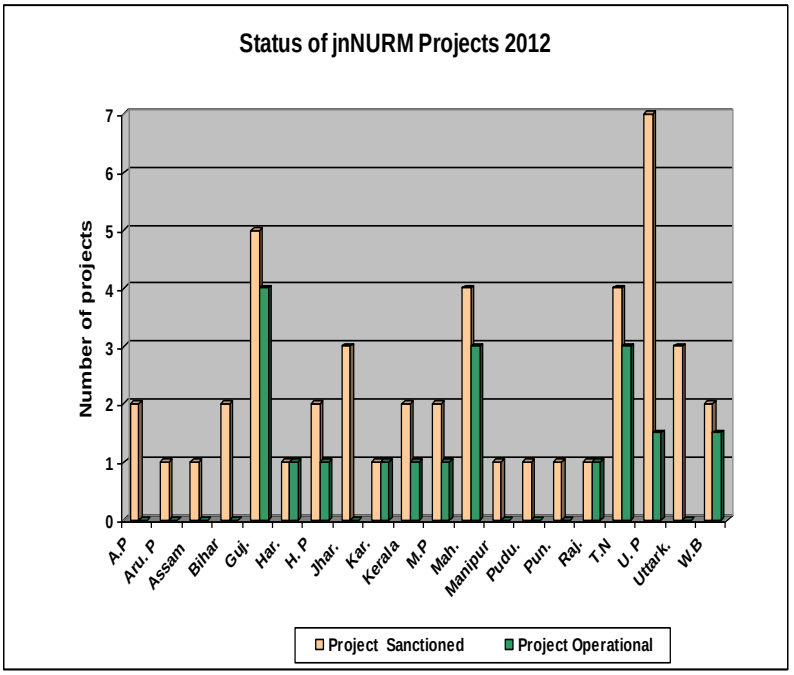
1.4. Current Financial Support and Incentives.

A. Financial Support

Shortcomings in the implementation of MSW rules 2000 led to financial support to states and cities by Government of India through 12th and 13th Finance Commission grants and funds under JnNURM and UIDSSMT Schemes. 46 MSW projects in 20 states were approved at a cost of Rs 1,925 crore and Rs 694 cr released. As on date 19 of the 46 plants supported are operational **(Table 3)**. The support enabled some improvements in MSW management in certain states and cities but much remains to be done.

Table 3: State-wise MSW Projects funded under JnNURM.

Sr. No.	States	Proj. Sanc	Proj. Oper
1.	A.P	2	0
2	Aru. P	1	0
3	Assam	1	0
4	Bihar	2	0
5	Guj.	5	4
6	Har.	1	1
7	H. P	2	1
8	Jhar.	3	0
9	Kar.	1	1
10	Kerala	2	1
11	M.P	2	1
12	Mah.	4	3
13	Manipur	1	0
14	Pudu.	1	0
15	Pun.	1	0
16	Raj.	1	1
17	T.N	4	3
18	U. P	7	1.5
19	Uttark.	3	0
20	W.B	2	1.5
	Total	46	19



The Ministry of Agriculture (MoA) has been actively promoting waste composting, and introduced a Centrally Sponsored Scheme (CSS) for balanced and integrated use of fertilizers in 1992 (Eighth Five-Year Plan, 1992–97). Under the CSS, support is given to local bodies and the private sector (included recently) for setting up composting plants for converting municipal solid waste into compost. This grant is available for up to one-third of the project cost, subject to a maximum of Rs 50 lakh per project.

The MOEF provides financial support of up to 50% of the capital costs to set up pilot demonstration plants on municipal solid waste composting. The ministry also extends limited financial assistance for waste characterization and feasibility studies.

The Ministry of New and Renewable Energy (MNRE) has designed schemes to promote waste to energy projects. The MNRE Scheme dated 12th September, 2013 promotes all technology options for setting up projects for recovery of energy from urban, industrial and agricultural wastes. Currently only five pilot projects based on MSW to energy are being supported.

Under the scheme the amount of capital subsidy is calculated on the basis of power generation from MSW. A minimum amount of Rs 2 crore and a maximum of Rs.10 cr per project are available as capital subsidy. The entire capital subsidy amount is released to the beneficiary's loan account.

Some State Governments — Uttar Pradesh, Madhya Pradesh, Tamil Nadu, Andhra Pradesh, Maharashtra, Haryana, Karnataka, Gujarat, and Rajasthan—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 is left to 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.

B. Incentives for MSW Management Infrastructure Financing

In addition to financial and technical support as above, from central and state governments, the following incentives are available for financing solid waste infrastructure in urban areas (WBI Development Studies “Improving solid waste management in India” – A source book for Policy makers and Practitioners, 2008).

i. Tax Exemption of Certain Bonds Issued by Local Authorities. According to section 10(15) of the income Tax Act, in recognition of the need for mobilizing resources for urban infrastructure projects, the central government has accorded a tax-free status to the interest on certain bonds issued by local authorities each year. These bonds are specified by notice in the Official Gazette.

ii. Tax Holiday for the Project Entity for Solid Waste Management. As announced in the Union Budget 2001/02, an undertaking or enterprise that is engaged in SWM projects is allowed a deduction under section 80IA of the act of profits and gains related to such projects. The deduction equals 100 percent of such profits for 10 consecutive assessment years in the first 20 years of the project. To qualify for tax holiday under this provision, the enterprise must satisfy the prescribed conditions.

iii. Tax Exemption for Income of Infrastructure Capital Funds and Companies. Section 10(23G) of the Income Tax Act provides that any income of an infrastructure capital fund or an infrastructure capital company that takes in the form of interest, most types of dividends and long-term capital gains is not included in the calculation of total income for tax purposes.

iv. Inclusion as Eligible Investments of Charitable Funds for Urban Infrastructure: Section 11(5) (ix) of the Income Tax Act provides for inclusion as eligible investments of charitable funds (a) any deposits with a public company or (b) any investments in any bonds issued by such a company, provided that the company was formed or registered in India with an objective of carrying on a business of providing long-term finance for urban infrastructure. This provision enables sponsors of urban infrastructure projects to have access to investable surpluses of charitable trust funds.

Availability of Funds by Sale of Carbon Credits: Greenhouse gas (GHG) emissions are causing climate change. Major initiatives have, therefore, been taken internationally to mitigate GHG emissions.

Sectoral lending by Financial Institutions: Municipal authorities can also take advantage of funding from financial institutions for MSW.

Bilateral and Multilateral Donors: Even though there is no dedicated SWM programme, technical assistance for such projects can be obtained under programs such as water and sanitation.

Tax Financing: Traditionally, funding for solid waste systems comes from the general municipal fund which includes government grants. Most ULBs use a percentage of property tax to support the MSW system. This tax is easy to administer because no separate billing or collection for MSW is needed. The disadvantage, however, is that in most Indian cities, assessment and collection of property tax is poor and this poor base provides very little income. Some States have introduced sanitation/ city cleaning tax to cover the cost of collection and disposal of MSW which however, does not fully cover the cost of service.

Central Excise Notification No. 33/2005-CE dated 8.9.2005, on Generation of Power from MSW, exempts all items of machinery from whole of excise duty

Customs Notification No. 81/2005 dated 8.9.2005, on Generation of Power from MSW grants relief from customs duty on all items of imported machinery.

However, there is lack of clarity in extending duty exemption for renewable energy generation devices/systems and equipments like Turbine, air cooled Condenser, transformers are not considered.

1.5. Constitution of a Task Force on Waste to Energy

In view of the current critical situation of MSW management in the country and need to minimize dumping of waste by ensuring resource recovery including energy and to attract private sector investments in providing MSW services in urban areas, the Planning Commission constituted a Task Force to look into all the aspects associated with waste to energy in the context of integrated MSW management. An order constituting the Task Force was issued on 5th June, 2013 (the original order has been placed at **Annexure I-B**). The specific Terms of Reference (TOR) of the Task Force are as follows:

i. To examine the technological aspects of W to E projects,
ii. Significance of segregation at source vis-a-vis waste collection and transportation model,
iii. Selection of centralized versus decentralized MSW-management models including Scale of operation and quality of wastes,
iv. Assessment of the current financing and financial models and propose the potentially sustainable model,
v. Incorporation of integrated waste management concept and preventive environment management strategies and,

vi. Assessment of the prevailing concession Agreements between developer, technology provider and municipalities.

The overall scope of the “Task Force” on Waste to Energy (W to E), encompasses, integrated waste management, identification and assessment of W to E technologies in the context of the contemporary Indian MSW scenario and recommend sustainable financial models for implementing W to E projects through Public Private Partnership (PPP) mechanism.

Chapter 2

Task Force on Waste to Energy

The Task Force (TF) decided to invite experts, local government authorities, private sector companies involved in W to E and concerned Ministries/ Departments to share their experience and suggest ways to promote integrated MSW management and W to E technologies in India. It was recalled that the Finance Minister in his budget speech had announced financial incentives for W to E projects under PPP and that the TF has been constituted as directed by the PMO to make recommendations on the ToR's in the context of private sector participation. The Task Force, in its first meeting decided to co-opt, Dr. Shyam R. Asolekar, IIT Bombay, Shri P.U. Asnani, Chairman, UMC Global Pvt Ltd, Dr. S. P. Kale, BARC and Dr A. K. Akolkar, Director, CPCB as members of the TF. The Task Force and members of the TF apart from interacting with all stakeholders also visited both operating and closed processing plants.

Issues that came up during the interaction with stakeholders and Observations of the TF are highlighted in **Table 4** along with facts regarding scientific management of MSW and lessons learnt in the operation of MSW processing plants especially technologies. Issues in the operation and application of technologies are detailed in Chapter-4.

The minutes of the meetings and site visit reports are part of **Vol-2** of the report. During the tenure of the Task Force five meetings were held. The key issues relating to MSWM raised during the deliberations were:

i. Absence of a comprehensive short and long term plan, to handle MSW in accordance with the MSW Rules, 2000, with municipal authorities.

ii. Lack of requisite preparedness, to set up waste processing and disposal facilities, with the majority of the municipal authorities.

iii. Waste management contract being looked at as a source of revenue by the municipal authorities.

iv. Non availability of suitable lands for processing and disposal of wastes in cities and towns.

v. Need to consider 'total' recycling and re-use of wastes and aim for negligible or 'Zero Waste' to be landfilled.

In addition, TF members were of the view that financial requirements for the collection, transportation, processing and disposal of MSW need to be worked out and viability gap, if any, for taking up such projects on a PPP mode need to be assessed to facilitate the preparation of financial models and estimating subsidy requirements. JnNURM grants could also be taken into consideration for making the project viable. It was felt that the existing database being inadequate, there is a need to assess, both the positive and negative aspects of the currently ongoing approaches and possible solutions to overcome the negative once.

Table 4: Issues raised during interaction with stakeholders and observations

Sr. No.	Local Govt., Experts, private Companies.	Views /suggestion made	Comments / issues for consideration of TF
1	M/S Blended Fuels Ltd, Bangaluru	The innovative part of the technology patented by the company is the use of travelling grate boiler which is comparatively cheaper than the reciprocating boiler grate and is suited to the Indian conditions which are characterized by high moisture and low calorific value waste.	This technology has been successfully implemented as a pilot project in Malaysia. The present system is designed to handle 700 tonnes of waste and generate 5.5 MW of electricity which is being supplied to the Grid.
2	Municipal Commissioner Ahmedabad	Five private sector partners are currently engaged in door to door collection of waste from entire city of Ahmedabad. They collect around 1700 tonnes out of the 3800-4000 tonnes generated per day. Currently, the projects in operation are of composting and preparation of Refused Derived Fuel (RDF). Exclusive processing of C&D waste has been entrusted to a private operator. In 2012, two projects for waste to energy were awarded to Abellon Clean Energy Limited and A to Z Infrastructure Limited.	No separate user charges are collected from households for waste collection as separate conservancy tax is levied as a part of property tax. Construction & Demolition (C& D) waste is collected separately. The vehicles for collection and transportation of street waste by municipal staff are financed through jnNURM grants. The criterion for bidding for waste to energy plants was the minimum quantity of land and water required.
3	Additional Commissioner Chandigarh,	Due to the small quantity of waste generated, waste to energy facility is not economically viable for a city like Chandigarh which has a population of 11 lakh. The city generates 370 metric tonnes waste / per day of which, 250 metric tonnes is processed and rest goes to dumping ground	No tipping fee is paid to the operator for processing of the waste. The private operator is reported to be running a loss of around Rs 10 lakh per month.
4	'Nisargruna' , technology for biogas patented by BARC	This technology is based on biomethanation process of segregated bio-degradable wastes and 172 plants are operational, 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 di oxide (CO_2).	The technology can be suitably implemented for a plant size of 0.5 to 20 MT waste per day. The land required for processing 5 MT of waste is 500 sq m. Multiple units in various parts of town/city could help in decentralized management of bio-degradable waste.
5	National Waste Management Association	Advantages and disadvantages of different technologies were highlighted, emphasizing quantity / quality of waste available was also as a key factor. Use of RDF in cement and metallurgical plants was stressed.	Segregation of waste at source. Centralized facility for W to E
6	IL&FS.	Highlighted the advantages of different technologies and its usage.	

Sr. No.	Local Govt ., Experts, private Companies.	Views /suggestion made	Comments / issues for consideration of TF
7	Dr. S. V. Chary, ASCI Hyderabad	Issues relating to and experience with PPP in infrastructure projects analysed by the institution and Pros and cons of tipping fee, outcome based subsidy , viability gap funding were presented	lay emphasis on an integrated MSW management as an essential step towards establishing W to E facility
8	Dr. N. B. Mazumdar, ILFS, Delhi	Issues relating to processing technology stressed were: Problems in the sector relate to choice of technology, design and bad construction / operation/ maintenance While designing both small and large RDF plant, it can be a combination of composting and RDF, especially where power generation is not planned. Apart from calorific value, size, inert / ash content, moisture, chloride *etc*., are important parameters. Waste characteristics should match technology selected. Otherwise pre-treatment is necessary.	International status of MSW management. Minimum of 5 years' commercial operation continuously needed for judging viability of technology and operations in the country.

In the third meeting of the TF held on 14th October, 2013, the structure of the report was discussed; type of inputs required and a drafting committee constituted for writing the report under the Co-chairmanship of Mr. P. U. Asnani and Prof. Shyam R. Asolekar.

Site visits and interaction with stakeholders: The TF visited one operating W to E plant and few other closed /partially functional integrated facilities to analyze the reasons for closure. The designated teams of the Task Force also visited a few waste to energy plants and interacted with several technology providers, developers and municipal authorities. **Table 5** indicates details of some of the plants visited, setup (2000-2011) and observations and remarks of the visiting team. Visit reports are in **Vol-2**.

2.1. Gaps and constraints observed

During the course of the study and interaction with stakeholders, the following gaps and constraints were observed

i. Lack of state policy or uniformity in policy guidelines amongst various states in the management of MSW.

ii. Local bodies have so far not prepared a time-bound action plan to undertake collection, segregation, storage, transportation, processing and disposal of MSW.

iii. There is no agency which can assist local bodies technically, either at State or national level to prepare the plans. Further, a detailed assessment does not exist as to how ULBs would meet targets as per MSW rules including financial requirements.

Table 5: Observations and remarks of the visiting team

Sr. No.	Unit Visited	Plant Details	Observations	Remarks
1.	Bio Gas plant Delhi Secretariat	Delhi Government has installed a pilot plant based on BARC, Nisargruna technology for converting kitchen waste/food waste/other organic waste generated within the Delhi Secretariat into biogas. The plant converts 0.5 tonnes of wet canteen waste into 30 M^2 of gas which is supplied back to the canteen. The sludge generated is used for gardening.	The plant converts canteen wastes to biogas and manure. The facility was in operation and biogás was being supplied to the Secretariat canteen.	Decentralised biogás plants should be part of the cities/ town plan. The technology can be used generate gas and energy. Gas can be used in residential, hotel, institutions, etc as fuel or converted into electricity for use in street lights. The operation of the plant has been outsourced to a private entrepreneur
2	Okhla W to E plant	In 2007 the Delhi and New Delhi Municipal Corporations enabled setting up '16 MW Waste to Energy Project' on BOOT basis as an integrated municipal waste processing facility at Okhla and Timarpur in New Delhi. M/s Jindal Urban Infrastructure Limited was selected based on the lowest tariff quoted for electricity generated of Rs 2.49 per kwh for the first year and a leveled tariff of Rs 2.83 per kwh. The Project became operational in January 2012 and generates 15-16 MW of electricity from 1100 MT of MSW. The emissions from the plant are required to be monitored and minimum temperature of 850 C maintained in the combustion zone	Presence of large chunk of C&D waste in the MSW supplied for processing was a major problem The performance of bag filter house had to be enhanced by replacing damaged fibre filter and optimizing pressure drop	Air emission control and monitoring especially dioxin and furan are essential in case of W to E plants. Viability gap funding could be extended to operational plants also. Data from periodic monitoring of air pollution by the plant should be communicated to CPCB regularly.
3	A 2 Z, Kanpur	Kanpur Nagar Nigam (KNN) through a process of competitive bidding (BOOT contract) selected A2Z Infrastructure, a private company, to take care of the responsibility of collection, transportation, processing and disposal of solid waste. 46 acres of land, for a period of 30 years was leased to A2Z Infrastructure to process 1,500 tonnes of solid waste per day. The total project cost was Rs 85 crore which included 30 crore for Equipment for Collection and Transportation and Rs 26 crore for Processing and Disposal facility (which came from two JnNURM projects) and Rs 25 crore from the State Government. The plant is	RDF and composting operations were suspended due to delay in payments by the municipal authority. The SLF was not built as per standards. The W to E plant set up separately was yet to be commissioned	While JnNURM support is essential in this sector, long term viability including continued operation also needs to be ensured. The reason for closure of the plant is attributed to non-supply of requisite quantity and quality of waste committed by the municipal authorities.

		not operational		
4	M/s SELCO International Ltd. Waste Management Plant, Hyderabad	The Processing Plant was initiated in 1999 with support from the Department of Science and Technology. The plant started with the production of Refused Derived Fuel (RDF). In 2003 it commenced generation of 6.6 MW of electricity. It is currently not in operation. In its 11 years of operation 6 lakh tonnes of waste was processed and 160 million units of electricity was generated. The plant is closed down for want of required quantity and quality of waste as well as gaps in agreement signed.	The plant was not operational. The reasons cited were malfunctioning of boiler and non-availability of MSW as per the agreement and no provision for tipping fee. Rs 10 crore is required for revival of the plant. The plant was set up with Rs.20 crore from TIFAC-DST (to be repaid over a period)	Policies for extending financial support to promote new technologies should be based on careful scrutiny of the viability of the project under local conditions. In view of non-availability of bank loans a review of the repayment of the financial support provided by DST was requested by the operator of the plant.
5	Bio-Gas Plant Aundward, Pune	5MT biomethanation plant based on hotel waste was operational for the last 5 years.	5MT biomethanation plant was in operation. Part of the gas was being converted to power and used for street lighting	The initiatives of the ward officials have enabled successful operation of the biogas plant. Municipal authorities can set-up such decentralized biogas plants to meet energy needs.
6	Composting Plant, Aundward, Pune	2 MT composting plant was set up by EXCEL	2 MT composting plant was in operation. A gm. of deodorizing agent and microbial consortium was being used per tonne to hasten the process of composting and keep the place odour free	Such plants with reduced composting time need to be replicated especially in cities with population <50,000.
7	Rochem W to E plant, Ramtekadi, Hadapser	250 MT plant based on German tech. producing Syngas had just commenced operation. The plant could convert syn into power as also ethanol.	250 MT plant has just commenced operation. The Pune Municipal Authority currently supplies segregated waste to the plant. Syngas is produced with a possibility of conversion to both power and ethanol	The plant needs to be monitored for a year before it is replicated.
8	Plastic waste to Fuel plant, Katraj, Pune	The pilot plant processing 50 kg plastic to liquid fuel was based on indigenous catalytic conversion technology. The batch operation in progress during visit was to convert metalized plastic into liquid fuel.	A 50 kg waste plastic to liquid fuel was in operation. The conversion efficiency was 50 kg plastic to 47 litres fuel oil. Trials were on to use metalized plastic waste with conversion efficiency of 50 kg plastic to 29 litres fuel oil. A no. of such plants have been designed and set up for various industrial units for disposal of off-specification plastic packaging material.	This emerging plastic waste to liquid fuel catalytic conversion technology needs to be supported for setting up such plants in the country.

iv. There is currently no guaranteed performance report of any waste processing technology and under such circumstances ULBs are not in a position to take decisions about technology to be adopted.

v. Guidelines on optimization of technology corresponding to the quantum of wastes generation do not exist.

vi. Lack of professional staff in ULBs for handling specific responsibilities for Municipal Solid Waste management.

vii. Non availability of adequate and suitable land for developing sanitary landfill and processing facilities. The lands identified outside municipal jurisdiction face stiff resistance from local population (Not in my backyard (NIMBY) Syndrome)

viii. Studies outlining comprehensive plan for land filling by smaller local bodies (example: ULB generating waste <100 t/d) are not available.

ix. Local bodies, particularly where population is less than 5 lakh, are not in a position to finalize contracts on waste processing and disposal.

x. Lack of awareness amongst households on source segregation & storage of waste at source Preparation of Detailed Project Report (DPR) with estimated fund requirement have not been initiated / completed.

xi. Most of the State/ULBs have yet to understand the benefits of integrated waste management which facilitates efficient utilization of different components of waste management and select suitable developers or agencies for collection, transportation, processing & disposal of waste.,

xii. Awareness amongst the States/ULBs about the benefits of integration of various technologies for MSW processing is lacking. This is necessary as different technological options are required for treating the different components of waste, such as Composting/ Biomethanation process for Organic component, incineration/ gasification/ Refused derived fuel (RDF) process for combustibles portion of waste, inert management facility for Construction and Demolition (C&D) waste, etc

xiii. SPCBs and PCCs do not have adequate infrastructure including personnel to maintain regular interaction with ULBs,

xiv. Fear amongst sanitary workers/private sweepers/ rag-pickers of losing their job/ livelihood if private developer a takes over waste management

2.2 Concerns Raised and Target Set for MSWM in the Twelfth Plan

Some of the major issues concerning solid waste management highlighted in the Twelfth Plan document are**:** 1) Absence of segregation of waste at source 2) Lack of funds for waste management with urban local bodies (ULBs) 3) Lack of technical expertise and appropriate institutional arrangement 4)Unwillingness of ULBs to introduce proper collection, segregation, transportation and treatment/disposal systems and 5) Indifference of citizens towards waste management due to lack of awareness. The Twelfth Plan (2012-

17) also clearly sets bench marks to be achieved for six parameters during the Plan period which are indicated in **Table 6**.

Table 6: Target Set for MSW Management in the Twelfth Plan

Sr. No.	Parameters	Benchmark
1	Household level Coverage	100%
2	Collection Efficiency of MSW	100%
3	Segregation of MSW	100%
4	MSW Recovery	80%
5	Scientific Disposal of MSW	100%
6	Cost Recovery of SWM	100%

A practical and workable follow up and support to meet the above benchmarks is critical to achieve the desired results.

The twelfth plan working group on urban capacity building has specifically recommended creation of cadres, training opportunities for all the staff and an arrangement whereby national institutes of strength relevant for municipal services are identified and the local bodies are authorized to be in touch with them directly for troubleshooting and problem solving. This arrangement need to be formalized and implemented.

Based on the extensive interactions and intense discussion with professionals, private companies, local Governments, TF has critically examined the existing system of MSW management and explored Waste to Energy options as an integral part of integrated MSW management.

Chapter 3

Technology Options for the Treatment and Disposal of MSW

A judicious choice of technology is essential for treatment and disposal of municipal solid wastes. The profitable utilization of fractions of municipal solid wastes can be achieved by employing a combination of technologies suitable for treating various components of wastes. **Figure 3** illustrates options available for municipal solid waste treatment and utilization.

Energy recovery in the form of electricity, heat and fuel from the waste using different technologies is possible through a variety of processes, including incineration, gasification, pyrolysis and anaerobic digestion. These processes are often grouped under "W to E technologies". Two groups of technologies could be used for processing the fractions of wastes:

1. Bio-chemical waste to energy technologies
2. Thermo-chemical waste to energy technologies

Bio-chemical conversion of biodegradable MSW can be categorized into composting, biomethanation and fermentation. Composting is an aerobic process in which biologically degradable wastes are converted through solid state biochemical transformation to yield stable granular material - which could be used as soil conditioners and nutrients. Biomethanation is an anaerobic slurry-phase process that can be used to recover both nutrients and energy contained in biodegradable waste. Biogas can be used either as a source of thermal energy or to generate electricity by using gas engines and turbines.

Thermal processing of MSW can be accomplished in several ways including incineration, pyrolysis, gasification and mass burning. Typically, the feedstock could be segregated or un-segregated MSW or refuse derived fuel.. Incineration is the complete combustion of waste with the recovery of heat, to produce steam, which in turn produces power through steam turbines. Mass burning of MSW is achieved by burning unprocessed wastes. Pyrolysis uses heat to break down organic materials in the absence of oxygen, producing a mixture of combustible gases (primarily methane, complex hydro, carbons, hydrogen, and carbon monoxide), liquids and solid residues. Gasification is a process that converts organic or fossil based carbonaceous materials into carbon monoxide, hydrogen and carbon dioxide at elevated temperature (500-1800^{o}C) in the presence of limited amount of oxygen – typically called as Syngas at temperature above 900^{o}C along with the conventional fuels like coal without any ill effects for generating heat. Operation of thermal treatment systems involves higher costs and a relatively higher degree of expertise.

3.1. Bio-chemical Waste to Energy Technologies:-The biological processes that are commonly used for MSW management in India are detailed in the following pages-25.

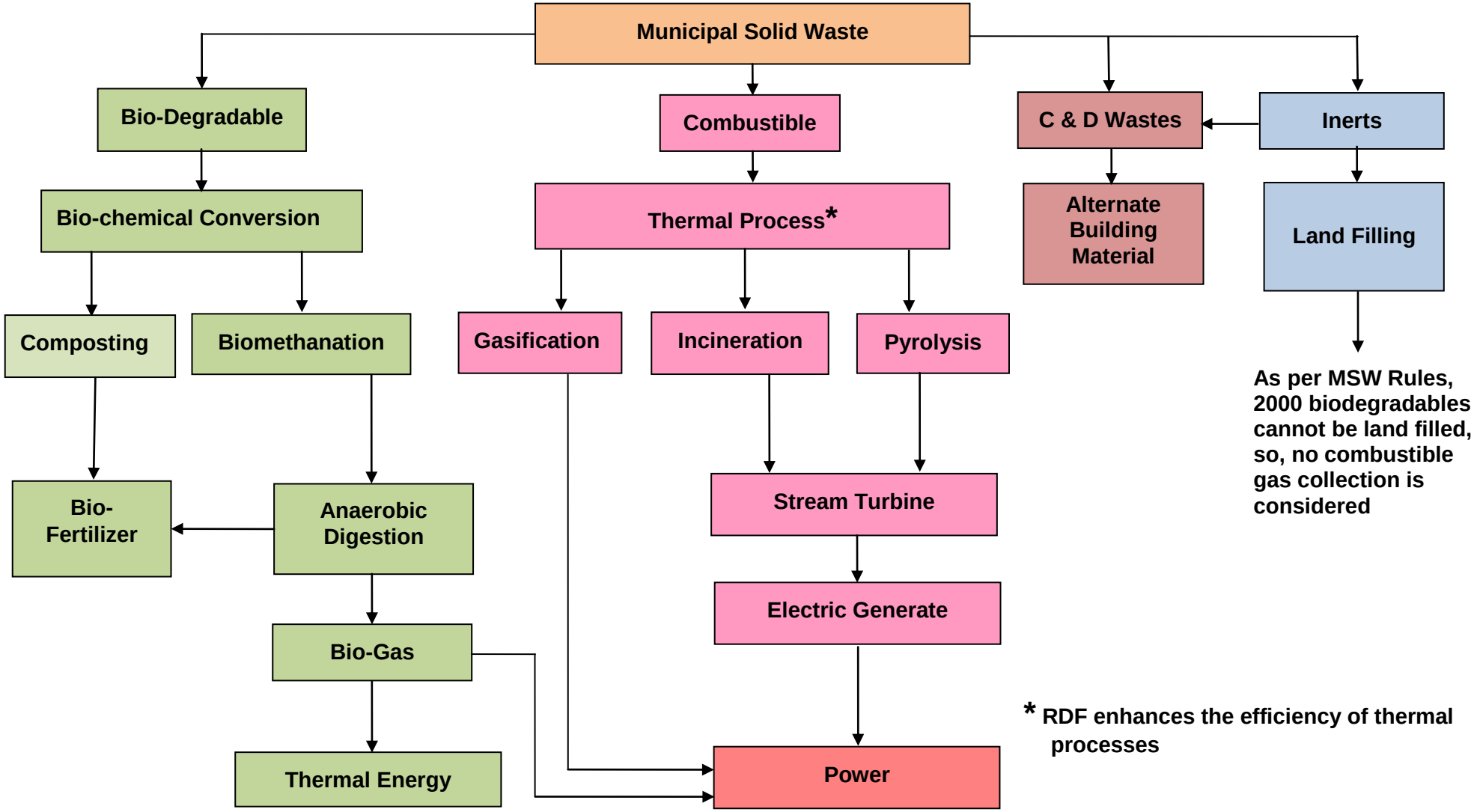


Figure 3: Options available for MSW treatment and utilization

A. Biomethanation As stated earlier biomethanation is anaerobic digestion of organic materials which is converted into biogas, a gaseous combustible mixture, of methane (CH_4). Biomethanation is a biological treatment method that can be used to recover both nutrients and energy contained in biodegradable municipal waste. Biomethanation of organic wastes is accomplished by a series of biochemical transformations - which include in the first stage hydrolysis, acidification and liquefaction followed by a second stage where acetate, hydrogen and carbon dioxide are transformed into methane. The process generates biogas with high content of methane (55–70%) which can directly be used as fuel and by employing gas engines can also generate electricity.

One of the most promising methods of treating the organic fraction of MSW and other organic wastes is anaerobic digestion which is well adapted for high-moisture wastes (Becidan, 2007). This technology has dual benefits. It gives biogas as well as manure as end product. Fibre fraction of waste can also be recovered for use as a soil conditioner after biomethanation. The fibre fraction tends to be small in volume but rich in phosphorus, which is a valuable and scarce resource at global level.

Apart from methane (55-75%), biogas contains significant amounts of carbon dioxide CO_2, (30-45%), which is non-combustible, along with smaller quantities and traces of Nitrogen (0-5%), Oxygen(<1%), Hydrogen sulphide (0-0.5%) hydrocarbon (<1%), Ammonia (0-0.05%) , water vapour (1-5%) and Siloxanes (C_nH_{2n}+1SiO, 0-50 mg/m^3).

The complete combustion of 1m^3 of CH_4 (methane gas) provides about 9000 kcal of heat and after proper pre-treatment, in internal combustion engines electric energy can be produced (or both heat and electricity if a cogeneration engine is used).

This technology can be conveniently employed 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. This technology can also be used to manage MSW in a centralized manner in small towns and decentralized manner in large cities provided the municipal authorities collect segregated biodegradable wet wastes from households and establishments. Currently, this technology has been successfully employed in 172 locations in India ranging from 100kg/day to 10 TPD. Details of five biomethanation plants successfully operated by municipalities and private operators are given in **Table 7**.

Commercially available digesters range from 70 m^3 to 2000 m^3 reactor capacity. The smaller digesters make use of the generated biogas (*i.e.* mixture of CH_4 and CO_2) for heating the digester while larger units generate up to 2 MW of electricity (Verma, 2002). Biogas produced through biomethanation technology can be upgraded into biomethane which can also be used as a transportation fuel. Alternatively, upgraded biomethane can substitute natural gas (a non-renewable fuel) in variety of domestic and industrial applications. Carbon dioxide is typically removed from biogas only when the target is to upgrade it into biomethane.

Table-7: Details of some successfully operated biomethanation plants

S .No.	Parameter	Firm/ Location and performance				
		Katol, Mah.2010-2014	**Bharuch, Ankaleshwar, 2006-2014**	**Pune Munc. corp. 2010-2014**	**Kottayam Med. College, 2009-2014**	**Auro Textile, HP,2010-14**
1	Capacity	2 MT/day	5 MT/day	5 MT/day	2 MT/day	2 MT/day
2	Installation (Month)	December 2010	June 2006	December 2009	June 2009	June 2010
3	Full potential (Month)	February 2011	September 2006	March 2010	September 2009	October 2010
4	Quantity of waste processed	Kitchen waste from hotels and household 800 MT	Kitchen waste from hotels and household 4000 MT	Hotel kitchen waste 9000 MT	Hostel kitchen waste 2000 MT	Kitchen waste 485 MT, Bio. sludge (7% solids) from ETP 1510 MT= 1995 MT
5	No. of working days	1200 (approximate)	2500 (approximate)	1200 approximate	1400 approximate	1150
6	Quantity of biogas generated	60, 000 m^3 (approximate)	3, 20, 000 m^3 (approximate)	6, 00, 000 m^3	1, 20, 000 m^3	63200 m^3 (meter installed on day-1)
7	Utility of biogas	Biogas provided free to few families below poverty line.	Biogas is provided for boiler	40 KVA generator installed ,electricity for captive use and 200 street lights.	Hostel kitchen	Factory kitchen
8	Quantity of manure generated	50MT (Used for city gardens)	350MT (Manure is sold)	20MT (manure not recovered due to space problem)	150MT (Nearby farmers use it)	70MT
9	LPG saved					Equivalent to 31000 Kg (1632 commercial cylinders of 19Kg)
10	Plant Address	Katol Municipal Council, Dist. Nagpur	Bharuch Environmental Infrastructure Limited, Gujarat	Pune Municipal Corp. Model Colony, Shivajinagar, Pune 4	Kottayam Medical College, Kottayam, Kerala	Auro Textiles, Vardhaman Group of Mills, Baddi, HP

B. Composting Composting is a process of decomposition of biodegradable fraction of MSW under aerobic conditions. It is an age old technology and has evolved over the years from stacking the waste in a heap for a couple of weeks / months or buried in pits to decay for 3 to 6 months to, mechanized processing. Microbial composting technology is generally used to handle large quantities of biodegradable wastes using windrow method of composting. Further advancement has been made to reduce the processing time by introduction of consortium of microbes and odor masking agents. Vermi composting technology is based on use of earthworms after initial pre-processing of waste under a shed. Here the earthworms eat the organic fraction of waste and excrete – the excreta is collected as vermi casting, sieved and utilized as bio-organic fertilizer. This technology is found suitable for small towns. The decomposed material (compost / vermi compost) is applied to farm land, parks and gardens to improve soil health, moisture retaining capacity, returns nutrients to soil and is generally called as bio organic fertilizer or soil enricher.

3.2. Thermo-Chemical Waste to Energy Technologies

MSW thermal technologies are processes that create energy in the form of electricity, fuel or heat from thermo-chemical processes such as, gasification, pyrolysis incineration or mass burning of municipal solid wastes. MSW after limited or full pre-processing is used in most of these thermal technologies. Thermal facilities are also referred to as waste to energy or transformation facilities. Incineration, which is a well-established process, has limited efficiency from the thermodynamics point of view. Incineration efficiency could improve up to some extent if it is preceded by conversion of combustible fraction of MSW to so-called “RDF” (refuse derived fuel) since the Indian wastes in raw form are not suitable for incineration.

Majority of the current combustion based projects are for power generation and limited applications are towards thermal usage or as an option for waste disposal. The conversion efficiencies vis-à-vis installed capacities for different technologies are given in **Figure 4**.

Attempts have been made to meet Combined Heat and Power (CHP) requirements using the reciprocating engine route for power generation. These have been possible using circulating fluidized bed gasification technologies with steam or air as the reactive medium. Fixed bed-updraft technologies using catalytic tar reforming and staged gasification technology to improve the carbon conversion have also been implemented. These fuel conversion devices are identified as better technology packages for small-scale power generation compared to direct combustion, on the basis of the existing data from the literature (Knoef, 2005). In view of the current experience on biomass gasification, attempts have been made towards using MSW after necessary processing to acceptable quality feed material. A full scale project of 10 MW based on MSW is under installation at Pune, whereas, a 250 kW project is under implementation by IISc, Bangalore

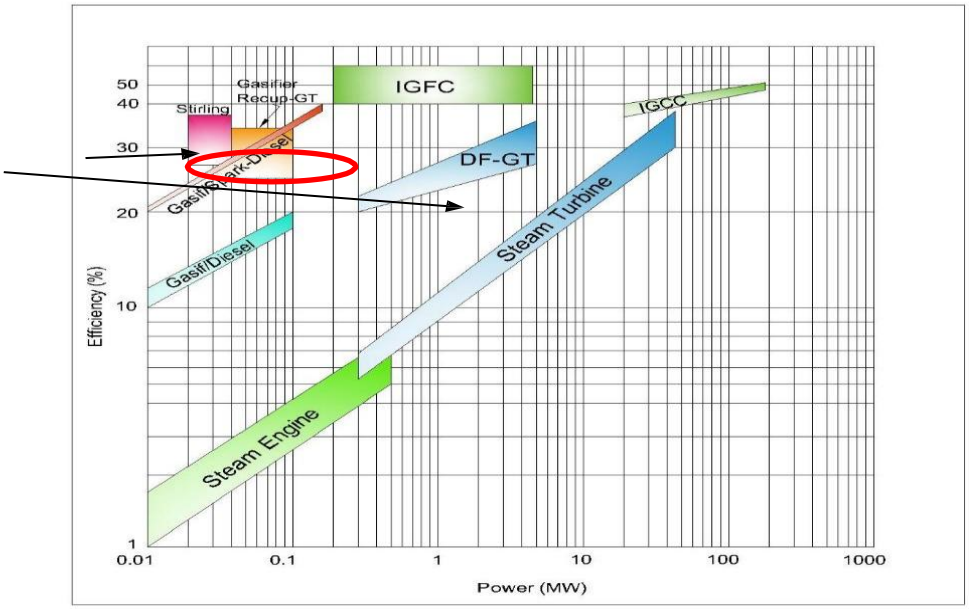


Figure 4: Performance of various thermo-chemical conversion technologies (Ralph, 1998) (IGFC - Integrated gasification and Fuel Cell, IGCC — Integrated gasification and combined cycle, DFGT — Dual fluid gas turbine).

Usage of CHP can help improve overall efficiency in situations where apart from electricity; there is a potential demand for heat in the form of either hot fluid or refrigeration (using absorption cooling). It is also important to recognize that this modern bio-energy technology is a promising candidate for mitigating climate change, insofar as it would offset kerosene used for lighting and diesel used for power generation

A. Pyrolysis: Pyrolysis uses heat to break down combustible polymeric materials in the absence of oxygen, producing a mixture of combustible gases (primarily methane, complex hydrocarbons, hydrogen, and carbon monoxide), liquids and solid residues. The products of pyrolysis process are: (i) a gas mixture; (ii) a liquid (bio-oil/tar); (iii) a solid residue (carbon black). Relatively low temperatures (400-900^{0}C, but usually about 650^{0}C) are employed compared to gasification. The proportion and composition of the various fractions depends on a variety of parameters. Two technologies exist and differ on the method of heat transfer: fast pyrolysis for production of bio-oil and slow pyrolysis for production of charcoal called carbon black (Becidan, 2007). The calorific values of pyrolysis gas typically lie between 5 and 15 MJ/Nm^3 based on composition of MSW and between 15 and 30 MJ/Nm^3 on RDF.

Low-temperature pyrolysis can also be used to produce a synthetic liquid fuel from waste plastic packaging materials and polymeric wastes. A beneficial byproduct of pyrolysis is a kind of charcoal called “carbon black,” which can be used as catalyst , filler material a and can also be used to absorb CO_2 and other emissions from coal-fired power plants. Gasification of waste, in contrast to pyrolysis, takes place in the presence of limited amounts of oxygen. The gas generated by either of these processes can be used in boilers to provide heat, or it can be cleaned up and used in combustion turbine generators.

The purpose of pyrolysis of waste is to minimize emissions and to maximize the gain and quality of recyclable products as well as to minimize the amount of organic waste and sterilize the hazardous components.

B. Gasification: Gasification is the main technology for biomass conversion to energy and an attractive alternative for the thermal treatment of solid waste. Gasification produces combustible gas such as hydrogen, synthetic fuels and is a process that converts dry organic or fossil based carbonaceous materials into carbon monoxide, hydrogen and carbon dioxide at elevated temperature (500-1800^{o}C). The syngas can be used as a feedstock for the chemical industry (through some reforming processes, or as a fuel for efficient production of electricity and/or heat. The number of different uses of gas shows the flexibility of gasification and therefore allows it to be integrated with several industrial processes, as well as power generation systems. Air gasification produces a low-energy gas (4-7 MJ Nm^{-3} net calorific value), while oxygen gasification produces a medium-energy gas (10-18 MJ Nm^{-3} NCV). The purpose of gasification of waste is to generate power more efficiently at lower power level (< 2MW) and also to minimize emissions.

MSW is segregated in this process to remove non combustible materials. Biomass, agro-residues and RDF pellets can be added to the gasifier to enhance the heat generation. Gasification is normally followed by combustion of the produced gases in a furnace and in internal combustion engines or in single gas turbines after comprehensive cleaning of the product gas. The process produces residual waste, as well as waste from cleaning of the gases, which have to be deposited at a controlled landfill (**Figure 5**). Wastewater is also normally produced and treated before it is discharged to the sewage system or evaporated in cooling towers.

The residue or ash that has to be landfilled is similar to that of incineration process. The gas can be used for thermal or power generation purposes. Internal combustion engines can be used for power generation with heat recovery. Typical efficiency of these systems is higher than that of incineration and is in excess of 25% at < 1 MW capacity. The engine exhaust can be treated to meet the environmental norms. Based on several fundamental studies, it is evident that the emissions from gasification process using MSW is lower and even the treatment, if required, will be for less than one third of the volume of combustion products.

The purpose of gasification of waste is to minimize emissions and to maximize the gain and quality of recyclable products.

C. Incineration and Mass Burning: Incineration technology is complete combustion of waste with the recovery of heat to produce steam that in turn produces power through steam turbines. **Figure 6** describes the thermal conversion of municipal solid wastes into electricity. There are a number of combustor designs used to burn combustible fraction of MSW. Complete combustion optimally involves a two-stage transformation of fuel, in this case solid waste, into CO_2 and water vapour.

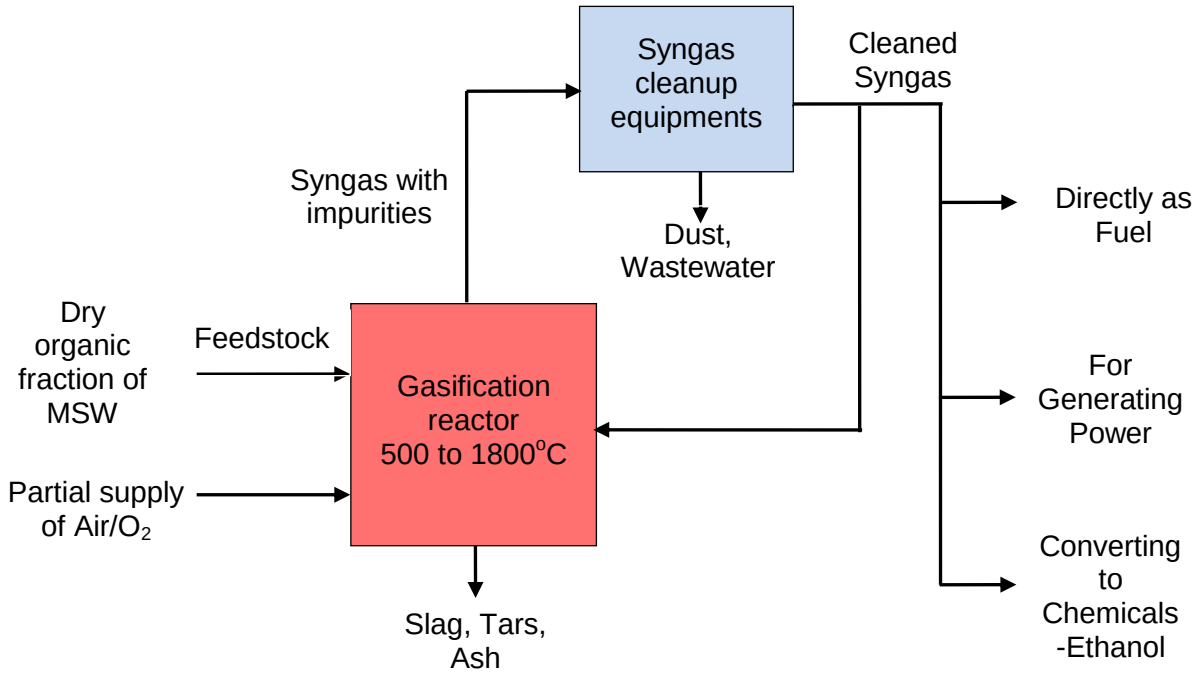


Figure 5: Schematic diagram of gasification

The secondary phase of incineration (combustion) takes place as the combustible materials (e.g., paper, plastics, organic materials containing carbon, hydrogen and oxygen) combine with oxygen to form carbon dioxide and water vapour (oxidizes). But in incinerators, since the waste stream is so heterogeneous, other compounds are also formed and buoyed upward off the grate by the heat of combustion. There are unburned carbon particles, incompletely burned carbon-based compounds (e.g. organic products of incomplete combustion (PICs) such as carbon monoxide, PAH's, and the more toxic dioxins and furans often referred to as "products of incomplete combustion, or PICs), and incombustible elements such as heavy metals, sulphur, nitrogen, and chlorine, which combine with oxygen and hydrogen in the furnace to form compounds such as HCl, SO_2 and oxidized metals.

In most mass burn plants the grate system moves the solid waste through the drying, burning, and burnout zones, while promoting combustion. This is done by ensuring that adequate (but not excessive) quantities of air enter from below via holes in the grates. The efficiency of the combustion process, and therefore incineration, is characterized by the "three T's": temperature, time and turbulence. To achieve the temperature requirement, an adequately high and uniform temperature profile must be maintained throughout the furnace volume at all times in order to destroy PICs reliably. In order to optimize combustion of these gases, it is generally considered that the temperature profile (or the secondary chamber) should not fall outside the range of about 1800-2000^{o}F. This means that the temperature should be uniform with no cool spots or short cuts for the gases to exit. Considering the heterogeneous nature of municipal solid waste, with some components highly combustible and others not, strict maintenance of at least a minimum temperature throughout the furnace is necessary.

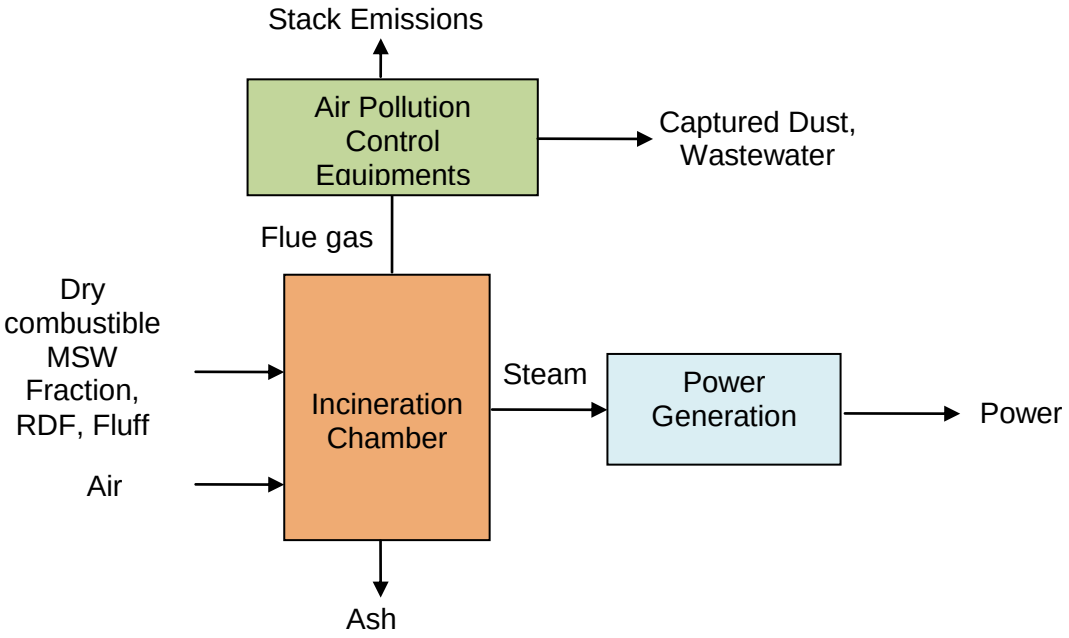


Figure 6: Incineration process block diagram

.RDF and pre-processed MSW are used as fuel in the specially designed boilers and for generation of electricity through steam turbines. RDF being low density fuel generates more fly ash during combustion. Fly ash acts as catalyst for de-novo synthesis (at 200-450 degrees) for production of dioxins and furans. In order to reduce formation of dioxins and furans, it is imperative that maximum fly ash is removed before gases cool to the range of 200-450 degrees. This requires multiple passes in radiative section of boiler and results in much bigger boiler for W to E plants. The flue gases produced in the boilers have to be treated by an elaborate air pollution control system. The resultant ash from incineration of solid waste can be used as construction material after necessary processing while the residue can be safely disposed of in a landfill.

Using RDF as a fuel in incinerators is a better option because it is typically formed by augmenting calorific value of combustible wastes with the help of some high calorie-rich industrial wastes or biomass and through application of pressure and/or heat and with the help from binders physical shapes of pellets or briquetts are extruded. It is a possible solution for making W to E a success in India because RDF is easy to transport, has adequate shelf life and it can be prepared in small and medium scale de-centralized facilities and conveniently transported to a regional W to E facility in a radius of 100 km catchment zone.

Some of the challenges in applying combustion technologies and their status are as follows:

i. Meeting emission standards (Particulates, NOx, etc) - Technologies are available for meeting strict pollution control norms

ii. High water consumption – Air-cooled condensers used in India have largely overcome this constraint

iii. Multi-fuel capability – being used in some cases

With the above challenges the major research trends in the area of incineration has been towards: i. Improving the efficiency of low power capacity steam turbines by achieving higher pressures, ii Issues related to super heater tube, iii Material life, *etc*., iv Co-firing, v. reduce the fossil fuel consumption, vi. Emission control techniques and vii. Hybridization.

D. Pelletization and Fluff as an RDF to Support Combustion Technology: Refuse Derived Fuel (RDF) is a segregated combustible fraction of MSW. The combustible fraction of the waste is transformed into fuel pellets by the compaction of waste or shredded and converted into fluff, enriched in its organic content by the removal of inorganic materials and moisture. Due to reduction in fuel particle size non-combustible material, RDF fuels are more homogeneous and easier to burn than the gross MSW feedstock. The RDF burning technology includes spreader stroker fired boiler, suspension fired boilers, fluidized bed units, and cyclone furnace units. In order to derive optimum advantage from RDF towards saving fossil fuel; secondary fuel like biomass, rice husk and other agro wastes can be used in small proportions for co-burning to generate energy.

Combustion of the RDF from MSW is technically sound and is capable of generating power. RDF can be fired at temperature above 900^{o}C along with the conventional fuels like coal without any ill effects for generating heat. Operation of the thermal treatment systems involves higher costs and a relatively higher degree of expertise.

E. Syngas: Syngas is a mixture of carbon monoxide (CO) and hydrogen (H_2) or very little quantity of CO_2, which is the product of high temperature steam or oxygen gasification of organic material such as biomass and MSW. In the gasification reactors, the feedstock is converted into a mixture of H_2, CO and CO_2, which produces a variety of downstream energy carriers. Bio-automotive fuels and chemicals can be produced from high-quality syngas (mainly H_2 and CO) which is obtained by gasification of biomass and wastes. Syngas plays an important role as an intermediate in the production of several industrial products, such as methanol and ammonia. Currently, syngas is produced from fossil fuels, mainly coal, natural gas and naphtha. Syngas from renewable resources, such as biomass, exhibits a promising prospective.

F. Catalytic conversion of waste plastic to liquid fuel : Besides conventional W to E technologies, new technologies are emerging in India for converting polymeric wastes to liquid fuel. Catalytic conversion and pyrolysis are the two technologies currently used for converting plastic waste to liquid fuel. Large size conversion plants are based on pyrolysis while catalytic conversions are used in small batch / cyclic operation (**Figure 7**). Similarly, soiled plastic wastes are being used for strengthening roads by blending chopped polymeric waste with molten bitumen which reported enhancing the life of the road by 30%.

These emerging technologies appear to be promising and need to be explored in conjunction with other MSW processing technologies to create viable alternatives.

Figure 7: 50 kg soiled plastic to liquid fuel plant, Pune

3.3. Discussion on Application of Waste to Energy Technologies

In conventional biogas Conversion to Heat and Power (CHP) plants the equipment for capturing CO2 is not required. Nitrogen and oxygen, the two main components of air, are found usually in biogas in a ratio 4:1. Their presence is mainly due to the air introduced in biogas mixture after the anaerobic digestion so as to remove the excess hydrogen sulfide amounts. Ammonia concentration in biogas is usually most of the times very low, not exceeding 0.1 mg/m3. The presence of ammonia in higher concentration is attributed to the increased nitrogen content of the substrate used (e.g. poultry manure).

Hydrogen sulfide quantity in biogas is a decisive factor for its quality. Without the integration of a biogas de-sulfurizing step, hydrogen sulfide concentration may exceed 0.5 % by volume which is a significant amount, capable of causing damages due to corrosion effects to the downstream piping or to the cogeneration engine. Actually, many engine manufacturers and providers suggest an upper limit in hydrogen sulfide concentration of 0.05 % by volume, for a long-life lasting effective operation of the engine.

The presence of water, in the gaseous form of vapour, is inevitable in biogas mixture due to the type of biochemical reactions and collection mechanism of the biogas which takes place during anaerobic digestion. Similarly, hydrogen sulfide gets oxidized to sulphuric acid in presence of water vapour– which is highly corrosive for the engine. High vapour concentration may turn the non-corrosive carbon dioxide into a corrosive compound due to formation of carbonic acid. As a result, water removal from biogas is another necessary pre-treatment step so as to eventually introduce biogas into the cogeneration engines.

Siloxanes are silica compounds which are derived from the anaerobic digestion of specific type of organic substrates. Such materials are rice straw and agricultural biomass. Siloxanes presence in biogas is extremely undesirable, since they have the ability to react with oxygen at high temperatures and form silicon dioxide (SiO_2), which is a substance that remains in various parts of the equipment thus causing serious damages.

The biogas plants feedstock materials are usually organic wastes (e.g. kitchen waste, animal manure, agro-industrial wastewater) which deteriorate the environmental quality of the region where they are produced. The collection and energy exploitation of these materials through biomethanation, not only provides significant amounts of green energy in a decentralized manner, but, also mitigates the pollution effects on the local ecosystems. The construction and operation of biogas plants also enable decentralized power production.

To avoid problems which arise from the digestion of solely one material, the majority of the biogas plants are combined anaerobic digestion plants. The advantages are - higher process stability, increased capacity of feedstock materials, increased biogas and energy production and more profitable investment. If the environmental factors are taken into account and as combined digestion provides an integrated solution to organic waste management the high rate of increasing number of combined anaerobic digestion plants worldwide clearly provides an answer.

The amount of energy produced from a typical biomethanation plant digesting 50 MT of segregated wet waste every day would generate 4000 Nm^3 of biogas - which is equivalent to 500 KW power. In the Indian context, biogas generated can either be fed to a *Gas Engine Alternator Set* of 10 KVA capacities to generate electricity for a period of 12-15 hours every day or can directly be used as fuel for cooking or boiler. **Table 8** indicates the overall viability in terms of both capital and O&M cost and output in terms of volume of products both gas and manure for various plant capacities. Additional cost will have to be incurred for converting biogas to electricity in plants up to 5 MT capacities, which is in the range of Rs. 15-20 lakh depending on the capacity of plant and capacity of generator. For 5 MT/day plant, cost of electricity generation infrastructure (balloon, balloon room, generator of 40KVA capacity, generator room and scrubber) would be around Rs. 20 lakh.

The biogas generated from biomethanation plants of 10 TPD and above can be commercially bottled and marketed. An additional investment of Rs. 60 lakh for 100 m^3 per hour bottling plant will be required.

In gasification, the gas produced from the process (syngas) is a mixture, which among others contains carbon monoxide, hydrogen, methane and other hydrocarbons; substances which are flammable and combustible. As a result, syngas can be fed to gas engines or turbines, only after it has been cleaned of any possible contaminants. The typical electrical efficiency of gas fired boiler and steam turbine system varies between 15-25%, while syngas fired gas engine and turbine system can achieve much higher electrical efficiencies (between 30-40%). Since gas engines achieve higher electrical efficiencies than steam turbines, gasification seems to be more attractive than combustion in terms of efficient energy production.

Apart from syngas, gasification is a process that simultaneously produces various other by-products, like carbon black. While combustion plants aim at minimizing the amount of char produced so as to achieve higher energy efficiencies, in gasification projects char is considered as a marketable product (as an additive for cement factories or as a

soil amendment). The gasifier type and the existing conditions affect significantly the amount of char produced, so it is a challenge to select the optimal gasifier so as to combine efficient energy production with sufficient and high quality char.

Table 8: Viability of Biomethanation plant

Sr. No.	Capacity (MT/day)	Installation cost (Rs. in lakhs)*	Quantity processed -life(30Y) of plant (MT)#	Space (m^2)	Annual O&M cost (Rs. lakhs)	Biogas output (Nm^3/day)	Power from Biogas (Kwh)**	Manure (Kg/day)
1	0.1	4	1080	25	0.5	8-10	NR	8
2	0.25	5	2700	30	0.75	18-20	NR	20
3	0.5	15	4900	40	1.5	30-50	NR	30
4	1	20	9900	60	1.5	60-90	4	60-80
5	2	30	19800	100	2.0	140-180	8	120-150
6	3	40	29700	200	3.0	200-270	12	150-180
7	4	60	39600	400	4.0	280-350	16	200-250
8	5	70	49500	500	5.0	350-400	25	350-450
9	10	150	99000	1500	9.0	700-900	50	500-600
10	25*	300	247500	4000	20.0	1500-2000	125	1500-2000

NR- Not Recommended

- Annually the plant operates for 330 days. Usually, these plants function round the year without any break.

* - Cost includes the gas utilization system (either generator or gas compression unit). Infrastructure cost like compound wall, land cost and office room are not included.

** -1 Kwh power can light 20 LEDs or CFLs of 40 W or 5 sodium vapour lamps of 150W for an hour. 1 MT plant will generate biogas to light up 160 LEDs of 40W or 40 sodium vapour lamps of 150 W for 10 hours.

This is a non-existing challenge for conventional biomass combustion plants.

Flue gases from biomass combustion can be only exploited in steam turbines by exploiting their thermal energy content. Syngas not only can be used as a fuel in gas engines, but also as a feedstock for the production of other fuels (like ethanol, methanol, biodiesel etc.) or other chemicals (like acetic acid, ammonia, *etc*.).

One aspect of this comparison that definitely favours the combustion processes has to do with the technology maturity and its cost-effectiveness, especially in smaller-scale projects. Even though several megawatts of biomass gasification plants has been installed and operated successfully over the last 20 years, it is still considered as an emerging technology compared to combustion which has been traditionally used for power production for at least a 100 years.

As already mentioned, gasification occurs when the oxygen supplied to biomass is less than required in order to fulfil complete combustion; actually gasification is biomass partial oxidization. But when referring to pyrolysis, it is essential to maintain absolute oxygen-free conditions during the thermal conversion of biomass.

During pyrolysis biomass is heated until it is liquefied and the contained volatile gases are driven off the solid mass. The volatile gases are then condensed in order to

eventually produce a combustible liquid biofuel, called bio-oil. Probably the most promising alternative of biomass pyrolysis is biomass fast pyrolysis. This takes place at a medium temperature range (450-500°C) with extremely small retention time of biomass inside the reactor (about 2-3 seconds). The conditions under which fast pyrolysis takes place result in the production of a low char and water content bio-oil, with increased energy value.

Both gasification and pyrolysis produce liquid fuels, first gaseous fuel and the second liquid. Even though syngas and bio-oil have certain similarities (utilization in engines and turbines, transportation through piping network, use as feedstock for the production of other fuels or chemicals), they have a major difference which is linked with the production process maturity. If gasification is considered emerging and technologically less mature process than combustion, pyrolysis should be considered as still being at pilot/demonstration stage of development. There are important issues that need to be resolved in pyrolysis. One of the biggest concern is the quality of bio-oil produced which is considered corrosive and its constant supply to power engines needs to be regulated. For the same reason, bio-oil storage and transportation is problematic. The comparison of the three main thermo-chemical conversion processes of MSW is summarized below in **Table 9**.

Table 9: Process details of conversion technologies

Conversion process	Air (or steam) supply	Temp. (°C)	Products
Gasification	Less than stoichiometric oxygen required	800-1200	Heat, Syngas fuel, Char
Incineration	In excess	800-1200	Heat
Pyrolysis	Total absence	300-600	Heat, fuel oil, Combustible Gas, Char

3.4. The Energetics and Economics of W to E

Rapid growth of industries and commerce in India necessitates uninterrupted power supply. Therefore, all options need to be explored to generate power from conventional and non-conventional sources. MSW provides an opportunity of tapping potential energy to meet part of the energy demand of the country. The current composition of MSW after purchase / salvaging of recyclable components by kabadiwalas / rag pickers have low calorific value (less than 2,000 Kcal/Kg) and is not suitable as a raw material for W to E plants. For utilization of the energy potential from the MSW it is felt necessary that other high energy biomass could be co-incinerated in a proportion not exceeding 20% and additional 10 % auxiliary fuel may be allowed to be used to meet the power generation benchmark.

The selection of technologies is based on the factors like the desired form of the energy, economic conditions, quantity and characteristics of feedstock, end-use requirements and environmental standards (Kalyani et al., 2014; Beede et al., 1995). The MSW conversion into energy is important from the energetic as well as the

economics point of view because it reduces the direct load on fresh resources and provides energy at reasonably low cost (Said et al., 2013).

Evaluation of different W to E technologies based on the patterns of energy consumption, production, and different levels of material recovery and on the cost–benefit analysis is necessary to arrive at a suitable technology that will be economically viable and energetically efficient.

3.5. Common Regional Sanitary Landfill Facility

The residual waste from the processing plants and other inert waste collected from the municipal area *i.e*. street sweepings etc., need to be disposed off in Sanitary Landfill Facility (SLF). As per MSW Rules, 2000, biodegradables cannot be disposed off in landfills. The percentage of inerts and residual waste therefore required to be disposed off in sanitary landfills in the country is less than 25% of the MSW generation – which will progressively reduce with improvement in waste management system. Considering, the need for 60,000 acres of land (@15 acre per 1 lakh population) for a period of 25 years to dispose 42,500 TPD of inerts and residual wastes, it is essential to consider setting up Common Regional Sanitary Landfill Facility. Cities above one million population should set-up their own landfill and permit all cities and towns within 50km periphery of the city to use that facility for disposal of their waste. Common regional facilities may be constructed for rest of the 7,882 cities, towns and urban centres by forming clusters within 50 km radius with a population of at least one million. Only in special cases, where, the distances between the cities are large the cluster size may be brought down suitably to handle at least 50 TPD of residual waste.

SLFs need to be sufficiently large so that they can be properly equipped, professionally managed, regularly monitored and planned for a minimum period of 25-30 years. The initial cell shall have a capacity to handle inerts and residual waste typically for a period of 5 years.

Serious efforts should be made by Municipal Authorities to treat street sweepings and slit from drains also so that they need not have be disposed of in SLF.

Dumpsite development/rehabilitation is another area of concern and should be initiated based on scientific assessment of contamination of soil and groundwater and projected future impact based on expected model scenarios. This would release large tract of land which can be put to other uses. As biodegradable kitchen / hotel food waste have been used in piggeries so far recovery of landfill gas (containing over 30% of methane) from current dump sites has hardly any potential in India.

In order to understand the issues associated with the existing W to E plants' operations in India an extensive field survey was carried out. Further, the literature review was carried out to understand the international scenario of currently adopted W to E technologies. Study was also conducted to assess the appropriateness of centralized and decentralized waste management approaches. The findings are presented in the subsequent chapter.

Chapter 4

Issues in the Operation of Waste processing Technologies

Indian experience of solid waste processing technologies till date is very limited. Till the notification of MSW Rules 2000, a very small (insignificant) proportion of municipal solid waste was processed adopting composting technology in a rudimentary manner. Efforts were made by Government of India in late 70s to set up, ten mechanical compost plants in selected cities. Unfortunately all of these were closed down for various reasons, including lack of maintenance, after a few years of operation.

Again a beginning was made by private sector companies by investing in composting and W to E plants but these plants also did not operate as per their installed capacity. The plants were closed down due to public outcry, problems of marketing of compost, poor quality of feed stock, improper choice of technology and due to non availability of the right quantity and quality of wastes as was promised or envisaged. The W to E plant (incineration plant) set up at Timarpur in Delhi in 1986, the RDF based power plants in Hyderabad and Vijaywada and biomethanation plant at Lucknow- all did not work as expected and eventually were shut down. A number of wastes to energy technologies have been introduced over a period of time at the initiative of the private sector but most of the waste processing plants in India have shut down or have not been operating as per their designed capacity. The reasons are cited in **Table 10**.

Table 10: Reasons for Closure of W to E plants

Reason	Timarpur	Vijaywada	Hyderabad	Lucknow	Kanpur
Lack of due diligence on the part of investor and public sector.	Yes	Yes	Yes	Yes	Yes
Non-supply of committed quantity / quality of waste to the plant by the municipal authority	Yes	Yes	Yes	Yes	Yes
Presence of inerts - dust & C and D waste in MSW delivered for processing, making the operations difficult and very expensive.	Yes	Yes	Yes	Yes	Yes
No market for sale of compost / RDF	NA	NA	NA	NP	Yes
Public outcry against the location of the plant	Yes	NA	NA	Yes	NA
Lack of financial viability of the project etc.	Yes	NA	NA	NA	Yes

Legend: NA = Not Applicable, NP = No Production

Failure of these plants have resulted in serious setback to the waste to energy projects in India and have raised doubts on the suitability of Indian waste for waste to energy projects. Considering the non performance of W to E plants, the Hon. Supreme Court of India has directed that MNRE, GOI may support five pilot W to E projects for the time being. The MNRE should take concerted measures to successfully demonstrate the pilot W to E projects at the earliest to enable private sector investments.

With a view to optimally utilize a large proportion of organic matter and recyclable material available in MSW and save national resources, it is imperative to address the short comings and find ways and means to promote waste processing and make processing plants viable.

4.1. Waste Composition

Studies conducted by NEERI shows that the waste composition has changed rapidly during 1996-2011 and the proportion of high calorific value waste is increasing. **Table 11** shows that there is over 380% and 1650% increase in paper and plastic waste respectively. This calls for serious effort to utilize compostable as well as burnable waste, adopting both compostable and waste to energy technologies.

Table 11: Change in Composition of Municipal Solid Waste

year	Composition (%)							
	Biodegradable	Paper	Plastics /rubber	Metal	Glass	Rags	Others	Inerts
1996	42.21	3.63	0.60	0.49	0.60	nil	nil	45.13
2005	47.43	8.13	9.22	0.50	1.01	4.49	4.016	25.16
2011***	42.51	9.63	10.11	0.63	0.96			17.00
2011***	52.32	13.8	7.89	1.49	0.93	1.00		22.57

Sources: For 1996 results, NEERI 1996; for 2005 results, http://www.cpcb.nic.in.
**** for North Eastern States as per a recent CPCB study conducted by NEERI

4.2. Significance of Segregation, Collection and Transportation

Currently, solid waste is collected by municipal authorities in a mixed form and delivered at the processing facility or directly taken to the disposal site. In the former case, the processing facility is saddled with the task of segregating the inerts from the mixed wastes. This substantially adds to the cost of operation and quite often makes it unviable.

To tide over this problem, first and foremost, a major awareness campaign should be launched to educate the waste generators on the importance of reducing waste generation and practicing segregation of biodegradable and non bio degradable waste at source to facilitate optimum utilization of reusable material and recycling of various components of waste. This will facilitate delivery of segregated bio degradable and combustible waste to the respective processing facilities. This initiative can be followed by making it mandatory for the citizens to segregate the waste through municipal bye laws or legislative framework as for instance in Bangaluru where segregation of waste at household level is mandatory.

In order to ensure that inert waste material such as street sweeping, silt from the drains and construction and demolition (C & D) wastes does not land up at the waste

processing facilities, the municipal authorities or the agencies engaged by the municipal authorities should collect and transport wastes in three different streams as under:

i. Domestic / commercial wastes
ii. Street sweeping and silt from drains
iii. Construction and demolition wastes

The domestic market, commercial and institutional wastes should be directly delivered at the waste processing facilities, whereas the street sweeping and silt from the drains should be directly taken to the disposal facilities. This would keep away inert wastes from biodegradable and recyclable/ combustible wastes and facilitate smooth processing of MSW. Till such time, door-to-door collection facility becomes fully operational, segregation of organic matter (tree leaves) and recyclables from street sweepings may be done at the disposal facility and sent to the respective processing facility and inerts may be landfilled. Construction and demolition wastes need not be taken to the disposal facility and instead should be utilized for making bricks, paver blocks, and aggregate as well as for bio-engineering works. The municipal authorities can immediately introduce this system without waiting for segregation of wet and dry wastes at source by the households to be fully operational..

The next step should be to undertake massive awareness drive for segregation of dry and wet wastes at source before it is collected and transported to the respective processing facility in order to minimize the burden on the sanitary landfills.

In order to economize the cost of transportation the cities where processing / disposal site is more than 15 km away from the collection area, transfer station may be set up at strategic locations and professionally managed to ensure that they do not cause nuisance to the neighbourhood for bulk transfer of wastes especially in large cities for example, Ahmedabad, Coimbatore, Surat, Hyderabad etc.

Sanitary landfills may be constructed on the site as per the MSW Rules, 2000 in large cities whereas regional / common facilities may be considered for smaller towns to facilitate professional and economic management of waste disposal facilities.

The municipal authorities should put in place plastic waste management system as mandated in the “Plastic Waste Management and Handling Rules 2011” to facilitate plastic reuse, recycling and energy recovery. This would facilitate deriving energy from plastic wastes.

4.3. Centralized and Decentralized Approaches for MSW-Management

Municipal waste can be managed through a decentralized approach or a centralized approache or a combination of the two. Currently both centralized and decentralized systems are in practice in different cities/towns in the country. These two approaches have been briefly discussed below.

A. Decentralized Approach: Municipal authorities should make serious efforts to minimize the cost of collection and transportation of biodegradable MSW as well as to minimize the problems of odour and public health issues by setting up decentralized waste processing facilities. Technologies such as composting, and biomethanation within the community (colony, housing society, institution premises, local area etc) through Resident Welfare Association (RWA), Community Based Organization (CBO), Non Governmental Organization (NGO), Advanced Locality Management (ALM), Self-Help Groups etc., can be introduced for decentralized processing.

Micro-entrepreneurs generally engage informal workers for collection and transportation of wastes. Successful decentralized waste management systems which manage wastes in a manner that is environmentally safe and economically viable can be seen in Chennai, Mumbai, Pune, Bangalore and Saharanpur. There are over 100 small bio methanation (bio gas) plants based on BARC technology which are good examples of decentralized systems in the country promoted by municipal authorities and private sector.

Municipalities should make a judicious plan of establishing decentralized and / or centralized facilities in their respective cities considering a) availability of suitable land b) community support c) availability of operator of the facility and d) environmental concerns.

The central and state governments may jointly demonstrate how decentralized approach can work by setting up at least one decentralized processing facility in each state at full government cost and technical assistance and also utilizing it as a training ground and opportunity for other local bodies to follow.

B. Centralized Approach : The MSW generated in areas where decentralized facilities cannot be set up by the municipal authorities should be transported to a centralized MSW processing facility such as composting, RDF, incineration, gasification, biomethanation, plastics to fuel etc as per the norms specified for different size of cities. The centralized approach to waste management is for handling bulk wastes at a central processing facility such as those built for composting or that which use waste to energy technologies like incineration, pelletisation, produce Refuse Derived Fuel (RDF), gasification, biomethanation. Here, the implementing agency (either the ULB or a private entity) has to collect and transport waste from households or community bins to a centralized processing facility. The implementing agency will therefore need to have a fleet of vehicles, manpower and cater for sufficient fuel. A few cities such as Delhi, Pune, and Sholapur etc., have set up centralized power plants for MSW as well as decentralized biomethanation plants which are operational

Selection of a centralized or decentralized model (**Table 12**) of solid waste management, is principally dependent on technology, quality and quantity of waste, Availability of land, community acceptance, health risk and cost implication are also very important factors to be taken into consideration..

Table 12: Selection of a centralized or decentralized approach

Type	Selection Criteria
Decentralized	• Land for composting/biogas are available in local area • Availability of informal workers for processing of waste • High degree of organic content in waste • Markets for compost/biogas is available • Possible to manage health risks adequately • Operational expenditure is generally low
Centralized	• Land is not available close to the community for decentralized model, • Local level resistance • economies of scale makes the project viable • In large cities high proportion of combustibles like paper, plastics etc in waste warrants setting up of large / centralized facilities.

Decentralized composting or BARC type small community based Biomethanation or Biogas plants are successful examples. Centralized or regional waste processing facility may be economically viable and can attract private sector investments. Smaller cities, can set up RDF plants to serve as feeder to centralized power plants or regional facilities.

4.4. Scientific selection of Centralized vs. Decentralized MSW Management option

It is to be noted that both the systems are technology driven. Therefore, an adequate understanding of the know-how of technological components of the system is essential before opting for one of the approaches. The decision for setting up centralized or decentralized systems and sub-systems will be crucial in the early stages of planning.

In order to have a clear understanding of technologies, their advantages, limitations and applications; the Task Force conducted a survey mainly recording opinion of experts in the form of scores.

Table 13 depicts the unit operation or steps involved in MSW management. The scoring has been given in the range of 1 to 10 (1 being the least beneficial) to address suitability of centralized and decentralized systems for each unit operation. The experts were made aware of the rationale behind suggesting scores for each unit operations in MSW management. The scores are based on attributes such as technical feasibility, managerial, social acceptance, operation and maintenance advantage, capital cost and recycling potential.

The "average scores along with the standard error" is displayed in **Annexure I-C**. For easy understanding the "average scores are rounded up" in **Table 13.** It is clear from the table that higher the scores more suitable is the step was waste processing in

integrated waste management. For example, in respect of segregation at source, fifteen experts who responded to the survey feel that technical feasibility, low capital, O&M cost and recycling potential attributes for segregation at source in a decentralized manner is more advantageous and has been rated higher compared to centralized approach. In respect of waste to energy through incineration, experts clearly suggest a centralized approach only. .

For the various steps in the integrated management of MSW, experts have recommended decentralized approach for segregation at source, transportation, pre-processing of wastes, biomethanation, conventional composting and vermi composting and centralized approach for others such as incineration, pyrolysis, gasification, RDF production, mechanical compost, C&D waste processing and engineered sanitary landfill.

4.5. International experience

As per June 2013 Report of 'ecoprog GmbH', there are 2,200 W to E plants in the world. They have a disposal capacity of about 255 million tons of waste per year. By 2017, another 180 plants with a capacity of 52 million tons will be added. Modern W to E technologies has been commercially deployed, especially in Europe, Japan, Australia, China and the USA. In US there are 86 W to E Plants - about 12 % of waste is combusted for energy recovery – mostly 'mass burn'. Number of plants built from 2008-11 the world over is shown in **Figure 8**. No new plants have been built in the US since 1995.

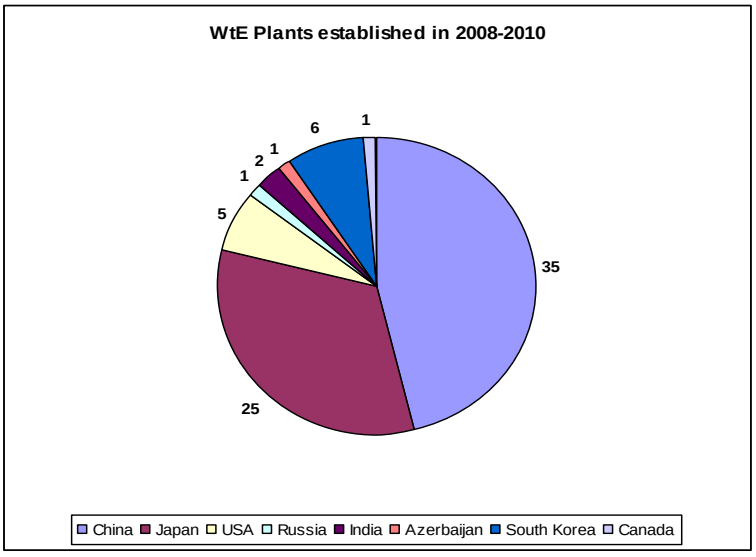


Figure 8: W to E plants established during 2008-2011.

Table 13 : Decision Support Matrix for Selection of Centralized (C) or Decentralized (D) Approaches based on Experts' Valuation

S. No	Attributes Unit Operation or Step in MSW Management	Technical Feasibility		Managerial Feasibility		Social acceptability		Low Capital Cost Advantage		Low O & M Cost Advantage		Recycling Potential	
		C	D	C	D	C	D	C	D	C	D	C	D
1	Segregation at Source	5	8	8	6	6	6	5	8	6	8	6	8
2	Transportation	7	8	8	7	7	7	5	7	5	7	4	6
3	Pre-processing of Wastes	6	7	6	6	7	6	6	6	6	6	5	7
4	W to E: Biomethanation	7	8	7	7	7	6	6	7	6	7	7	8
5	Conventional Composting	6	6	6	6	7	6	5	7	6	7	6	7
6	Vermi-Compostiing	4	7	4	7	6	6	5	7	5	7	5	7
7	Mechanical Composting	6	6	7	6	6	5	5	6	5	6	5	6
8	W to E: RDF Production	7	5	7	5	8	6	6	5	6	5	6	6
9	W to E: Incineration	9	3	8	4	6	4	6	4	7	4	6	4
10	W to E: Pyrolysis / Gasification	8	5	7	4	6	4	5	4	6	3	6	5
11	W to E: Plasma Arc Gasification	6	3	5	3	7	4	4	3	4	3	6	3
12	Disposal of Road Sweeping & C&D	7	5	6	5	6	5	6	5	6	5	5	5
13	Engineered Sanitary Landfill	9	4	8	4	8	3	7	4	7	4	4	2

May be treated as indicative.

A. European Union: The total number of waste-to-energy plants in the 18 European countries is 455 compared to 86 in the United States. The number of plants in EU country wise is shown in **Figure 9**. The data has been compiled by ISWA in 2013 and collected in 2011 and 2012. In some countries very large waste-to-energy plants are common. The European Union's strategy is to become a 'recycling' society, seeking to avoid waste as far as possible and to reuse waste generated as a resource. The EU has set a cap on the amount of recyclable and compostable waste that can be sent for energy recovery via incineration.

It also seeks an end to waste to landfill. In the EU, the W to E Plant is considered a 'recovery' option only when it gainfully uses both electricity & heat generated.

B. Japan : In Japan, Incineration has been the primary disposal route for waste due to lack of space for landfills - 74% of all waste produced in Japan is incinerated with just 2% sent to landfill. The households are required to sort waste into at least eight fractions – to increase recycling. The modern W to E plants is incentivized to recover energy (as well as recycling ash).

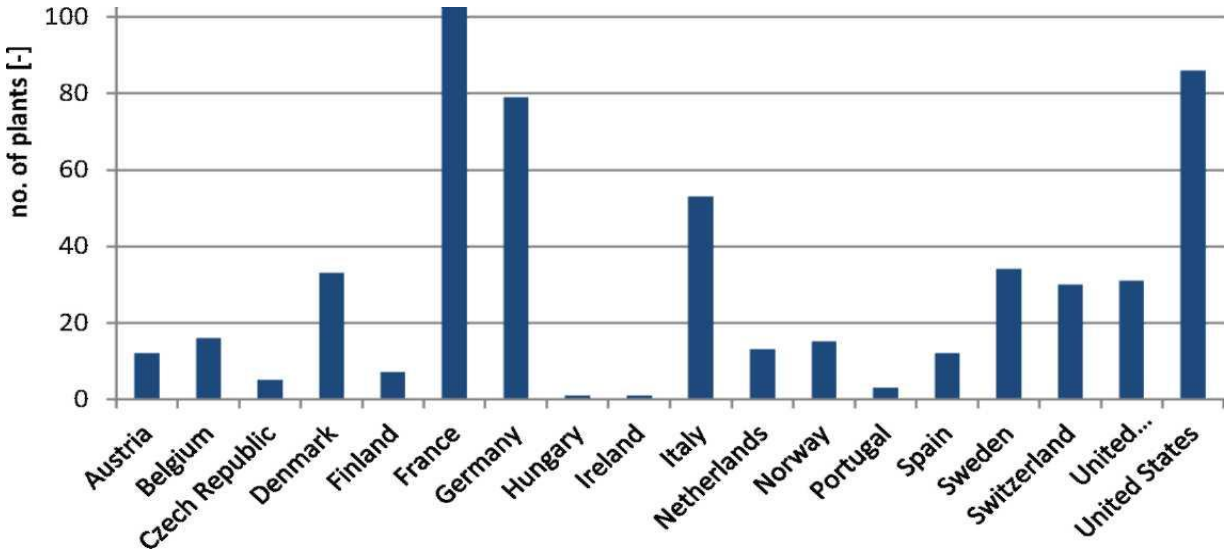


Figure 9: Number of W to E plants in EU and USA

C. Australia : In Australia, the biomass based components of MSW are considered to be 'eligible' renewable energy. As per Renewable Energy Target (RET), 20% of Australia's electricity supply will be sourced from renewable sources by 2020.

D. China : With MSW growing at 9% annually in China, the cities are under great pressure to deliver effective waste management solutions. Rag picking' activity of picking incinerable items like paper, wood & plastics is common. Incineration, as a mainstream MSW treatment method, has received prime attention due to its advantage of energy recovery and volume reduction. Currently, 20% of MSW is incinerated and incineration is growing at a feverish pace. China already has 150, W to E plants and another 150 plants will be operational by the year 2015. A central target calls for 30% of MSW to be treated by W to E incineration by the year 2030. Currently, the average

calorific value of MSW in China equals 5000 kJ/kg. The reasons for the low calorific value are the high moisture and high proportion of kitchen waste and in China almost all MSW incineration plants are designed to produce only electricity as a by product. China uses two types of MSW incineration technologies - Stoker and Fluidized Bed. The Circulating Fluidized Bed (CFB) technology is based on the co-firing of MSW with Coal (Maximum 20%) in CFB incinerator. The small and mid-sized cities appear to prefer CFB incinerators to combust their non-sorted MSW with high moisture content and low calorific values – CFBs account for half of China's MSW treatment capacity. However China has immense environmental challenges. The standards are quite lax compared to the EU standards. The challenge for future is monitoring of BOT incineration plants, ensure compliance, reduce air emissions especially dioxins and heavy metals. In fact, only a few W to E plants dispose incinerator ash scientifically – they dump or sell the ash privately. On February 28, 2005, the Standing Committee of the National People's 14th Congress passed the 'Renewable Energy Law of the People's Republic of China'. W to E was singled out as an important renewable energy. The Chinese government is encouraging support from the private sector for establishing and operating W to E plants on BOT basis. The following incentives are extended:

i. Tipping Fees
ii. Beneficial electricity generated prices: W to E plants receives a feed-in tariff, which means higher price for renewable energy. Recently Beijing announced a fixed subsidized price for power purchased from W to E plants, which is about double that from coal-powered plants.
iii. Tax Incentives: W to E plants are exempted from corporate income tax for the first 5 years of operation and are eligible for the immediate refund of value-added tax.

E. Best Plant in the World- AEB's Amsterdam

AEB's Amsterdam W to E plant has the best credentials in the world. Every day, 600 trucks and a number of freight trains deliver 4,400 tons of waste to the plant. Only the waste that is not suitable for 'reuse' or 'recycling' is incinerated. It produces electricity with a net energy efficiency of 30.6% - the highest in the world. The excess heat generated during combustion is used to provide district heating and hot water. The Incinerator Ash is recycled to convert into useful products. Out of every 1000 kg of waste, only 0.5 kg of residual waste remains for which there is no use. This is land filled.

F. Overall International perspective

The situation prevailing in various countries indicate that concerted efforts are being made to minimize waste generation and maximize recycling of waste. Incineration or mass burning is in vogue in counties where availability of land is scarce. However in US , as per USEPA data of 2013 only 86 W to E plants in 24 states with a capacity of 97000 TPD generating 2790 MWH are currently operational. Of the MSW generated only 7% is incinerated, 24 % is recycled and the remaining 69 % is landfilled. From 1995 to 2005 strict emission norms especially for dioxins and furans prevented more plants to be set up. Thrust is on recycling , reuse and recovery.

G. Lessons for India

i. Cities with population above 2 million and cities generating more than 300 TPD or more of combustible fraction of MSW are suitable for setting up W to E power projects.

ii. Concept of 5Rs should be actively promoted like in the European Union.

iii. Tipping Fees should be introduced.

iv. Beneficial electricity generated prices.

v. W to E plants be given a feed-in tariff, which means higher price for renewable energy.

vi. Tax Incentives: W to E plants be exempted from corporate income tax for the first 5 years of operation and eligible for immediate refund of value-added tax.

vii. A target of setting up 215 W to E plants by 2031 be formalized and generate 1075 MW of power.

viii. A target be set for effective utilization and recycling of C&D waste.

Chapter 5

The Proposed Models for MSW Management

India has 7935 urban centres, 468 class 1 cities with over 1, 00,000 population and 53 metropolitan cities with over 1 million populations (Census, 2011). By 2031 the number of metropolitan cities is expected to increase to 87. With increasing urbanization and corresponding generation of high levels of wastes quantity, the selection of combination of waste to energy technologies, which will address the problem of waste management in India in a sustainable manner, is a challenge by itself.

Now that measures have been taken to address the financial constraints of ULBs by the Government of India through JnNURM/ UIDSSMT schemes and with the help of grants from 13th Finance Commission it has become even more important that the ULBs build in-house capacity to identify appropriate technologies and utilize the allocated funds in the management of MSW in an environmentally sound and cost-effective manner. Planning and adopting sustainable decentralized waste management solutions that suits the socio-economic and geographical profile of the urban areas should be given priority. Large size plants or even setting up regional facilities may be considered on the basis of their merits such as economy of scale, commercial viability of the project, technical feasibility etc. when decentralized solutions may not work out to be technically and economically viable.

In addition to the challenges associated with technology selection; the issues pertaining to availability of land and footprint for MSW management as well as scarcity of capital for creation of MSW infrastructure also need to be addressed. Thus, before proposing models for MSW management, it was felt that a clear understanding of the waste to energy technologies would be helpful. An overview of the available technologies was given in Chapter 3 and 4 of the Report while in the following sub-sections an attempt has been made to articulate the strengths, weaknesses, opportunities and threats (SWOT) posed by the various technologies.

5.1. SWOT Analysis of MSW Treatment Technologies

In order to adopt appropriate technological models, one should understand what is appropriate? As reported by Asolekar and Gopichandran (2005), any technology which is acceptable, affordable and manageable is called as "Appropriate". There are two angles to technology evaluation. One, what the customer or the consumer expects from a technology and the other is how the manufacturer designs the technology to meet customer expectations. The four elements embedded in a typical SWOT analysis is meant to throw light on the internal characteristics of a given technologies (i.e. strengths and weaknesses or limitations) and external influences on the technology (i.e. opportunities and threats). Thus, the four essential elements, which constitute the SWOT analysis, could be envisioned as follows:

1. Strengths: advantages over others,

2. Weaknesses: disadvantages relative to others
3. Opportunities: elements that the project could exploit to its advantage
4. Threats: elements in the environment that could cause trouble for the project

As opposed to the routine SWOT matrix, an attempt has been made in the present analysis to derive deeper insights from the points of view of consumer as well as manufacturer.

A two-pronged SWOT analysis has been suggested. The opportunities driven by internal strengths of a given technology from the customer's point of view is nothing but the internal strengths of the technology enhanced by the help from external opportunities – as viewed by the technology provider (+ + interaction). Similarly, the opportunities compromised by internal weaknesses of the technology from the customer point of view, could be seen as internal strengths by the technology provider compromised on account of external threats (+ - interaction). The threats minimized on the basis of internal strengths from the customer's point of view are the weaknesses diminished by the presence of external opportunities from technology provider's view (- +). Also, threats aggravated due to internal weaknesses of technology from the customer view are nothing but the weaknesses aggravated for the technology by external threats from technology provider view point (- -).

The technology-wise SWOT analysis has been detailed in the **Annexure I-D**. On reading the table from bottom up the justifications of the technology provider is discernable. The Annex thus, can act as a decision support platform for selecting appropriate technologies as it provides choice for the consumer to adopt suitable technology in spite of drawbacks which could be overcome by internal strengths. The green column in the Annex gives all the advantages and the red column shows all the disadvantages of a given technology. However, the decision maker will have to contemplate more on the two yellow columns since they combine positive and negative elements.

5.2. Environmental Implications of Treatment Technologies

The environmental footprint of technologies is also considered in this study along with the SWOT analysis of technologies. **Table 14** highlights the environmental implications *i.e*. in terms of air and water pollution, rejects/sludge formation and volume reduction associated with composting, biomethanation, incineration, RDF burning, gasification technologies and land filling. As can be seen from the Table 14, Incineration including RDF burning and gasification technologies pose medium to high threat of air and water pollution and require, installation of pollution control equipments to meet the standards and monitoring. However, there is considerable volume reduction of the waste and the rejects are comparatively low. Biomethanation has an edge over composting technology in terms of the extent of air pollution, release of green house gases, volume of reduction and waste generation. The process is faster, generates biogas which can be used as fuel or for power generation.

Table 14: Environmental Footprint of Waste to Energy Technologies

S No.	Associated Factors	Composting	Biomethanation	Incineration and RDF Burning	Gasification	Engineered Landfills [#]
1	**Air Pollution**					
(a)	Extent	Low	Low	High	Medium	Medium
(b)	Requirement of Air Pollution Control	-	-	Yes	Yes	-
(c)	Dioxins or Furans Formation	-	-	Possibility exists; but minimized due to removal of chlorinated plastics from waste by Rag pickers	-	-
(d)	Release of Green House Gases	Uncontrolled	Controlled and Utilized	Controlled and utilized	Controlled and utilized	Most uncontrolled. Only in very few cases is controlled and utilized if mechanism for gas recovery exists.
2.	**Water pollution**					
(a)	Exists	Yes	Yes	Yes (Due to water use in scrubbing and Quenching)	Yes (Due to water used in scrubbing & Quenching)	Yes
(b)	Requirement of Waste water treatment	Yes; for leachate	Yes; for press water	Yes	Yes	Yes, for leachate
(c)	Quality of Treated water	May be discharged into water bodies	May be used in process or discharged into water bodies.	May be used in the process.	May be used in the process.	May be discharged into water bodies.
(d)	Degree of Pollution	Medium -High	Medium	Medium	Medium	Medium –High
3	**Solid waste gen. due to rejects/ sludge formation in the process**	high	low	low	low	Nil
4	**Volume reduction of waste**	15- 30%	45 - 50 %	75 - 90%	90%	70 - 80 % if waste contains biodegradables[#]

Biodegradables are not allowed to be land-filled in India as per MSW - 2000 rules.

5.3. Framework for Appropriate Technological Options and Integrated MSW Management

The SWOT and environmental footprint analysis of technologies helped in identifying appropriate technologies for MSW management. At the outset, it was felt that identification of technologies alone may not be a solution for the integrated MSW management to succeed and hence a rigorous study was carried out to provide suitable combination of technologies based on the learnings from SWOT and environmental footprint analysis and it was strongly felt that integrated MSW management is essential to manage the waste scientifically and for utilization of all components of waste.

A. Appropriate Technological Options: Under the Indian context following technologies are identified for processing of MSW:-

i. Biomethanation for wet biodegradable wastes

ii. Conventional microbial windrow/mechanized/ vermi composting for wet biodegradable wastes

iii. Preparation of briquette/ pellets/ fluff as Refuse Derived Fuel (RDF) from dry high-calorific value combustible wastes

iv. Incineration / Gasification / Pyrolysis for dry high-calorific value combustible wastes

v. Plastic wastes to fuel oil

The technologies listed above were identified on the basis of the range of populations and quantity and composition /quality (% biodegradable) of wastes generated. In addition, the cost of setting up of processing plants along with the expected quantities of value added products and by-products were also considered. Choice of suitable technologies based on these five criteria for various classes of cities as per census, 2011 is depicted in **Table 15**.

For successful application of the combination of technologies suggested, wet waste, dry recyclable waste and other inert waste should not be allowed to be mixed as it would necessitate expensive technology and machinery to segregate these at the processing facilities making the process very expensive or even unviable. Therefore, instead, improvements may be made in the primary collection system of MSW as suggested in the report.

Following are a combination of suitable technologies based on the five criteria discussed above for various classes of cities:-

i. For cities with population of 2 million and above, which generate more than 1100 TPD of MSW a standalone waste to energy plant based on thermal route is suited. These cities should also set up a combination of biomethanation, composting (VC/CC) plants besides setting up W to E plants to optimally utilize biodegradable

wastes. Conversion of waste plastic to fuel oil which is an emerging technology is also suggested as an option.

Table 15: Population based Technological options to Manage MSW in a Variety of Towns and Cities

Sr. No.	Population range	Waste Gen.TPD	Composition	Technological options	Minimum requirements	Va lue added products	Approximate cost (excluding land cost)
1	Above 2 Million	>1100 TPD	Biodegradables 35 to 50 %	IWP comprising - BM +CC+ RDF W to E plant for power, based on: gasification , pyrolysis, incineration and mass burning. RDF to cement industry Plastic to fuel oil	Segregate wet wastes at source for BM and / or CC, dry wastes to be recycled or converted into RDF as feed stock for its own power plant / cement industry or any other power plant. Inerts to be land filled RDF must be burnt under controlled condition not below 850^{o} C	$75m^{3}$ of bio gas or 100 KW of electricity per 1 TPD of segregated wet wastes + 60 kg manure in case of BM , 200 kg per TPD vermi castings / CC per TPD 20 % RDF + 15 % compost. 1 MW power per 100 TPD of MSW.	Rs 5-7 cr per 100 TPD of MSW composting + RDF Rs 15/20 lakh capital cost per 1 TPD for gas / electricity through Bio-methenation Rs 10 cr per MW power plant. Rs 20 lakh per 50kg capacity / shift catalytic conversion technology plastic waste to liquid fuel. Rs 16 crore per 10 tonne of plastic (pyrolysis technology)
2	1 M to 2 Million	550 to 1100 TPD	Biodegradables 40 to 55 %	IWP comprising - BM +CC+ RDF W to E plant for power, where wastes exceeds 500 TPD based on: gasification , pyrolysis, incineration and mass burning. RDF to cement industry Plastic to fuel oil	Segregate wet wastes at source for BM and / or cc, dry wastes to be recycled or converted into RDF as a feed stock for large power plant and landfill the inerts RDF must be burnt under controlled condition not below 850^{o} C	Likely output from BM, as above. 20 % RDF + 15 % compost. 1 MW power per 100 TPD of MSW.	As above

Sr. No.	Population range	Waste Gen.TPD	Composition	Technological options	Minimum requirements	Va lue added products	Approximate cost (excluding land cost)
3	1 lakh to 10 lakh	30 to 550 TPD	Biodegradables 40 to 55 %	IWP-BM, CC + RDF as feed stock to power plant / cement industry. Plastic to fuel oil	Segregate wet wastes at source for BM and / or CC, dry wastes to be recycled or converted into RDF as a feed stock for large power plant / cement industry and inerts to be landfilled	As above for BM + CC and RDF to be used as feed stock for power plants / cement industry likely output: (20 % RDF + 20 % Compost). 25 to 40 litres from 50kg plastic wastes	Cost for BM, CC and RDF as above Rs 20 lakh per 50kg capacity / shift catalytic conversion technology for plastic waste to liquid fuel. Rs 16 crore per 10 tonne of plastic (pyrolysis technology)
4	50,000 to 1 Lakh	10 to 30 TPD	Biodegradables 45 to 60 %	BM, VC or CC RDF	Segregate wet wastes at source for BM and / or VC / CC, dry wastes to be recycled or converted in to RDF as feedstock for power plants and landfill the inerts.	As above for BM +25 to 40 litres liquid fuel from 50kg plastic wastes	Rs 15/20 lakh capital cost per 1 TPD for gas / electricity through Bio-methenation Rs 7- 10lakh per TPD for VC/CC
5	Less than 50,000	Less than 10	Biodegradables 45 to 65 %	BM VC / CC and RDF	Segregate wet wastes at source for BM, /CC, dry wastes to be recycled or converted into RDF as a feed stock and inerts to be landfilled	As above for -BM	As above
6	Hill towns	State capitals	Biodegradables 30 to 50 %	BM, CC / RDF as feed stock. Plastic to fuel oil	Segregate wet wastes at source for BM / CC, dry wastes to be recycled and landfill the inerts. Dry wastes to be recycled or converted into RDF as a feeder stock. Plastic waste can be converted to liquid fuel and inerts to be landfilled	As above for BM + CC and RDF to be used as feed stock likely output: (15 to 20 % RDF + 15 % compost).	As above Rs 20 lakh per 50kg capacity / shift catalytic conversion technology for plastic waste to liquid fuel Rs 16 crore per 10 tonne of plastic (pyrolysis technology)

IWP: Integrated Waste Processing, CC: Conventional Composting, VC: Vermi Composting, BM: Biomethantion, RDF: Refuse Derived Fuel

ii. Cities with population between 1-2 million, which generate more than 550 TPD of MSW are suited to setting up a waste to energy plant based on thermal route only with the support of adjoining cities supplying RDF to make the W to E plant viable These cities should also set up a combination of biomethanation, composting (VC/CC) plants besides setting up of W to E plants to optimally utilize biodegradable wastes. Conversion of waste plastic to fuel oil which is an emerging technology is also suggested as an option.

iii. In respect of 415 Class I Cities which have a population range of 1 lakh to 1 million generating 30 to 550 TPD of MSW, the technological options are a combination of biomethanation, composting (VC/CC) plants to optimally utilize biodegradable wastes. However, these cities may set up a common / regional W to E plant after ensuring adequate availability of RDF on a regular basis from participating cities. Conversion of waste plastic to fuel oil which is an emerging technology is also suggested as an option. Hill stations are also included in this set of cities and local bodies will have to ensure that recommendations made for hill cities in respect of technological options be used for ensuring proper disposal of MSW.

iv. Towns below 100,000 populations which generate less than 30 TPD waste and have 45 to 65% of biodegradable fraction of MSW. A combination of biomethanation, composting (VC/CC) and RDF preparation is considered as the most suitable technological option for management of MSW. These cities should segregate dry waste, prepare RDF and can supply RDF prepared as fuel to W to E plants established in cities above 1 million populations.

B. Integrated MSW Management System: In order to transform MSW management practices in the country, it is essential to address all activities namely, storage of segregated waste at source, door-to-door collection, secondary storage, transportation, transfer stations, processing and disposal of MSW in a coordinated manner. It is envisaged that such an integrated approach alone will optimize tapping the potential of MSW through recovery of recyclables and generation of energy / compost and minimizing the wastes going to landfills. The Integrated MSW Management system recommended by the Task Force attempts to bring together the various components / activities which are necessary to ensure, scientific, technological and environmentally sound processing and disposal of MSW, robust management practices and financial viability. The flow diagram of integrated MSW management for any class of city depicts the four necessary streams of waste collection namely, 1) street sweepings, scattered wastes and silt from drains 2) construction and demolition (C & D) wastes 3) single source bulk wastes collected from market yards, restaurants and canteens, slaughter houses, *etc*., 4) wet bio-degradable and recyclable fraction from households, institutions and commercial establishments.

To enable the municipal authorities to put in place a MSW management system a logical diagram (**Figure 10a**) which enables easy connect to the appropriate system flow diagram for a designated class of city and a set of five flow diagrams indicated by **Figures 10b to 10e**, proposing integrated MSW management systems for various classes of cities is recommended.

In addition to the four major streams mentioned above, proper recycling and disposal of used batteries and electronic waste which are regulated under the Rules notified under the Environment (Protection) Act, 1986 has to be ensured. While the State Pollution Control Boards can monitor the implementation, the municipalities have to ensure separate collection and disposal of this waste stream

With the twin objective of ensuring scientific management of MSW generated in the country along with maximum recovery of energy and resources, establishment of an integrated MSW management system is proposed. It is envisaged that such an integrated approach alone will optimize tapping the potential of MSW through recovery of recyclables and generation of energy / compost and minimizing the wastes going to landfills.

It is emphasized that source segregation of MSW (Transforming Our Cities, Ahluwalia, 2014) and recycling enabled through the informal institution of kabadiwalas and rag pickers need to be appropriately integrated into the system through recognition and strengthening of this informal arrangement.

The synchronization of all the steps of MSW management mentioned below in a coordinated manner is considered as Integrated Municipal Solid Waste Management (IMSWM).

i. Segregation of wastes at source and involvement of all stakeholder's in effectively managing MSW and minimizing waste going to landfills by practicing the concept of reduce, reuse, recycle, recover and re-manufacture..
ii. Separation of four streams of MSW at source, namely, 1) construction and demolition wastes, 2) street sweepings and silt from drains, 3) wet bio-degradable and recyclable fraction separated at source in households, institutions and commercial establishments and, 4) single-source bulk wastes collected from market yards, restaurants and canteens, slaughter houses, etc by the municipality.
iii. Technological options which are feasible, financially affordable, and environmentally sound for processing and scientific disposal of MSW along with the financial mechanisms and institutional arrangements to set up treatment plants to recover maximum possible resources and energy from the wastes. Thus, reducing the amount of wastes going to landfill and ensuring better public health and the environment.
iv. Disposal of domestic and commercial waste stream rejects by setting up regional / common sanitary landfills through PPP mode or by municipalities,
v. It also recognizes the role of information and communication technology (ICT) systems for tracking, routing and monitoring operations (generally referred as smart management).
vi. It focuses not only on recovering resources and energy from the MSW, but, promotes conservation of energy and encourages minimization of waste and promoting recycling of waste in all possible manner by adopting the "concept of 5-R" i.e. Reduce, Reuse, Recover, Recycle and Remanufacture.
vii. It recognizes the role of kabadiwalas and ragpickers and incorporates this informal sector in IMSWM. It facilitates sorting of recyclable materials collected by informal

sector and support recycling industry by permitting the informal sector to use designated storage and transfer station facility for segregation of recyclables..

viii. Use of combination of factors based on a range of population, quantity and quality (% biodegradable) etc of wastes generated the cost of setting up of processing plants, expected quantities of value added products and by-products generated leading to choice of suitable technologies.

The residual waste from all the processing facilities needs to be sent to sanitary landfills. For minimizing the requirement of land for disposal of such waste, to ensure economy of scale, regular monitoring and professional management of the facility, large common regional sanitary landfills covering at least one million populations may be setup for the disposal of only inert wastes in a cost effective manner on a cost sharing basis among the beneficiaries municipal authority. Independent landfills may be considered to be setup in cities above one million populations. Cities above one million populations should permit all cities and towns within 50km periphery of the city to use that facility for disposal of their waste. Common regional facilities may be constructed for the rest of the 7,882 cities, towns and urban centres by forming clusters within 50 km radius with populations of at least one million. Only in special cases, where, the distances between the cities are large the cluster size may be brought down suitably to handle at least 50 TPD of residual waste.

It is envisaged that by adopting the principle of integrated waste management, more than 75% of the MSW will get treated and less than 25% waste only will end up at the landfills saving 75% of land otherwise required for landfilling the entire waste. The percentage of processing of waste will further increase with advancement of technologies over a period of time. Municipal authorities should make serious efforts to reduce the inert wastes going to landfill. It is anticipated that if concerted efforts are made by all municipal authorities with the support of central and state governments, the waste processing facilities needed as shown in **Table 16** could be established.

Table 16: Estimated Waste to Energy processing facilities

Type of processing plant	Indicative number of plants	Waste to be treated (in TPD)	Cumulative power/ energy generation	Cumulative Estimated compost generation
Recyclable waste available to recycling industries through rag pickers		17,000		
Biomethanation plants (decentralized/ 1 to 20 TPD capacity	7,935	18,590	72 MW	1,260 TPD
Vermi compost/compost plants (decentralized as well as centralized plants) +RDF separation	7,935	59,020	Nil	14,755 TPD
Power plants based on combustible/ RDF produce @ 1 plant per 500 TPD RDF	88	32,890	439 MW	
Establishment of MSW based power plants by 2030	215	85,514	1075 MW	
Establishment of MSW based power plants by 2050	556	2,22,336	2,780 MW	

Justification for population cut-off at 5,000:
Villages and peri-urban centres which have population > 5,000 and more than 75% male population involved in non-agricultural activities are classified as “urban centres” as per the Census of India.

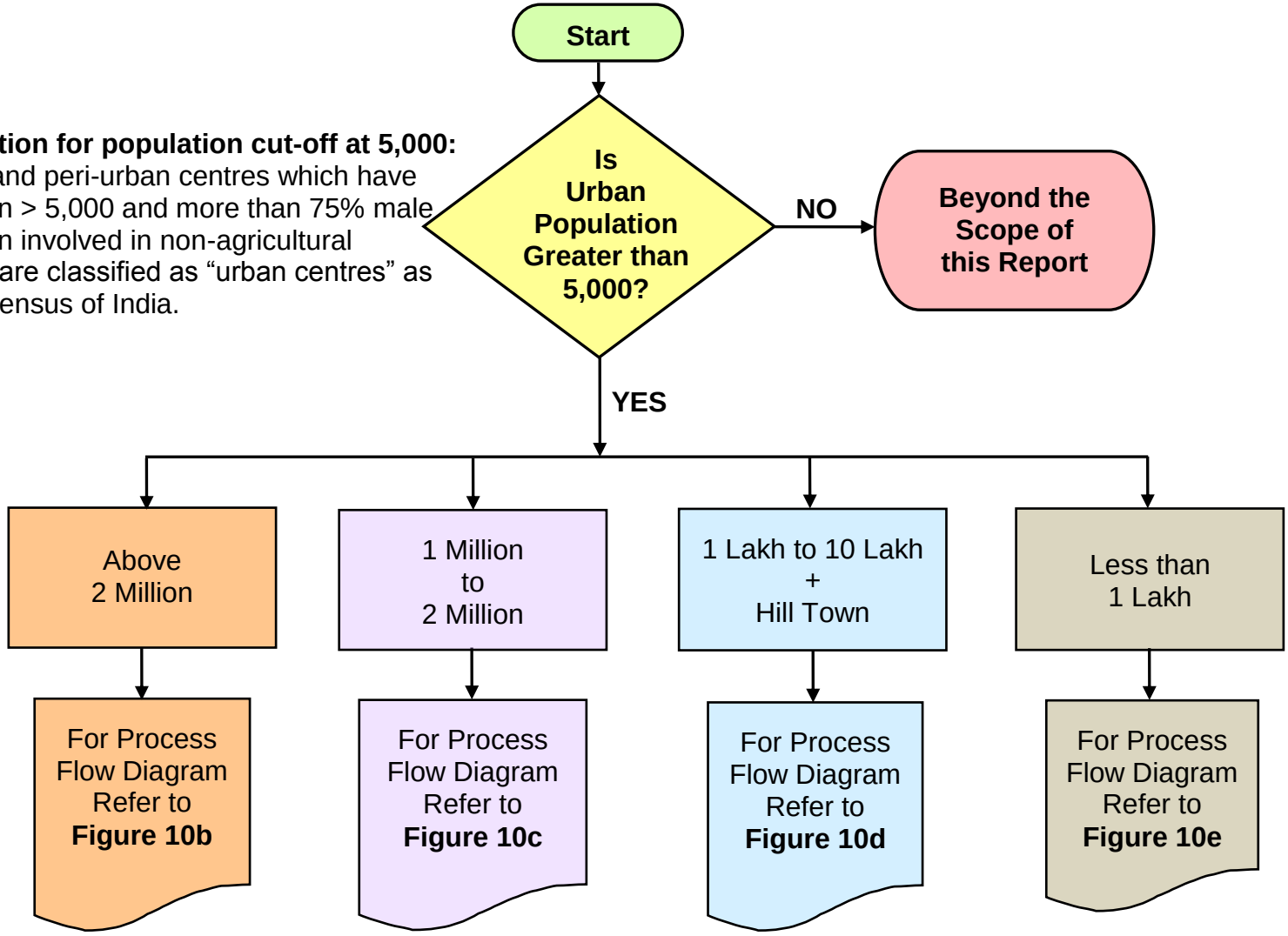


Figure 10a: Logic Diagram for Selection of Integrated Municipal Solid Waste Management Scheme for a given Local Self Government

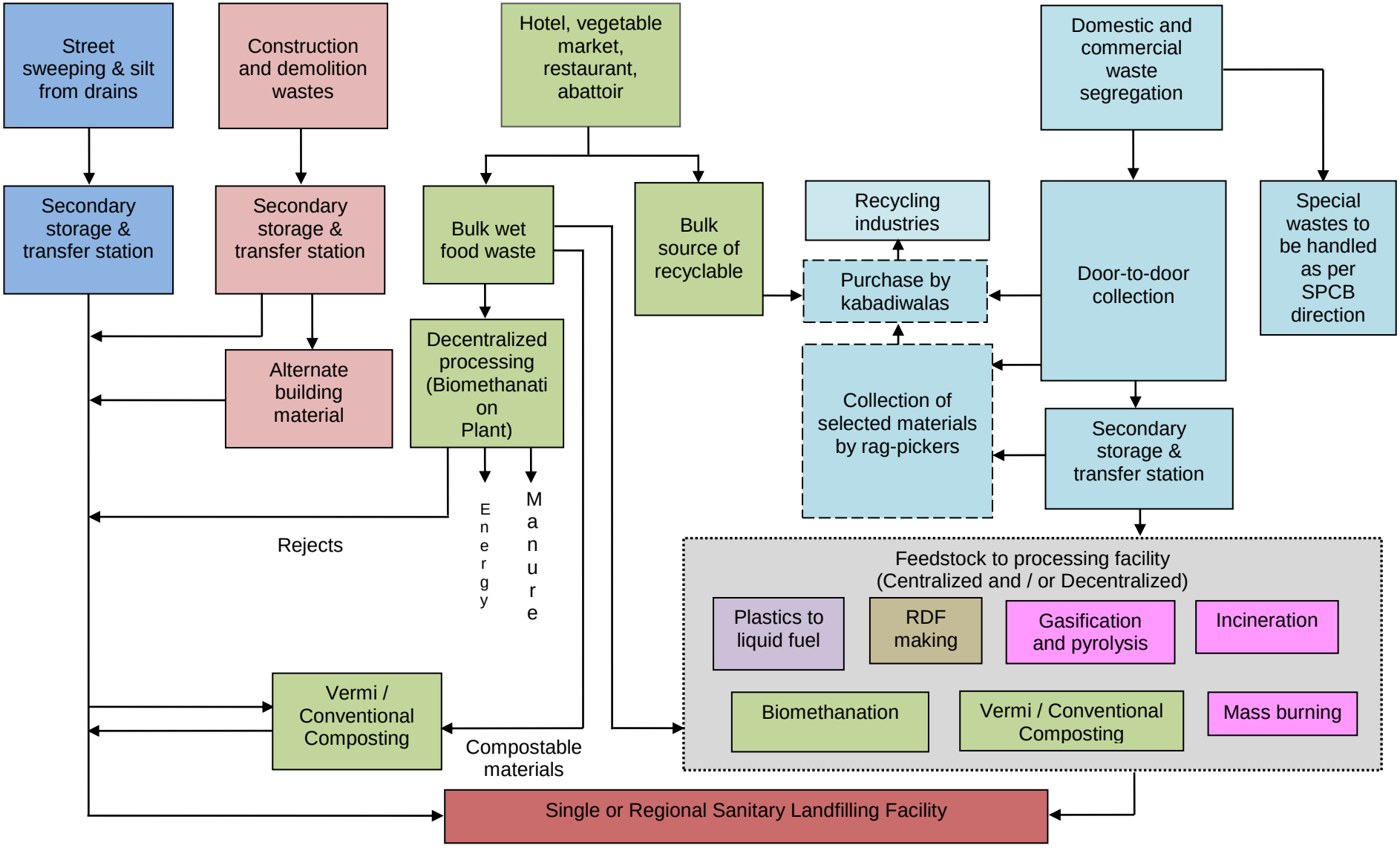


Figure 10b: Integrated MSW Management System for the Population of more than 2 million

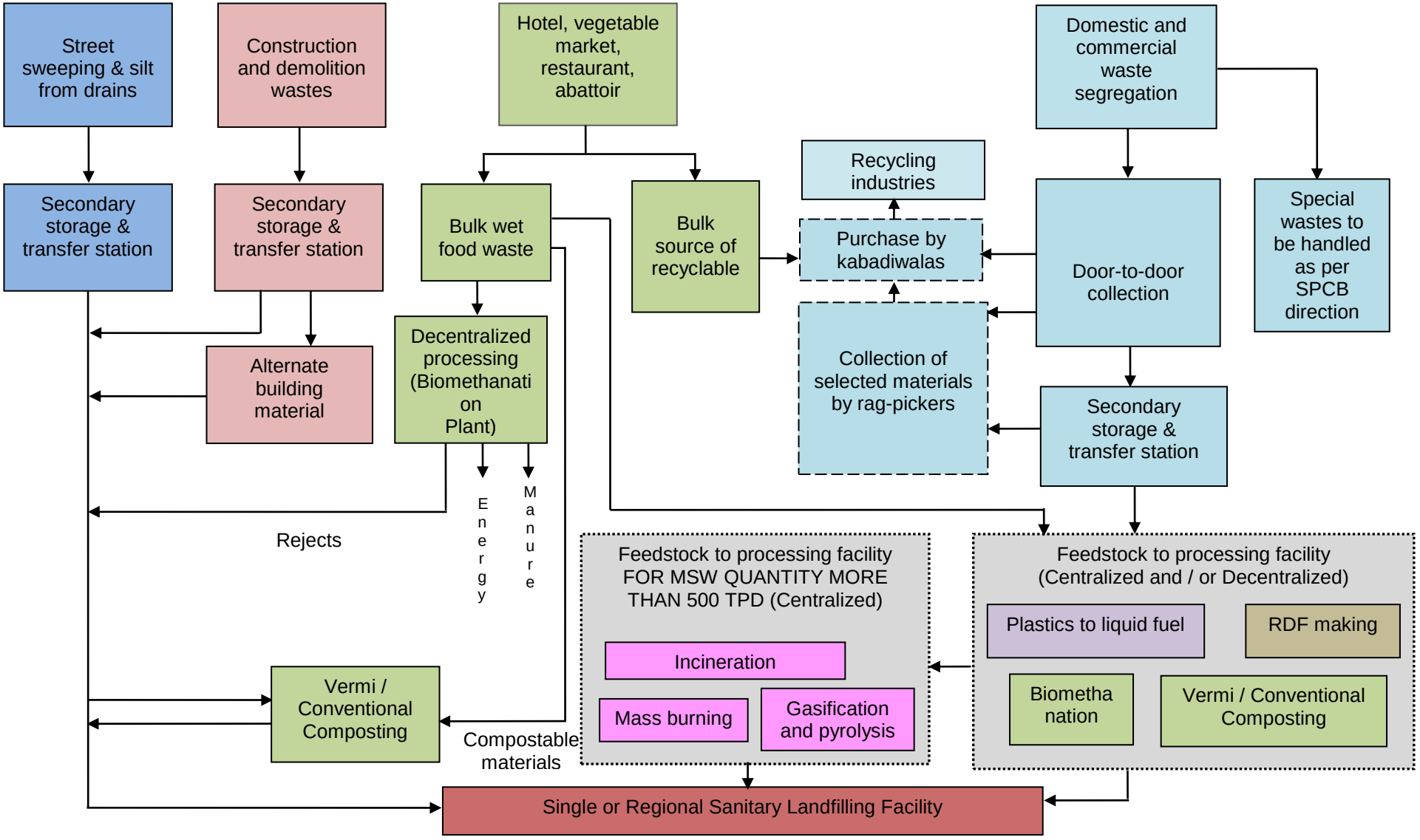


Figure 10c: Integrated MSW Management System for the Population Ranging from 1 to 2 million

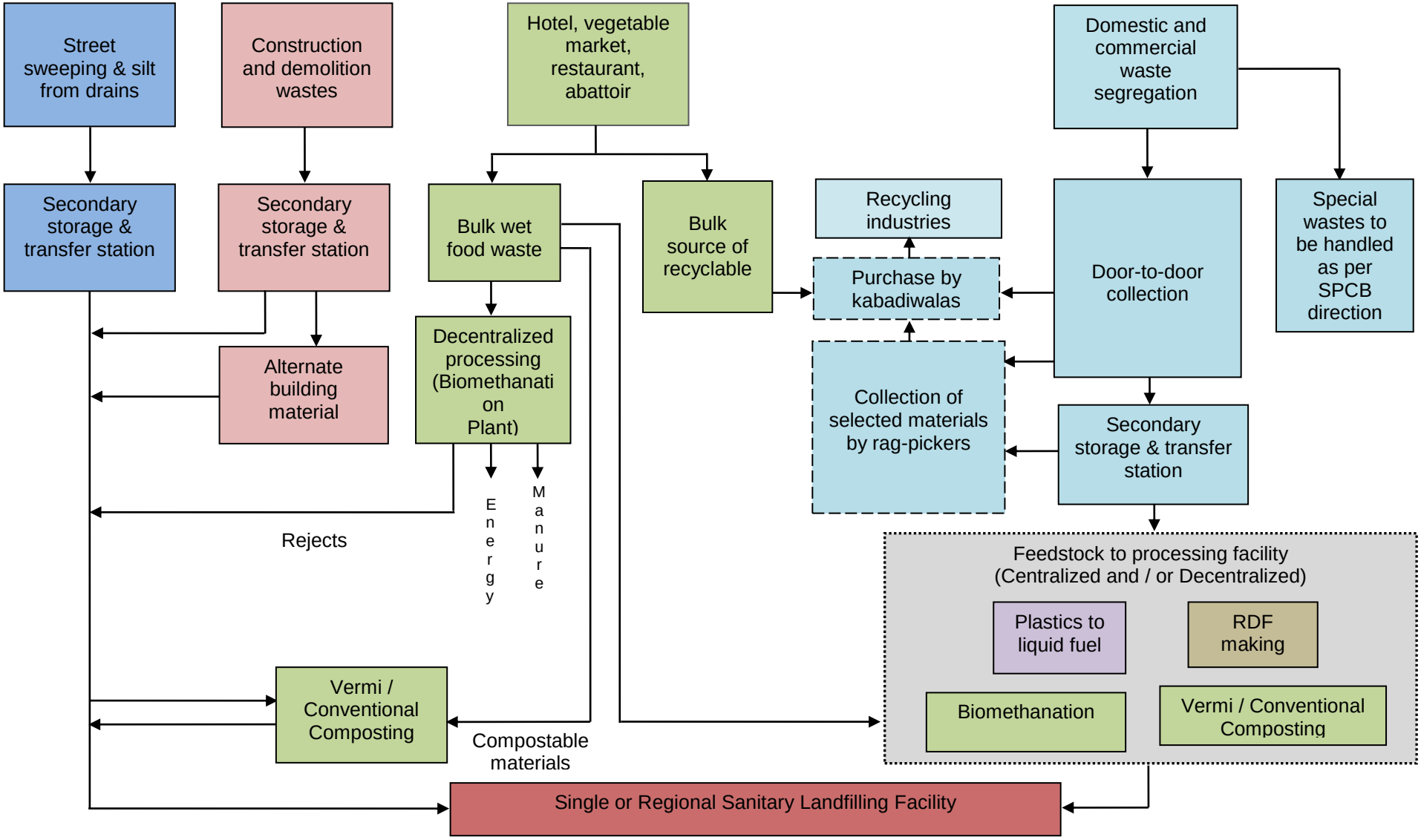


Figure 10d: Integrated MSW Management System for the Population ranging from 1 to 10 lakh as well as for Hill Towns

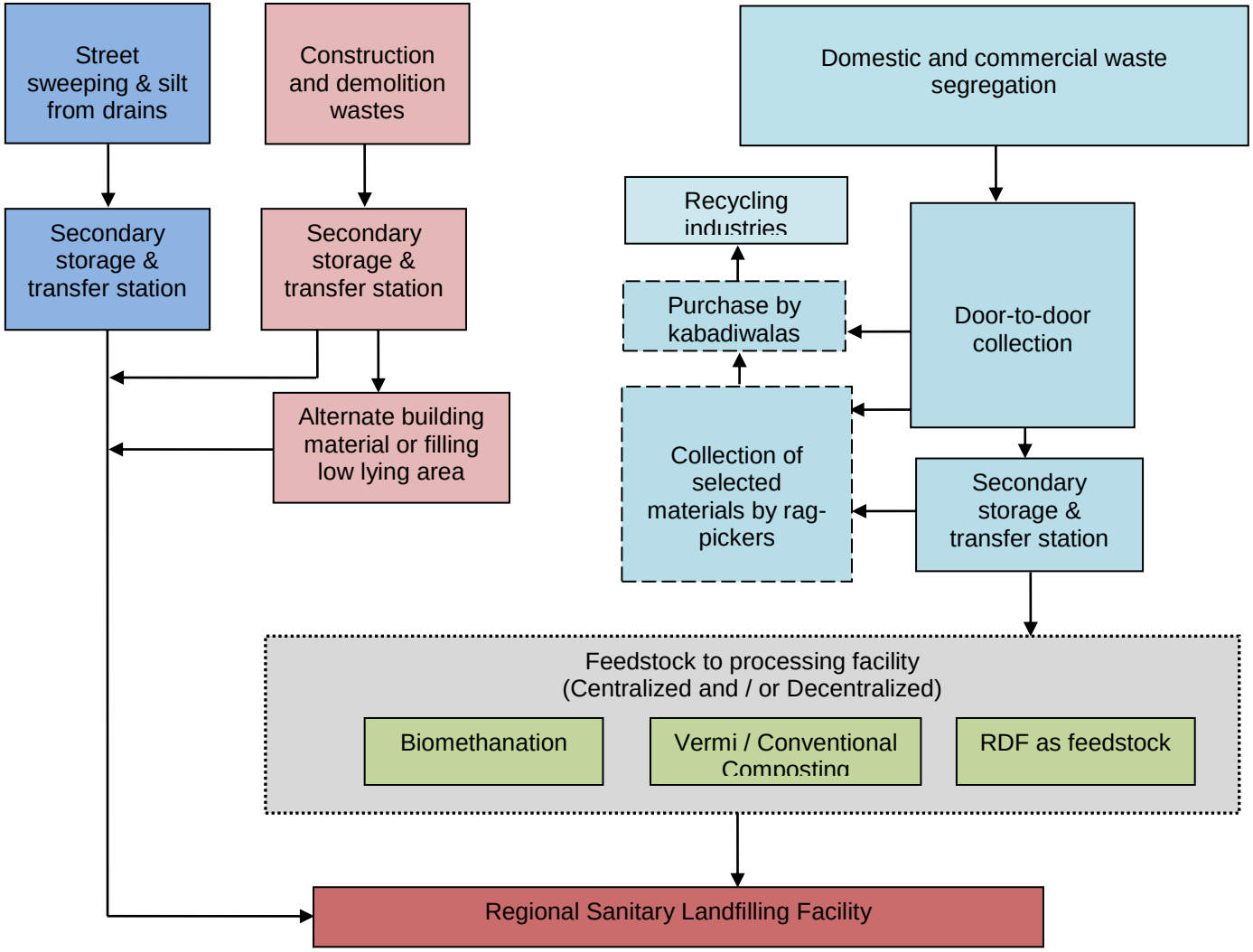


Figure 10e: Integrated MSW Management System for the Population Less than 1 lakh

Chapter 6

Public Private Partnership

The public–private partnership (PPP) is a mechanism through which Government authorities and private entities come together for setting up specified facilities or for the delivery of specified services on mutually agreed terms and conditions. Through these partnerships, the benefits of the private sector's dynamism, access to finance, knowledge of technologies, managerial efficiency, and entrepreneurial spirit become available to local authorities who on their part retain oversight and control over all critical elements of performance and outcomes expected from the private entity and make performance based payment to the private sector usually called the concessionaire. In this arrangement, normally the private partner is responsible for both construction and operation of processing facilities at his cost or for providing desired services with partial or complete investments from municipal authority. Allocation of risks is done among parties which are best suited to manage the risk.

PPP projects facilitate investment of private money into public projects (Ahluwalia, 2014) and pave way for infrastructure development. Through this mode of procurement, the government/municipal authority can hope to tackle serious problems of municipal waste management by combining the respective strengths of the public and the private sector.

PPPs as an efficient mode of implementation of public projects has already been demonstrated in several sectors such as highways, airports, ports, power, railways, etc. MSW sector has similarly, a huge potential of PPP in setting up municipal solid waste processing & disposal facilities as well as in providing door to door collection, secondary storage and transportation services either along with waste processing and disposal in an integrated manner or independently.

The objective is to enable viability of integrated MSW management including W to E projects and improving the present system of waste management. This specifically aims at developing, processing and disposal facilities which are economically viable and environmentally friendly. For the PPP mechanism to be adopted, among other factors, availability of state policy and clearly stated guidelines and training to municipal authorities on PPP are essential to encourage urban local bodies to adopt PPP mode of service delivery. Where necessary, handholding may be done to facilitate project implementation.

6.1. Framework for PPP

As per the MSW Rules 2000, it is the responsibility of the municipal authorities to ensure scientific collection, segregation, transportation, processing and disposal of MSW. Keeping in view the current status of MSW management in India, the Task Force envisages that the MSW functions of municipal authorities could be classified under three groups for formulation of PPP projects:

i. The functions that could be best performed by the municipal authority only (green box in **Figure 11**)

ii. The functions that could be performed by the municipal authority and / or private sector (purple box in Figure 11)

iii. The functions that could be best performed by the private sector only (blue box in Figure 11)

However in all the three scenarios the Municipal authority shall remain accountable for efficient delivery of service.

A. Framework for setting up waste processing and disposal facilities: In this framework, it is envisaged that the function of street sweeping and removal of silt from surface drains, which are traditionally being performed by municipal sanitation workers, should continue to be performed by the municipal authority. Further the functions of secondary storage and transportation of street sweepings and silt, could either be performed by the municipal authority or private sector, on a PPP mode, to ensure that waste collected by sanitary workers is stored in appropriate container and transported to disposal facility expeditiously. In situations where new areas have developed and/or municipal authority does not have adequate manpower to cope with the work of street sweeping within the city or in the newly developed areas, it may involve private sector keeping in view Contract Labour (Regulation and Abolition) Act,1970.

C&D waste could be collected and transported by municipal authority or through private sector.

The work of door to door collection of domestic, trade and institutional waste as well as street sweeping and removal of silt from surface drains all require punctuality and regularity in delivery of service. Door to door collection service can be efficiently and cost effectively performed by private sector on a PPP mode by deploying its own trained manpower, tools, equipment and vehicles. PPP mode of service delivery for this essential task will ensure efficiency of collection, segregation and transportation of waste and conservation of energy. Private sector will be able to invest money on creation of necessary infrastructure comprising modern tools, equipments, vehicles for collection, systems for tracking, routing and monitoring operations (generally referred as smart management), setting up of secondary storage and segregation facilities to ensure optimum utilization of waste components.

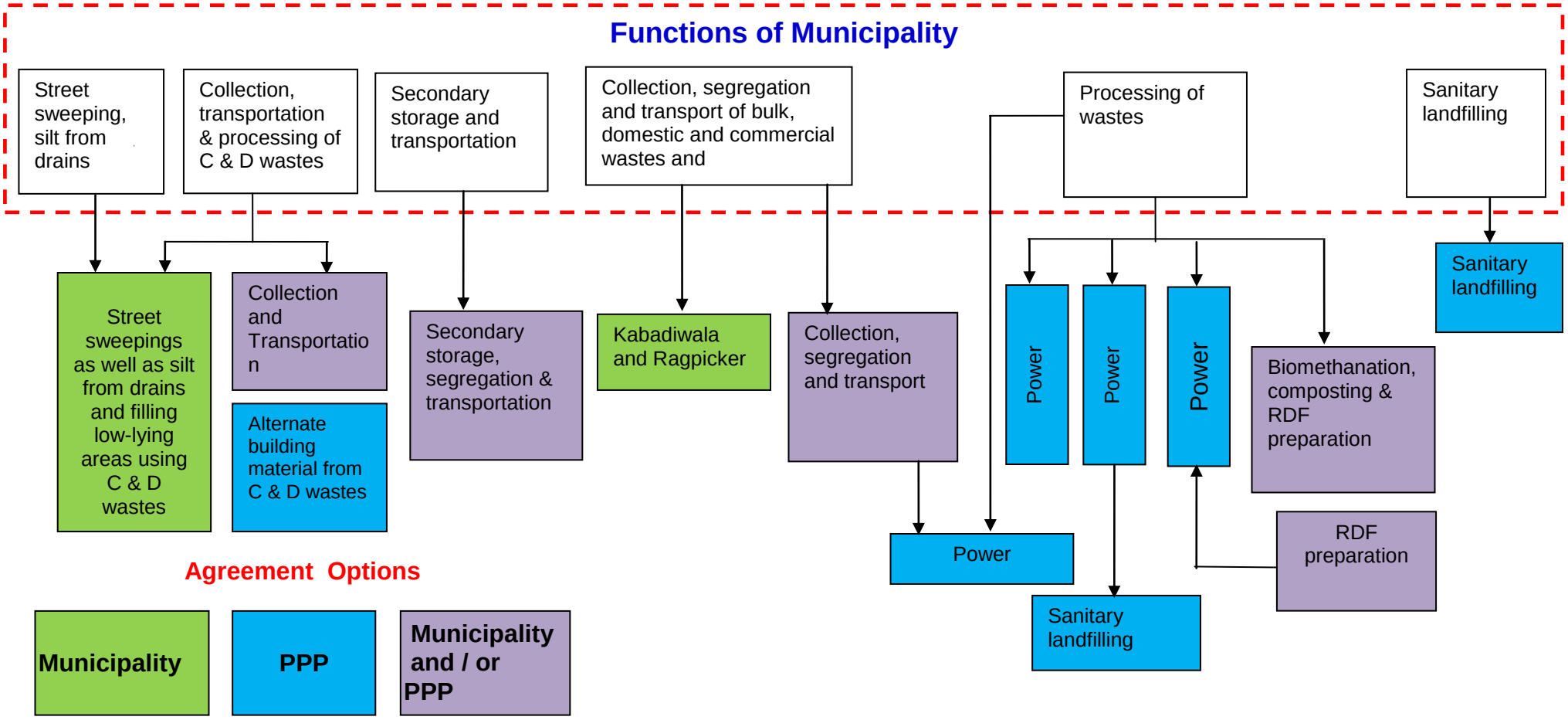


Figure 11: PPP Agreement Options for Integrated MSW Management available to Municipal Authority

B. Framework for setting up waste processing and disposal facilities: Municipal authorities are generally not well equipped, either financially or technically to process MSW and set up and operate plants for conversion of waste to electricity / energy or compost nor do they have in house capabilities to set up and operate sanitary landfills for disposal of inerts and residual waste from the processing facilities. Hence, it is essential to introduce PPP in this sector to set up waste processing facilities such as waste to energy projects to generate power from the segregated combustible waste or RDF, compost plants or Biomethanation plants to process biodegradable fraction of municipal solid wastes and C&D waste process plants to make bricks, paver blocks, etc., and for setting up sanitary landfills for safe disposal of waste.

The private sector partner could be entrusted to take up the task of setting up waste processing and disposal facilities as under:-

i. Waste to energy technologies for deriving energy from segregated combustible waste mainly consist of incineration, gasification and pyrolysis. For adopting any of these technologies, the minimum capacity of the plant should be about 300 tonnes of segregated combustible waste per day (TPD) or about 300 tonnes of RDF per day to make W to E facilities commercially sustainable.

ii. Biomethanation or vermi-composting or microbial composting plants or their variants could preferably be community based (typically up to 20 TPD) or situated in the vicinity of source segregated wastes from kitchens, canteens, institutions, vegetable markets or slaughter houses. Their management could be decentralized in various parts of the city and in case of non availability of suitable land, centralized plants may be set up. Centralized Compost plants should be preferably under 300 TPD capacity. Larger plants can however be set up through careful planning

iii. Sanitary landfills for disposal of inert wastes and residual waste from the processing plants must be of large capacity designed for a period of not less than 20 years to handle waste not less than 50 TPD of inerts and residual waste for their economic viability and professional management. Regional facilities for cluster of small cities therefore need to be promoted to the extent feasible.

Under this framework, it is envisaged that private sector would bring trained manpower, necessary finance and suitable technology. The PPP contracts should be awarded for integrated waste management as shown in **Figure 11**.

6.2. Responsibility of Municipal Authority and PPP Partner

Municipal authority should identify suitable land with the help of town planning department, GIS and satellite imagery which meets the Pollution Control Board parameters for setting up processing/ disposal facilities and obtain all necessary

clearances including EIA clearance before inviting bids and allot such land to the selected concessionaire on a token license fee for a term of not less than 20 years.

The municipal authority should also supply door to door collected waste at the processing plant free of cost and also ensure that the quantity and quality of waste supplied to the concessionaire as agreed in the concession agreement. The municipal authority should further ensure that Construction and Demolition (C & D) waste as well as street sweeping and silt removed from the surface drains is not delivered at the processing facility as it would be detrimental to the functioning of the plant.

Municipal authority may, preferably entrust the concessionaire with the task of waste from households, shops and establishments on levy of user fees from the beneficiaries or on payment of pre-determined charges by the municipal authority and take such waste to the processing facility directly.

The selected concessionaire will be responsible for implementing the project according to the scope of work and terms and conditions that may be laid down in the type of contract entered.. This should include design, construction, operation and management of the waste to energy/ compost plant as well as landfill facility. The concessionaire would be responsible for delivery of services in accordance with laid down parameters and key performance indicators. The concession would be as per the contract model adopted.

6.3 Approaches to Facilitating PPP Projects

The municipal authority should determine the functions to be performed on a PPP mode. **Figure-11** illustrates the areas where it is considered desirable to involve private sector participation and the areas where the municipal authority or private sector is the only option or the best options for efficient and cost effective delivery. They may also take in to account functions that can be outsourced or can be performed on a PPP mode.

Having determined the functions to be performed on a PPP mode, municipal authority should carefully assess the most appropriate technological option to be adopted based on the recommendations of the Task Force given in this report. The selection of technology would not be prescriptive and the bid process should be technology neutral.

Municipal authority should broadly assess the requirement of funds and modalities of financing for ensuring construction, operation and maintenance of the facility/ services.

This should be followed by preparation of a Feasibility Report by an expert entity to be selected through competitive bidding. A financial consultant-cum-transaction advisor should also be engaged for structuring and managing the bid process. The

selection of consultants as well the concessionaire may be undertaken through the model documents published by the Ministry of Finance for this purpose.

The consultants should assess the viability of the technology options and suggest ways and means to bridge the gap to ensure that the project taken up on PPP basis would sustain throughout the concession period. Provision of paying affordable tipping fee may be seriously considered by the states and municipal authorities (e.g. Gujarat state has considered levy of tipping fee of Rs.100/tonne for the waste landfilled from the ULB and rest to be paid by state in the form of viability gap funding). The current practice of some municipal authorities asking for royalty from the concessionaire instead of paying tipping fee needs to be discontinued for the sustainability of PPP projects.

Municipal authority should open an ESCROW account to ensure timely payment to the concessionaire for the sustainability of the project, create a mechanism for objective monitoring, evaluation, through independent engineers, public grievances redressal and invoke penalty clause if required in case of deficiency in service. To further infuse confidence among concessionaries State Government may provide counter guarantee on behalf of the municipal authority for timely payment. An inbuilt mechanism may be put in place to adjust the payments made to contractor from the grants payable to municipal authority.

The concession agreement should provide for tariff revision based on pre-determined parameters at regular intervals to cover the risk of steep increase in the fuel price and wage structure and ensure viability of the project.

6.4 Contracting Models

Municipal Authorities may adopt the Design, Build, Finance, Operate and Transfer (DBFOT) for PPP projects so that the land and other assets are returned to the municipal authorities after completion of the concession period.

For outsourcing of various services, the municipal authorities can also enter into :

i. Service Contract (door to door collection and transportation of waste); and
ii. Management Contract (door to door collection, C&D waste collection, secondary storage and transportation of waste)

6.5 Engagement of PPP Partner

A transparent process based on competitive bidding should be adopted for the selection of PPP partner after preparing a feasibility report. The Model documents published by the Ministry of Finance and the Planning Commission should be used for this purpose. The transparent bid process would generally include the following steps ;

i. Preparation of EoI, RFP Document and Concessionaire Agreement

ii. Obtain Approval from concerned Authority.
iii. Issue of Notice for Pre-qualification / EoI
iv. Short-listing of Firms
v. Issue of RFP Document to the Shortlisted Firms
vi. Conduct Pre-bid Meeting
vii. Receiving Financial bids in separately in response to the RFP and opening of bids.
viii. Evaluation of the Bids received
ix. Evaluation of financial bids
x. Selection of most preferred bidder
xi. Negotiation and Signing of Agreement
xii. Award of Contract

Where separate contracts are given for collection, transportation, processing and disposal of wastes, care has to be taken to ensure that the contractors perform their assigned functions in a coordinated manner enabling smooth operations of the processing facilities operated by other concessionaire. Any lack of coordination may lead to claims against the municipal authorities. Hence the integrated contract should be preferred.

6.6 Concession agreement between Public and Private Entity

A concession agreement specifying the rights and obligations of both parties shall be signed between the public authority and the selected private entity. This will enable the private entity to raise funds from the financial institutions for meeting its capital expenditure.

The concession agreements will specify the over-arching principles while sufficient flexibility should be provided to private entities to manage the plants in conformity with the requirements of different States/ Cities. Regular monitoring should be undertaken by the government / public authority for enforcing the provisions of the concession agreement. The key features of the concession agreement should be:

i. Adherence to MSW and Plastic waste Rules and other Environment Regulations
ii. Scheme of financial support
iii. Key Performance Indicators
iv. Incentives and penalties

v. Monitoring & inspection mechanism;

vi. Suspension/ Termination for breach of Agreement

The concession agreement should be enforced by regular inspections, audit and monitoring for quality assurance. There should be stiff penalties for violation of the agreement or for shortfalls in key performance indicators coupled with incentives for good and better performance. Since processing of waste and generation of energy can lead to emission of toxins like Sox, NOx, dioxins and furans, and compost plants giving rise to odour and leachate, it is essential that the waste to energy as well as compost plants conforms to the environment norms and standards specified by the Central/State Pollution Control Boards.

Detailed arrangements should be spelt out in the concession agreement for regular reporting of outcomes which will be monitored by the government through extensive use of IT and UID systems besides appropriate tests, inspections and surveys. Since payment to the private entity will be based on output parameters, a close monitoring thereof should be ensured. Detailed arrangements for regular monitoring should be spelt out and enforced as part of the concession framework.

Government should continue to retain and discharge its obligations relating to adherence to the Acts, Rules and Regulations in force and ensure a clean environment.

Key performance indicators

The output parameters should be developed in accordance with the best practices and specified clearly in the Concession Agreement. The performance of the plant should be monitored by a set of key performance indicators. A pre-determined system of incentives and penalties will be specified based on the key performance indicators such as amount of waste processed, energy /compost generated, emission standards and quantity disposed at landfills.

6.7 Key Areas of Concern

PPP in MSW sector is relatively new in India and several projects have failed on account of the following reasons:

i. Municipal authorities fail_to appreciate the concept of PPP. They treat the partner as any other contractor.

ii. Lack of due diligence on the part of the concessionaire,

iii. Non supply of the quantity / quality of waste committed to and presence of inerts such as street sweeping, silt and construction and demolition wastes in a high proportion in the wastes delivered at the processing plant

iv. Municipal authorities making their PPP partner responsible for collection of user fees from the beneficiaries and linking their payment with the fees collected without extending any regulatory support.

v. The municipal authorities fail to extend support to the concessionaire by invoking penal provisions for collection of user charges from the defaulters leading to poor recovery making the PPP project unsustainable

vi. Tariff structure that does not adequately cover the risk of increase in the fuel price and wage structure resulting in non viability of the project

vii. Absence of ESCROW account mechanism resulting in inordinate delay in release of payment to the concessionaire and serious financial crunch

viii. Absence of supervision by a professional. Multiple agencies supervising the concessionaire lead to complications in assessment of performance

ix. NIMBY syndrome: Public objections against the location of facilities

The municipal authorities should therefore ensure that the above short comings do not occur while structuring the PPP contracts and develop a positive attitude towards PPP arrangements. They should take the following measures in particular for the success and sustainability of PPP projects:-

i. Municipal authorities should treat the PPP concessionaire as their partner and seriously work towards successful service delivery.

ii. The municipal authority should ensure supply of committed quantity/ quality of waste and absence of inerts such as street sweeping, silt and construction and demolition wastes while delivering at the processing plant.

iii. Municipal authorities should undertake the responsibility of collection of user fees and should not link the recovery with the payment to the concessionaire

iv. The tariff structure should adequately cover the risk of steep increase in the fuel/ power price and wage structure to ensure viability of the project

v. Escrow account mechanism should be created to avoid delay in release of payment to the concessionaire

vi. Supervision of the performance of concessionaire should be done through independent professionals and supervision by multiple agencies and elected representatives should be avoided

vii. Selection of appropriate site and all necessary clearances (such as EIA, Consent to Establish etc) should be ensured by the Municipal Authority before the bidding process

viii. Dispute resolution mechanism must be a part of the contract Agreement clearly binding both the parties for resolution of dispute through a mutually agreed arbitrator.

ix. While imposing penalty on the concessionaire the reasons for failure need to be carefully ascertained

6.8 Adopting PPP Scheme in MSW Management

Municipal authorities which have a population above 2 million and where large W to E projects have been recommended should consider adopting the PPP scheme drafted by the planning commission taking into consideration the position paper (DEA 2009) on "The Solid Waste management Sector in India" as detailed here under:-

Scheme for Setting up Waste to Energy Plants through Public Private Partnership

1. Background

1.1. Rapid urbanisation and changing consumption patterns have accentuated the problem of Solid Waste Management (MSW). Effective waste disposal is, therefore very critical for ensuring a safe and clean environment. Recognising the magnitude of the problem, the Finance Minister had announced in his Budget Speech for 2013-14 financial support to cities and municipalities for taking up waste-to-energy projects in Public Private Partnership (PPP) mode in a manner that would be neutral to different technologies. This scheme has been formulated keeping in view the objective of the Government to develop viable waste to energy projects.

1.2. According to Census 2011, the total population of India is 1.21 billion. Out of this, 377 million (31.16%) of the total population lives in urban areas. The number of cities with one million plus population has increased to 53 from 35 during 2001-2011. Per capita waste generation in cities varies from 0.2 kg to 0.6 kg per day. With growth of urban population ranging between 3 to 3.5% per annum, the annual increase in overall quantity of solid waste is assessed at about 5%. The annual municipal solid waste generation is estimated to grow more than five-fold from the current level of 70 million tonnes to 370 million tonnes by 2030.

1.3. Generally the collection efficiency ranges from 70% to 90 % in major metro cities while in smaller cities it is below 50%. It is also estimated that the Urban Local Bodies spend about Rs.500 to Rs.1500 per tonne on solid waste for collection, transportation, treatment and disposal. About 60-70% of this amount is spent on street sweeping of waste collection, 20 to 30% on transportation and less than 5% on final disposal of waste, which shows that hardly any attention is given to scientific and safe disposal of waste.

1.4. Policy interventions in this sector began as early as in 1960s but focused initiatives were taken in 1990's after the outbreak of plague in Surat. The Ministry of Health and Family Welfare initiated a National Mission on Environmental Health and Sanitation in 1995. A draft policy paper was prepared on funding issues and requirements for Municipal Solid Waste Management by Central Public Health Engineering Organisation (CPHEEO). However, the key initiative in this area was the Municipal Waste (Management and Handling) Rules 2000 notified by the Ministry of Environment & Forest. The rules made it mandatory for urban local bodies to improve waste management systems in a given time frame ending 31st December 2003 and lay out procedures for waste collection, segregation, storage, transportation, processing and disposal. The Ministry of Environment & Forest is

now in the process of issuing the Municipal Waste (Management and Handling) Rules, 2014.

1.5. The Ministry of Urban Development also plays a prime role in SWM and supports various projects under the Jawaharlal Nehru National Urban Renewal Mission (JnNURM) and Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT) schemes. JnNURM was launched by the Government of India in 2005, envisaging an investment of more than Rs.1,00,000 crore during a period of 7 years from 2005-06 to 2011-12 with a Central Government share of Rs. 66,000 crore. JnNURM is a reform driven, fast track programme to ensure planned development of identified cities with focus on efficiency in urban infrastructure/service delivery mechanisms and covers 65 cities and towns. For the remaining urban areas, the Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT) has been launched.

1.6. Urban development, including Solid Waste Management, is a State subject and is basically a municipal function vested with the Urban Local Bodies (ULBs). The 74th amendment of the Constitution also empowers the ULBs to shoulder this responsibility. However, due to lack of resources, institutional weakness and improper choice of technology, the ULBs are unable to deal effectively with the issue of SWM. It is, therefore, imperative to involve private sector participation in solid waste management in order to attract investment and to improve the waste disposal system in the cities. The High Powered Committee (Bajaj Committee) constituted in 1995 encouraged PPP on a pilot basis. The Barman Committee in 1999 also recommended PRIVATE Sector participation in solid waste management. This scheme aims at evolving a mechanism for setting up waste to energy plants in an efficient and environment friendly manner through public private partnership (PPP).

2. Objective of the Scheme

2.1. *Improving the Waste Management System*

The objective of the scheme is to develop viable waste to energy projects and thereby improve the present system of waste management ranging from collection, transportation, segregation, processing and disposal of waste. Given the prevailing situation, waste disposal has become an issue of high priority. Scarcity of land coupled with increasing rate of waste generation has worsened the problem. The scheme aims at developing waste to energy projects which is economically viable and environment friendly.

2.2. *Generating Electricity*

The scheme aims at generating electricity from municipal waste and in the process leads to two beneficial outcomes comprising waste disposal and energy generation. Given the current scenario of renewable and non-renewable energy options, waste is a useful resource that can be used for electricity generation.

2.3. *Public Private Partnership*

The scheme aims at involving the private sector in setting up of waste to energy plants. The Municipal Corporation which is vested with the function of waste management is not equipped, either financially or technically, to handle the entire system and set up plants to process the waste for conversion to electricity. Hence it is envisaged to introduce public private partnership in this sector.

3. PPP - the concept

PPP in waste to energy projects is essentially an arrangement where the private sector partner participates in the provision of services traditionally provided by the urban local bodies (ULBs). It is usually characterized by an agreement between the ULBs and the private sector, with the latter undertaking to deliver an agreed service on the payment of a unitary charge by users and/or a public authority. The need for PPP in waste to energy primarily arises out of the need to attract private investment and to improve the present waste management system ranging from collection to effective disposal.

3.1. PPPs are sometimes mistaken for privatisation which normally involves withdrawal of the ULBs in favour of market based operations. In fact, a sound PPP contract enables the government to retain oversight and control over all critical elements of performance and outcomes while payments are typically made against services delivered. Through this mode of procurement, the ULBs can hope to achieve a comparatively better outcome by combining the respective strengths of the public and the private sector in the form of a true partnership that would ensure a better outcome as compared to public or private project.

3.2. PPP waste to energy projects will not be private enterprises acting solely in pursuit of profits. Nor will their management have the freedom that a private firm normally enjoys in matters such as fixing of user charges. These projects will essentially be public projects run by private entities which are to be guided by the public objectives set by the government and enshrined in an enforceable contract. The arrangement normally involves a whole-life approach where the private partner is responsible for both construction and operation. There is also some degree of risk-sharing based on allocation of risks to the party best suited to manage it. The success of PPPs as an efficient mode of implementation of public projects has already been demonstrated in several sectors such as highways, airports, ports, power, railways, etc

3.3. PPP is usually characterised by an agreement between the government and a private partner who undertakes to deliver an agreed service on the payment of a unitary charge by the ULBs or a user charge by the beneficiaries of the service rendered.

4 Benefits of the PPP Approach

Some good reasons for adopting the PPP approach in waste to energy projects are as follows:

(i) The investments required may be too large compared to available budgetary resources, and private capital could, therefore, enable an accelerated roll out of waste to energy projects;

(ii) functional efficiency of private entities would enable delivery of an efficient waste management system;

(iii) risk of project completion and delivery of agreed outputs would be transferred to the private entity;

(iv) public funds would be expended only upon delivery of agreed outcomes; and

(v) private sector efficiency in the context of a long-term agreement is expected to optimise on life-cycle costs and improve on quality of waste management .

5 Proposed framework for PPP in setting up waste to energy plant

The proposed framework for setting up waste to energy plant under this scheme would be as follows:

5.1 Waste to Energy Plant.

The scheme aims at setting up viable waste to energy plants where the municipal solid waste would be processed and output in the form of energy would be generated. The concessionaire would be responsible for setting up the waste to energy plant and process the waste by adopting an appropriate technology.

Waste to energy technology mainly consists of incineration/mass burning, gasification and pylorisis. For adopting incineration, the minimum capacity of the plant should be 300 tonnes of waste per day (TPD) and for gasification or pylolysis, the minimum capacity should be 500 TPD.

5.2 Collection of Waste

The collection of household waste and street sweeping should be separated. The Municipal Corporation should be responsible for collection of waste from street sweeping which should be deposited at designated places. The door to door collection of waste from all households should be the responsibility of the Concessionaire. The Concessionaire may also select suitable material from the waste collected through street sweeping and carry it to its plant.

The segregation of waste would also be the responsibility of the Concessionaire. This may be done at the household level, intermediate level or at the plant level.

5.3 Pre-determined tariff for energy

The scheme envisages that the entire power generated from the waste processing plants would be supplied to the grid. The designated power utilities would purchase the power generated by the plant at pre-determined rates. Before awarding the project, the Authority would seek approval of the State Electricity Regulatory Commission (SERC) for determining the rates. Further, the rates would also be indexed annually to the variation in WPI or as may be specified by the SERC prior to invitation of bids.

In accordance with the extant policies, the Renewable Purchase Obligation for energy generated from waste to energy plants is to be fixed by the respective SERCs in line with the National Tariff Policy (NTP) 2006 which enables procurement by distribution companies at preferential tariffs.

5.4 Sale of other output

In the process of energy generation, the plant may produce by-products like compost and RDF. The concessionaire may sell the compost and RDF to the users at market determined rates and the scheme does not aim at providing support in the sale of Compost, RDF or any other by product of the system.

5.5 Scheme to be technology neutral

The technological options available for energy generation from waste include incineration, gasification and plasma pyrolysis. However, the choice of technology is

to be left to the private partner. The technology used should, however, be consistent with the objectives of the scheme.

5.6 Location of PPP projects

Selection of the location of the project is critical given the nature of public resistance to projects of this nature. The location of the project would be dependent on several factors including the quantum of waste generated, technology and land area available for setting up the plant. If decentralized plants are to be set up, multiple locations in a city would be required.

5.7 Construction, operation and management by private entities

The selected entity will be responsible for construction, operation and management of the waste to energy plant. A Design, Build, Finance and Operate and Transfer (DBFOT) model would be followed for this purpose. At the end of the concession period, the project would be transferred back to the Authority. The concessionaire would be responsible for financing, constructing and maintaining the physical infrastructure and for delivery of services in accordance with laid down parameters and key performance indicators.

The Concession may be for an initial period of 20 years, to be extended by another 10 at the option of the Concessionaire.

5.8 Land to be arranged by Government

The land required for establishing a waste processing unit will be provided by the public authority i.e State Government/ Urban Local Bodies (ULBs) on license basis for the concession period. The requirement of land will vary as per the technology adopted for energy generation.

The provision of land will also include an area for sanitary landfill where the inert or rejects from the waste processing is disposed. Sanitary landfill needs to be developed to take care of the issues related to the ingress of water into the landfill, the production of leachate, its subsequent outflow and uncontrolled dispersions into surrounding aquatic environment and the accumulation, migration and uncontrolled release of landfill gas into the atmosphere.

5.9 Viability Gap Funding Support

The private entity would be eligible for viability gap funding (VGF) support of up to 40% of the project cost. The total VGF would be the bidding parameter and would be determined by competitive bidding, in accordance with the extant VGF scheme. The private entity which seeks the lowest viability fund will be selected to execute the project. **Twenty per cent of the viability gap fund can be provided from the VGF scheme of the Ministry of Finance and balance up to 20% can be provided by Ministry of Urban Development under JNNURM or other Central schemes**. Alternately, the entire VGF of 40% could be provided under JNNURM. The States/ ULBs could provide an additional 20% by way of interest free loan with a moratorium of five year from commencement of commercial operation.

5.10 Standard Documents

The projects would be bid out based on standard documents. The Model Request for Qualification (RFQ) and Request for Proposal (RFP) issued by the Ministry of

Finance would be used for bidding process. The Model Concession Agreement (MCA) would be developed for waste to energy projects and approved by an **inter-Ministerial Group (IMG) under the chairmanship of Secretary (Planning)**. The draft MCA would be provided by the Planning Commission, if so desired.

5.11 Approval Procedure

The project would be sponsored by the concerned State Government/Urban Local Bodies (ULBs) and approved by the Public Private Partnership Appraisal Committee (PPPAC) or the Empowered Institutions (EI) in the Ministry of Finance as per extant procedure. Viability gap funding support would be provided by the Ministry of Finance, State Government, urban bodies and local bodies as per the VGF scheme.

5.12 Key performance indicators

The performance of the plant would be monitored by way of key performance indicators. A pre-determined system of incentives and penalties will be specified based on the key performance indicators such as the amount of waste processed, emission standards and quantity disposed at landfills. The output parameters would be developed in accordance with the best practices and specified clearly in the Concession Agreement.

5.13 Standards & Specifications

The infrastructure would be built in accordance with the specified standards and specifications and predefined parameters. Failure to do so would attract significant penalties. Any change in environmental standards by the Government will be treated as Change in Law and tariff will be suitably revised.

5. 14 Nodal Cell

The State Government would form a nodal cell in the department of urban development to deal with the waste to energy projects. The nodal cell would contain two to three experts on issues related to PPP and legal contracts. This cell would provide support to the ULBs in implementation of these projects.

5.15 Concession agreement between government and private entity

A concession agreement specifying the rights and obligations of both parties shall be signed between the government and the selected private entity. This will enable the private entity to raise funds from the financial institutions for meeting its capital expenditure. The concession agreements will specify the over-arching principles while sufficient flexibility would be provided to private entities to manage the plants in conformity with the requirements of different regions. Regular monitoring would be undertaken by the government for enforcing the provisions of the concession agreement. The key features of the concession agreement would be:

- Adherence to MSW Rules
- Scheme of financial support
- Key Performance Indicators
- Incentives and penalties
- Monitoring & inspection mechanism; use of UID
- Suspension/ Termination for breach of Agreement

5.16 Additional obligations of the private entity

The private entity shall also perform the following:

- Create awareness in the society regarding the importance of waste management.
- Obtain carbon credits as municipal solid waste is a significant source of methane emissions.

6 Concession structure

A Design, Build, Finance, Operate and Transfer (DBFOT) model would be followed for this scheme. At the end of the concession period, the waste management plant would be transferred to the public authority. The concessionaire would be responsible for financing, constructing and maintaining the physical infrastructure of the plant and for managing it in accordance with laid down parameters and key performance indicators.

7 Enforcement and inspections

7.1 The concession agreement would be enforced by regular inspections, audit and monitoring for quality assurance. There would be stiff penalties for violation of the agreement or for shortfalls in key performance indicators coupled with incentives for better performance. Since processing of waste and generation of energy will lead to emission of toxins like SO_x , NO_x, dioxins and furans, it is very essential that the waste to energy plant conforms to the environment norms and standards specified by the Central/State Pollution Control Boards.

7.2 Detailed arrangements would be spelt out in the concession agreement for regular reporting of outcomes which will be closely monitored by the government through extensive use of IT and UID systems besides appropriate tests, inspections and surveys. Since payment to the private entity will be based on output parameters, a close monitoring thereof would be ensured. Detailed arrangements for regular monitoring would be spelt out and enforced as part of the concession framework.

8 Expected Outcomes

8.1 Safe and clean environment

It is expected that the waste management plants will lead to effective disposal of waste and thereby provide a safe and clean environment.

8.2 Performance-linked payments

The private sector would not only bear the construction risk but would also be accountable for the quality and performance specifications set by the government. Use of a standardised concession agreement would help in speeding up the procurement process as well as in ensuring compliance with performance standards. Payments to private entities would be linked to performance-based outcomes.

8.3 ULB's overarching role to continue

ULB would continue to retain and discharge its obligation relating to the provision of a clean environment, and deciding on policy matters.

6.9 Sale and Purchase of Products

In respect of compost, biogas, RDF, power, syngas, ethanol and all other end products of MSW processing, the concessionaire will be free to sell to the users at market determined rates. In case of W to E projects, the power generated from the waste processing plants could be supplied to the grid or used for captive consumption.. In case of biomethenation , the gas could be directly supplied to the consumer through pipes or through cylinders. Alternately the gas may be converted to power and supplied to the grid for street lights etc.

The municipal authority or state agency should also consider purchase the power generated by the plants at pre-determined rates to the extent of its requirements and may permit sale of electricity to any other agency. Before awarding the project, the authority should seek approval of the State Electricity Regulatory Commission (SERC) for determining the rates. SERC also need to consider awarding higher rates as applicable to renewable energy sources.

The producers of RDF should sell the RDF to power plants or cement and metallurgical industry. The municipal authority, on its part should extend full support to facilitate marketing of the products.

Chapter 7-
Modes of financing MSW Projects

Lack of adequate financing of MSW sector has led to continuance of primitive systems of waste management in most of the cities in India leading to public outcry on inadequate service delivery. The Task Force has looked at the problems encountered by the municipalities in managing the MSW and by the private operators in setting up and operation and maintenance of the waste processing and disposal facilities. The gaps and constraints observed by the Task Force are detailed in Chapter 2.

The Finance Minister in his budget speech for 2013-14, proposed to support municipalities that will implement Waste to Energy projects through different instruments such as viability gap funding, repayable grant and low cost capital.

The task force has holistically examined the problems and issues of MSW management in the country and explored the options of optimally utilizing the potential of various components of wastes including use of W to E option from the combustible fraction of MSW. Deriving energy or nutrients from the MSW largely depends on the improvement of current system of collection, segregation and transportation of wastes to facilitate segregated wastes reaching the processing facilities.

It's a considered view that thrust should be given to "Integrated MSW" and the entire chain of activities in MSW should be taken up in a well synchronized manner and strategically supported to achieve the desired objectives. Adequate financial support may be given to the MSW sector in general and processing and disposal facilities in particular.

7.1. Existing Financial Support from Government of India

The Government of India, through various schemes extends financial support for introducing appropriate solid waste management systems and for setting up processing and disposal facilities. These include the following:-

i. Support under erstwhile JnNURM and UIDSSMT Schemes of MoUD
ii. 13th Finance Commission Grants from Ministry of Finance
iii. Grants from MNRE for Supporting W to E Projects
iv. MNREGA and Nirmal Bharat Scheme Under MoRD
v. TAC-Tariff Advisory Committee
vi. Viability Gap Funding from Ministry of Finance
vii. Support for Purchase of Compost from Ministry of Agriculture

The municipal authorities and respective State Governments nodal agencies i.e.MSW mission or authority as recommended in this report may avail the existing grants and proposed grants in this report after assessing the gap, if any, in putting the entire system in place as recommended. The gap could be bridged partly, by levying user charges/taxes, tipping fee and from additional grants from the central and state governments as detailed in this report.

The municipal authority through respective State Governments may request the Government of India, Ministry of Finance to extend viability gap funding in capital investments and/or performance based Operation and Maintenance (O&M) grants to the operator for ensuring running of the project efficiently. The Government of India may consider formulating a policy of gradually replacing the initial capital subsidy by outcome based subsidy to meet the viability gap in O&M of the project.

7.2. Tipping Fee

Tipping fee is a charge which municipal authorities are required to pay to a private operator, who undertakes the responsibility of processing the waste aimed at minimizing the waste going to the landfills and in the process derive some useful products to meet part of the cost. The Tipping fee is meant to bridge the gap between the amount spent by the concessionaire on processing the waste and the income derived from the products. The municipal authorities therefore need to provide for tipping fee for the sustainability of the projects undertaken on PPP mode. The gap is generally in the range of 30-50%. This gap should be partly bridged by payment of tipping fee by the Municipal Authorities and the rest by VGF. Internationally such projects are viable because of payment of adequate tipping fee to bridge the gap. The proposed state MSW Mission should determine the percentage of the gap to be bridged through tipping fee depending on the financial status of the municipal authorities. Innovative revenue models should be explored and encouraged.

7.3. Proposed Support for Capital Investments and O&M Costs

Under JnNURM all cities and towns are eligible for Grants, under UIG component or under UIDSSMT schemes. The current UIG support covers only 65 cities, it is proposed that efforts should be made to widen the coverage and extend financial support to at least 468 class 1 cities which will cover over 70% of the urban population. The central govt can look at the needs of these cities critically and monitor their performance. The remaining 7,467 small local authorities not covered under such schemes may also be given financial support through state agencies to put their MSW management systems in place to ensure that MSW systems improve in all small towns and large cities simultaneously.

Looking at the financial health of municipal authorities in making capital investments and sustain operation and maintenance of the assets created, the following financial support is recommended.

A. Segregation, Collection and Transportation

The capital investment required for these activities may be shared as under:

i. 35% grant from central government
ii. 35% grant from state government
iii. 30% investment from the private sector.

B. Processing of Wastes

Centralized Plants

i. 40% viability gap funding for capital investment from the Government of India
ii. 10% support from the State Government towards capital investment

Decentralized Plants

i. 40% from the Central Government towards capital investment
ii. 20% from the State and/or ULB's as a viability gap for capital investment.
iii. 40% investments from private sector

It is suggested that the MoUD may consider aligning the aforesaid support with the existing or proposed support programme of the Ministry.

C. Support to existing defunct/partially functional processing plants

The municipal authority may consider inviting private sector to operationalize defunct plants earlier funded by Central or State grants/schemes. Funding support of **Capital Subsidy** may be extended as under:

i. 50 % from government of India
ii. 20% state government
iii. 30% investment by private operator

D. Construction of Waste Plants

i. 30% grant from central government
ii. 20% grant from state government
iii. 50% to be borne by private sector

E. Common Regional Sanitary Landfill Facility (SLF) for Disposal of Inerts

Cities above one million populations generating over 100 TPD residual wastes for disposal should set-up their own landfill and permit all cities and towns within 50km periphery of the city to use that facility for disposal of their waste. Common regional facilities may be constructed for rest of the 7,882 cities, towns and urban centres by forming clusters within 50 km radius having a population of at least one million. Only in special cases, where, the distances between the cities are large, the cluster size may be brought down suitably to handle at least 50 TPD of residual waste. For smaller cities, common / regional facilities are recommended as individual facilities are both neither economically viable nor can be managed sustainably. Construction of SLF's and common SLFs can be financially supported as under:

i. 33% grant from Central Government of India limited to Rs 2 crore

ii. 33% from the State Government authority limited to Rs 2 crore.

The Government grants for SLF's and CSLF may be 33% limited to Rs 2 crores of the cost per 2 million populations. If the landfill covers larger population the support could be proportionately increased. As a pre-condition to aforesaid grant, suitable land for SLF should be made available by the ULB/State Government to the concessionaire with all necessary clearances.

7.4. Rehabilitation and Capping of Dumpsites

Rehabilitation and Remediation of abandoned landfills including capping of dumpsites should be initiated on priority in the cities where water table is generally high and the amount of waste being deposited is large. Scientific assessment of contamination of soil and groundwater should be undertaken and extent of damage and possibilities of remediation may be ascertained. Based on the outcome and cost implications, a strategic decision regarding remediation and or capping should be taken. Capping should be planned to minimize further damage and release of the part of the land by scraping and accumulating scattered waste and using it for sanitary landfills or putting it to a profitable use. Need to consider remediation to release precious land is therefore recommended. The financial support proposed to be extended is as under:

i. 50% cost by the Central Government and,

ii. 20% cost by the State Government may be considered

iii. 30% cost by the private sector

The operation and maintenance cost of primary collection and transportation of waste in an efficient manner may be met with by ULBs by levy of user fees as per paying capacity and waste generation rates of the users as recommended in this report and ensuring its recovery by timely billing and efficient collection. Municipality may meet the gap in the O&M cost by levy of sanitation tax. The basic principles to

be considered by Local Bodies while prescribing norms for levying user/service fee for MSW services include: polluter pays principle, proportionality and capacity to pay. One of the parameters for determining the capacity to pay could be the electricity bills paid by the consumers.

7.5. Viability Gap Funding Support

The private entity should be eligible for viability gap funding (VGF) support of up to 40% of the project cost. The total VGF should be the bidding parameter and should be determined by competitive bidding. The private entity, which seeks the lowest viability fund, will be selected to execute the project. 20% of the viability gap fund can be provided from the VGF scheme of the Ministry of Finance and the balance, up to 20% can be provided by Ministry of Urban Development under JnNURM or under other Central schemes.

7.6. Cost Implications

The Task Force has recommended a framework for technological options leading to optimum utilization of all components of wastes and to extend financial support for setting up MSW processing facilities in all cities and towns including urban centres declared as census towns and regional landfills. The preliminary estimates indicate that 88 W to E power plants generating 439 MW power from the combustible non-recyclable fraction of waste can be set up in large cities preferably with populations over 1 million. Besides large power plants, biomethanation and compost plants @ 1 plant in each urban centre and about 200 large and 300 medium size regional sanitary landfills (in all 500) to cover all 7935 urban centres are required to be set up. All small towns need to segregate combustible waste and supply as feed stock in the form of RDF to power plants/cement plants to facilitate utilization of such waste.

i. **Cost estimates for processing facilities:** With a view to facilitate the GoI in determining the financial support to the ULBs; a cost estimate has been prepared (refer to **Table 17**)

ii. for setting up waste processing plants including W to E plants, preparation of RDF, biomethanation, composting and vermi-composting facilities. The estimated capital investment works out to be approximately Rs. 11,951 crore.

ii. Cost estimates for tools, equipment, vehicles and regional landfill facilities: The ball-park cost estimates for procurement of tools, equipments and vehicles for meeting the capital costs for collection and transportation of MSW as well as for setting up of engineered sanitary landfills have been made. The preliminary estimates indicate that the capital costs for collection and transportation of MSW and for setting up of approximately 500 engineered sanitary landfill facilities (SLF) worked out to be approximately Rs. 10,740 crore (**Table 18**). This includes provision of mechanized sweeping as advised by MoUD in one million plus cities at a cost of Rs.

208 cr. This amount may have to be spent over a period of 3 years at the rate of 3,580 crore per year. The central government and state government could support this cost by giving grants as recommended in the report.

The share of Government of India, State Government and private partner for the various activities to be undertaken in a PPP mode including revitalizing the defunct MSW processing plants set-up through government grants, remediation and capping of dumpsites and C&D waste processing are indicated in **Table 19** and is as under:-

I. . Government of India share Rs. 7,670
II. State Government share Rs. 4,302
III. Public partner share Rs. 8,181

Total investment required for the sector is estimated at Rs. 24,691 crore assuming availability of assets worth 20% with the municipal authorities, the total investment works out to be Rs.20,153 crore.

Apart from this, Rs 600 crore is to be devolved to Centre of Excellence to be set up in the IITs in the four regions of the country for R & D in technology for MSW management and recycling.

With a view to facilitate smooth disbursement of funds, MoUD should be designated as the single point of support. The support of Ministry of Agriculture, Ministry of New and renewable energy, CPCB etc could be channelized through MoUD in a well coordinated manner.

Table 17: Capital Cost Estimates for Processing of various Fractions of MSW

Sr. No.	Classif-ication of Cities	No of Cities	Population, % of Total Urban population & GPCD*	Quantity of waste Generated TPD	Waste to be treated (65%)** TPD	I Waste for W to E		II Waste for Bio-Methanation		III Waste to Compost		Cost I (10/12** *Cr per 75 TPD)	Cost II (15 Cr per 100 TPD)	Cost III Rs 5 Cr per 100 TPD)
						TPD	in %	TPD	in %	TPD	in %			
1	More than 1 M	53	160 M, 42.4% & 550 gm	88,000	57,200	22,880	40	5,720	10	28,600	50	3,050	858	1,430
2	0.1 to 1 M	415	105 M, 27.9% & 450 gm	48,000	31,200	7,800	25	6,240	20	17,160	55	1,248	936	855
3	Below 1 lakh	7467	112 M, 29.7%, 300 gm	34,000	22,100	2,210	10	6,630	30	13,260	60	354	995	665
	Total		377 M, Average 450 gm	1,70,000	1,10,500	32,890		18,590		59,020		4,652	2,790	2,950
												# Grand Total approx. Rs 10,392 cr		
Add 15% on account of likely price rise during procurement over a period of 3-5 years												**1,559 crore**		
TOTAL												**11,951 crore**		

Note: The total cost can be reduced by about 15-20% by deducting the cost of existing operational plants

The cost figures are tentative and hence the estimates could be ± 15% .

* GPCD is grams per capita per day

** This does not include 17,000 TPD (10%) recyclable wastes collected by rag pickers and 42,500 TPD (25%) of inert waste

*** 2 Crore per100 TPD addition amount is proposed for segregating RDF in smaller towns

Table 18: Cost estimates for procurement of vehicles, tools and equipments for MSWM and SLF

Item	Numbers Required	Unit cost (in Rs.)	Total cost (in Rs.)
Door to door collection vehicles @ 1 vehicle per 10,000 population	37,700	5.5 lakh	2,073 crore
Containerized Tricycles for door to door collection from narrow lanes and low income settlements (20% areas)	75,400	16,000	121 crore
Handcarts for street sweepings @ 2 per 1000 population	7,54,000	8,000	603 crore
Mechanical road sweepers @ 2 for One Million plus cities	320	65 lakh	208 crore
Secondary Storage containers (1.1 m^3) for street sweepings and inerts only (30% waste)	1,80,000	20,000	360 crore
Compactors for transportation	4,875	31 lakh	1,511 crore
Transfer stations for 50% waste	250	4 crore	1,000 crore
Common Sanitary Landfills for 25% waste for 5 years capacity	about 500 for disposal of 42,500 TPD	500 per tonne/day for 5 years	3878 crore
TOTAL			9754 crore Or 9760 crore
10% increased on account of likely price rise during procurement over a period of 3 years			10736 Or 10,740 crore

Table 19: Recommended cost sharing for MSWM activities

Sr. No.	MSWM Activity	Total Investments (Rs in Crores)	Required Investment (80%) (Rs in Crores)	GoI Share (%) (Rs in Crores)	State Share (Rs in Crores)	PPP Share (%) (Rs in Crores)
1	Collection, Storage and Transportation *etc*	6,862	5,490	1,922 (35%)	1,922 (35%)	1647 (30%)
2	MSW processing such as Bio-methenation, composting, Gasification etc.	11,951	9,561	3824 (40%)	956 (10%)	4,780 (50%)
3	C&D Waste Processing	500	500*	150 (30%)	100 (20%)	250 (50%)
4	Support to Non-Functional Plants	500	500*	250 (50%)	100 (20%)	150 (30%)
5	Support to Regional Common Sanitary Landfills	3,878	3,102	1,024 (33%)	1,024 (33%)	1,054 (34%)
6	Remediation of Dump Sites /Capping	1,000	1,000*	500 (50%)	200 (20%)	300 (30%)
	Total	24,691	20,153	7,670	4,302	8,181

Note: * Budget provision suggested

Chapter 8
Institutional Mechanism, Role of Municipal Authorities and Smart Waste Management

Even after 300 years' of existence of municipal institution in the country and 13 years after the notification of MSW Rules 2000 under the Environment (Protection) Act 1986, the systems of solid waste management has not been standardized and municipal authorities are still grappling with the problems of waste management. The situation of waste management is alarming. It is therefore necessary to give a serious thought to the creation of an institutional mechanism and management structure that shall facilitate adoption of appropriate MSW systems and technologies and efficient delivery of service. The following arrangements at central, state and municipal levels are proposed.

8.1 Institutional Mechanism

A. Central Government

i. Establish an Authority or Mission on Solid Waste,

ii. Set up Special technical cell under the Authority which could guide states on appropriate technologies of processing and disposal of waste in consultation with CPCB

iii. Allocate funds to states/ ULBs for improving MSW systems and setting up waste treatment and disposal facilities.

iv. Support programmes of training and capacity building

v. Central and State Governments may consider giving Tax holidays /incentives to waste processing and recycling industries for at least 10 years.

vi. Central and State Governments may promote use of compost or energy from waste

B. State Government

All the states should have a solid waste management authority with experts on various aspects of MSW, including contracting and financial management. This authority may be made responsible for the following:-

i. Document the status of MSWM and, create a mechanism for continuous update of the status.

ii. Assess the correct situation of MSW in the municipal areas in the state and identify the gaps that need to be bridged.

iii. 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 guidance outlined in this report.

iv. Classifying the cities and towns as per their size and population and assess the need of funds for putting systems in place in consultation with the respective ULB and for setting up processing and individual/ common

v. Facilitate establishment of regional sanitary landfill facilities as per the norms developed.

vi. Obtain resolution from the respective ULB authorizing the State MSW Authority to avail MSW grants from State and Central Government to improve MSW in the city / town, indicating their willingness to contribute their matching share as per this report and agreeing to maintain the system / plants from its internal resources or through private sector.

vii. Obtain State Governments' concurrence to give matching state grants.

viii. Get detailed project reports (DPRs) prepared for MSW for each city or for a group of identical cities and prepare proposal for obtaining Central Government assistance clearly indicating the commitments of ULBs and State Government to contribute their share envisaged under the scheme.

ix. Prepare design, specifications and cost estimates for central procurement of tools, equipment and vehicles and qualification and experience of professionals that need to be recruited and appointed to manage the services in the ULBs

x. On getting Government of India grants, invite Bids for procurements of tools, equipment and vehicles and for selection of PPP partners with or with out availing transaction advisory services as may be considered expedient and award contracts

xi. Facilitate selection and / or procurement of appropriate land from state / private agencies for setting up waste processing and disposal facilities. and assist / guide ULB in obtaining necessary clearances / authorizations

xii. Oversee the construction, operation and maintenance of waste processing and disposal facilities

xiii. State energy development agencies may promote setting up decentralized waste to energy plants and utilize Bio - gas for domestic or institutional consumption.

xiv. The State Agencies may provide training to young entrepreneurs in setting up and operating and maintaining such plants under various skill upgradation schemes of GoI and state government, and

xv. State Governments may extend financial support to such enterprises under Swarna Jayanti Shahari Rojgar Yojana (SJSRY) scheme or various other prevalent schemes

C. Municipal level

i. All municipal corporations should have a MSW Management Department and other municipal authorities should have a MSW Management Cell and minimum technical and supervisory staff as per the yard stick prescribed by the State MSW Authority to ensure efficient MSW service delivery.

ii. Implement the integrated MSW management system recommended by the Task Force which consists of four streams of waste collection for all class of cities.

iii. Municipal authority may make serious efforts to educate the waste generators to minimize the waste and segregate the waste at source. It should make separate arrangements for collection, transportation of domestic , trade , institutional and market wastes and ensure that such waste is directly delivered at the waste processing facility meant for bio degradable and recyclable waste.

iv. Municipal authority may continue street sweeping and drain cleaning operations with their permanent sanitation staff or contracted sanitation workers and store such waste separately at temporary waste storage depots and transport such inert waste separately to the waste disposal site without mixing this waste with door to door collected waste. This will reduce unwanted waste going to the processing facilities and save the cost of transportation of such inert waste from the processing site to disposal facility.

v. Municipal authority may make separate arrangements for collection, transportation and processing of construction and demolition (C&D) waste and ensure that such waste is not delivered at the waste processing facility meant for bio degradable and recyclable waste. Private sector may be encouraged to process C&D waste may be utilized for making bricks, paver blocks, aggregates etc

vi. Municipal authority may promote to the extent possible, decentralized processing of waste such as composting, bio -gas generation etc to minimize cost of mechanized processing and transportation and create job opportunities for the unemployed youth in waste industry.

vii. Municipal authority may allot suitable parcel of land as per yardstick that may be prescribed on a token lease rent / license fee of Rs. 1/- per sq.meter /year to the concessionaire / private developer (big or small) willing to make investments in processing of municipal solid waste.

viii. Municipal authority may deliver MSW at the plant site / transfer station free of cost and may not insist on getting royalty on the income derived by the concessionaire.

ix. Municipal authority should be willing to purchase power from the concessionaire if offered at a rate approved by the regulatory authority.

x. Municipal authority should avail the facility of regional landfill and agree to share the associated costs

xi. Municipal authority to make adequate arrangement to supervise the work of the contractors/ concessionaires on a day to day basis through qualified staff and evaluate the performance of concessionaire through independent agencies when any dispute arises between the PPP partners..

8.2 Smart Waste Management

Smart technologies and solutions are related to all aspects of waste management, where Information Communication Technology (ICT) can be applied as hardware, software or used as a total solution.

Waste such as mixed MSW, active biological material, residue from shredding of End of Life Vehicle (ELV) and Electric and Electronic Equipment Waste (WEEE) and C&D material can be easily recovered by Smart Waste Management System (SM-WMS).

SM-WMS are aimed at optimizing operations in time management, fuel efficiency, and overall asset management. SM-WMS is an important part of waste management, as it plays a crucial role in effectively collecting and transporting waste and has a significant influence in the downstream processing costs and efficiency. SM-WMS is a combination of software and hardware which is generally outsourced to specialist IT companies or is internally applied to support company performance and integration. Logistic solutions are the intelligent frameworks that tailor together the best combination of a collection system, comprising the best container and appropriate truck type (rail or road), plan the route, and provide a summary of the material estimated for recovery. All the elements of the waste collection and management system influence the final cost, quality of material, and timing of the delivery.

There are examples of CCMC at Coimbatore using an online waste truck monitoring system using radio frequency identification, which is linked with the weighbridges commissioned at the waste transfer stations as well as at the waste processing and disposal facility at Vellalore. Another transfer station in Coimbatore is equipped with an electronic weighbridge. In Bhopal, the Municipal Corporation has installed GPS devices in 50 of its vehicles for solid waste management, which has resulted in a net saving of 2000-3000 litres of diesel per day. Municipal authorities should carefully study these successful models of SM and suitably adopt to bring efficiency in waste management services.

SM-WMS can also support the recognition of high value material quality and recovery, backed by high performance efficiency with minimal generation of low economic value by-products and the highest quality of secondary material possible. This will include sensor based sorting, customized waste segment sorting, and a material recovery unit which are based on a concept that combines optical sensor recognition, software, and robotics.

Smart recycling systems are the answer to long standing needs of waste management companies, whose problems are mostly related to quality and quantity of collected waste, efficiency of overall processes, as well as the downstream material value offered to final customers

Moreover, smart recycling systems are increasing the overall efficiency of the waste management process and as a result, they have a positive impact on the specific cost of internal treatment (measured in Rs per ton), thus, improving the bottom line of operations. Smart revolution in the waste industry is also positively influencing all market participants such as individual clients, municipalities, and waste management

companies, as it is provides a collaborative platform for good data exchange and promotes greater cooperation.

8.3 Information Communication Technology in MSW Management:

The Information Communication Technology (ICT) revolution has indelibly changed how services are organized, planned and delivered worldwide. The urban sector in India, particularly, city governments are yet to make effective use of information communication technology to further urban service delivery. The use of ICT to further municipal service delivery can revolutionize the mechanisms and outcomes of service delivery especially in better deployment of resources for information retrieval, decision making, ongoing management, service delivery and outreach.

All evidence points to the obvious benefits of the use of ICT; therefore it is crucial to ensure that the potential gains from ICT do not bypass Indian cities in the provision of quality urban services and responsive governance. This is particularly so in the context of large scale investments and implementation in infrastructure development and service delivery initiated under programmes like the Jawaharlal Nehru National Urban Renewal Mission, Urban Infrastructure Development in Small and Medium Towns, RAY and similar initiatives for Service Level Benchmarking, E-Governance initiatives, Sanitation Planning etc.

ICTs present a revolutionary approach to addressing MSW issues due to their unequalled capacity to provide access to information instantaneously from any location across great geographic distances at a relatively low cost. An explicit focus on using ICTs in pursuit of sound MSW goals could allow countries to achieve more sustainable cities.

Today a key challenge faced by waste management industries is efficient delivery of MSW services. Trucks, hand carts and trolleys are the means of removing garbage & other waste materials from the city. They perform multiple trips in a day. Monitoring and tracking these vehicles is a vital activity. Any manual method is incapable to do this work effectively. The technological approach in solid waste management reduces the manual efforts and enhances the efficiency of collection, transportation, identification of dumping site, manpower management, resource management and addressing citizens' complaints.

ICTs are applied for the selection of appropriate landfill sites, the design of a planning system for autonomous landfill compaction. Furthermore, precise estimations of SW generation and optimum allocation of commercially available containers could be realised through GIS (Geographic Information System)-based analysis. These will result in a more rational and efficient design of collection, transport and disposal systems. The GIS-based analysis could use triangulated irregular network (TIN) for waste estimation, allocation to containers and removal frequency, taking into consideration the available container size, type and placement possibilities.

The tracking devices can be mounted in the trucks to collect location information in real time via the GPS. This information is transferred continuously through GPRS to a central database. The users are able to view the current location of each truck in the collection stage via a web-based application and thereby manage the fleet. The trucks positions and trash bin information are displayed on a digital map, which is made available by a map server. Thus, the solid waste of the bin and the truck are being monitored using the proposed system which consists of GPS as tracking device, GPRS/GSM as web server, GIS as map server and MIS as database server.

Some of the waste workers don't attend their duties thus leaving many areas of the city full of waste. An automated system can track hours of work at each household and generate report instantly. To ensure the full attendance of the waste workers bio-metric technology is implemented. The information is imported to a Computer network (Management Information Systems) through scanning and imaging.

Automated system eliminates the manual data entry tasks & also avoids the paper record keeping & human errors.

ICT offers opportunities to achieve broader development goals by improving monitoring and response systems and enabling more efficient resource use. ICT can make a valuable contribution to ISWMS. Factors that should be addressed to maximize the benefits of ICTs for development include deploying ICTs infrastructure, building human capacity, establishing a transparent and inclusive policy process, creating incentives for enterprise, and developing appropriate content.

Following are the advantages of Information Communication Technology (ICT) in MSW management.

i. It will reduce the manual effort and enhance the efficiency of collection, transportation, and identification of dumping site, manpower management, resource management and addressing citizens' complaints.
ii. It will enable synchronization of waste vehicle tracking and quality monitoring to ensure better performance of the system.

Chapter 9
Policy, Strategy, Regulatory Framework and Capacity Building

The Ministry of Environment and Forests, Ministry of Finance and Ministry of Urban Development may consider framing the following policies, strategies and Legislations

9.1 Policy, Strategy and Regulatory Framework

Policy

i. The MoUD should come out with a national policy on MSW outlining the country's intentions about handling waste of all types and clearly demarcating the role of central government, states and local authorities. The national goal should be clearly stated, specifically indicating what will be achieved by the end of each plan.

ii. A national policy on "Recycling, Resource Conservation and Preventive Environmental Management" be notified ,

iii. A performance based viability gap funding for waste processing projects be adopted.

iv. A performance based incentive in the field of environment and waste management for rewarding excellence be initiated and implemented.

v. An action plan to implement specific recommendations made regarding this sector in the National Environment Policy to be actively pursued (Details are in Chapter-1).

Strategies

i. There should be a national strategy as to how the problems of municipal solid waste management will be handled including what type of funding and support will become available.

ii. Each state should come out with its own policy and strategy keeping in view the national policy and strategy as envisaged in the draft MSW Rules, 2013.

iii. There should be a national standing task force/committee of eminent persons and experts to oversee the progress and report independently on the progress made by the states and the shortcomings that need to be addressed.

iv. Small landfills are not technically feasible and economically viable. An option to have a common regional facility at a reasonable distance (to avoid high cost of transportation) for disposal of waste for group of cities contiguous to each other need to be encouraged to save land, operational cost and facilitate scientific management of landfills.

v. Separate guidelines/ may be issued for management of municipal solid waste (MSW) in Hilly towns.

ix. Preparation of “model DPR”, RFPs including concession agreements for PPP contracts, guidelines on setting up common and regional Sanitary Landfill facility (SLF) and waste management in hilly towns and north east region should be undertaken by MoUD with the help of appropriate expert consultation.

vi. Evolving a mechanism at state level for capacity building and handholding, where necessary, of municipal authorities and making sure that all the local bodies implement the rules in a given time frame and achieve the service level benchmarks prescribed by MoUD and adhere to national sanitation policy in place.

vii. National Recycling Programme (NRP): The NRP will be an overarching framework to create and mainstream the organized waste management and recycling industry. Under the NRP structured frameworks and guidelines for recycling industry should be developed to integrate it with the existing waste management rules & guidelines. Industry and sector specific recycling standards will be developed under the NRP.

Legislation

i. MoEF should consider re-introducing a reasonable timeframe for the implementation MSW Rules and Plastic Waste (Management and Handling) Rules 2011, by all the local bodies in the country.

ii. The State governments should be mandated to identify suitable lands to set up MSW processing facilities and for construction of sanitary landfills for large cities and regional landfills for group of small cities/towns, in cases where suitable lands are not available with the urban local bodies.

iii. The town planning departments of respective states should be directed and authorized to reserve from time-to-time, suitable parcels of land for setting up MSW storage, processing and disposal facilities while preparing development plans/ land use plans for cities and towns.

iv. Mandate citizens/waste generators to segregate the three major components of wastes namely biodegradable waste, non-biodegradable waste and domestic hazardous waste at source.

v. Making it mandatory for municipal authorities to have at least three streams of waste collection namely

   a. Biodegradable and combustible wastes stored at households, shops and establishments and collected from the door step to be directly delivered at the processing facility.

   b. Inert waste such as street sweeping and silt from the drain to be collected and transported separately and taken directly to waste disposal site without mixing with waste collected from the door step.

   c. Construction and demolition waste to be collected separately and utilized for making bricks, paver blocks, aggregate or any other useful product and for filling in low lying areas, bio-engineering works for mosquito breeding prevention *etc*.

vi. Mandate preparation of an action plan at state level to ensure municipal authorities implement the rules in a given time frame.

vii. Specify most appropriate and viable waste processing technologies for small, medium and large cities in the country.

viii. In respect of sanitary landfills the rules should specify the minimum size of the sanitary landfill and encourage setting up of regional landfills for small cities and towns

ix. Separate provisions should be made for management of municipal solid waste (MSW) in Hilly towns.

9.2 Capacity Building

Steps towards capacity building and strengthening of institutions shall both play the most crucial role in achieving the scientific management of MSW generated in the country. There is a growing recognition among the municipal authorities, technical personnel as well as service providers that technologies and skill sets required for engaging into MSW related tasks are different from other sanitary services offered by municipalities.

It is envisaged that all municipal corporations must have separate entities entitled: *Department of MSW Management* and. smaller cities must have at least a *MSW Management Cell*.

The larger municipalities should build their engineering staff in *Department of MSW Management* with mixed expertise including environmental engineering, civil engineering, mechanical engineering and electrical engineering so that they can address all the issues related to larger MSW management facilities. Cities should consider having independent engineers with a team of subject experts to supervise the performance of the concessionaires and maintain records of each inspection. Such independent engineer should report to the chief executive or to another senior officer designated by the chief executive.

As a result of the recent efforts of GoI and State Governments to encourage and fund MSW management; the demand for institutional strengthening and trained man power is expected to escalate several folds in the coming years. In order to address these challenges following interventions have been proposed.

i. Capacity Building of Municipal Personnel

Efforts must be made to strengthen the technical knowledge of the engineering staff within *Department of MSW Management.* A long-term view, therefore, will have to be taken by municipal authorities who will need to build professional relationships with academic and research institutions in the region. More importantly, the *State MSW Management Authority* will have to take the leadership role in capacity building of municipal staff in the State and conduct training courses, workshops, conferences and awareness drives at different levels. Through training it must be ensured that municipal

authorities, both, technical and administrative as well as the elected representatives in municipalities and Local Self-Governments should understand rules and regulations related to MSW management and recognize the importance of appropriate treatment and disposal of MSW - especially in the context of the potential threat MSW can pose to ground water, surface water resources and create public health disaster.

ii. Capacity Building for Success of PPP Approaches

An "independent engineer" should be appointed and made responsible to ensure smooth functioning of the MSW management tasks undertaken by the municipal authorities through PPP mode.

The private sector participation in MSW sector is new and emerging. The management should take pragmatic view while initiating action against the concessionaires and make efforts to build the sector by promoting healthy competition and sustainable partnership. On any dispute arising between the municipal authority and concessionaire, the latter should remember that this is a dispute between the partners and it should be resolved amicably, subject to protecting the public interest. The municipal authority should desist from imposing its will upon the concessionaire and should involve a third party mediator such as commissioner/director of municipal administration to find a fair solution to the dispute. Several disputes are currently pending in various Courts of Law in the country and hence special efforts will have to be made to avoid arbitration or litigation.

9.3 Research & Development for Appropriate Technologies

Research and Development in MSW sector is not a priority area in the country. Vendors bring in technologies, vehicles and equipment from developed countries and try to market them to municipalities, which have no means to ascertain appropriateness of the technologies and suitability of tools and equipment. It is recognized that, the cities and state MSWM cells need expert advice while selecting technology as well as while deciding on tools, vehicles and equipment needed. Research and Development in this sector to identify appropriate technologies and tools and equipment for use in various levels of city with different quality and quantity of waste generated is therefore considered essential. It is recommended that Indian Institute of Technologies (IITs) and leading scientific institutions be encouraged to take up research projects and programmes in this sector, including recycling processes. At least four institutions can be identified one each in north, south, east and west where Centre of Excellence can be set up with government of India support. This support may be extended for a period of 10 years and budgetary provisions of Rs.150 crore per institution (total Rs 600 crore) could be made to support research and development. These institutions may also undertake R & D activities on the various processing technologies in vogue, their suitability to Indian conditions in addition to developing new technologies, products, and management practices.

9.4 Dissemination of information and training:

The government of India and the state governments should play a major role in dissemination of information on the outcomes of R&D conducted by centres of excellence, on the recommendations contained in this report as well as other relevant reports and provide adequate training support to the Municipal Authorities in achieving the desired objectives.

Chapter 10
Recommendations

The observations and discussions presented in different chapters of this Report clearly indicate that Sustainable and Integrated MSW Management is an integral part of good local governance. Solid waste has to be managed by technologies and methods that enable recovery of resource and energy and most importantly help keep our cities clean, prevent pollution and protect the environment. To attain the twin objectives of sustainability and sound solid waste management, emphasis has to be laid on Integrated Waste Management, De centralized and Centralized Approaches for Waste Processing, Identification of appropriate Technological Options and Operational Models based on quantity and composition of waste, Sustainable and Implementable Framework for PPP and Financing. Needless to emphasize, that there is an urgency to ensure implementation of these recommendations. The summary of the recommendations are given below:

1. **Integrated Municipal Solid Wastes Management** (IMSWM)

The Integrated Municipal Solid Wastes Management) system proposed by the Task Force attempts to bring together the various components/ activities which are necessary to ensure scientific ,technological and environmentally sound processing and disposal of MSW , robust management practices and financial viability. The synchronization of all the steps of MSW management mentioned below in a coordinated manner is considered as Integrated Municipal Solid Waste Management (IMSWM).

i. Segregation of wastes at source and involvement of all stakeholders in effectively managing MSW and minimizing waste going to landfills.

ii. Separation of four streams of MSW at source, namely, 1) construction and demolition wastes, 2) street sweepings and silt from drains, 3) wet bio-degradable and recyclable fraction separated at source in households, institutions and commercial establishments and, 4) single-source bulk wastes collected from market yards, restaurants and canteens, slaughter houses, etc by the municipality.

iii. Technological options which are feasible, financially affordable, and environmentally sound for processing and scientific disposal of MSW along with the financial mechanisms and institutional arrangements to set up treatment plants to recover maximum possible resources and energy from the wastes. Thus, reducing the amount of wastes going to landfill and ensuring better public health and the environment.

iv. Disposal of domestic and commercial waste stream rejects by setting up regional / common sanitary landfills through PPP mode or by municipalities,

v. Recognizing the role of information communication technology (ICT) systems for tracking, routing and monitoring operations (generally referred as smart management).

vi. Focusing not only on recovering resources and energy from the MSW, but also promoting conservation of energy and encouraging minimization of waste and promoting recycling of waste in all possible manner by adopting the “concept of 5-R” i.e. Reduce, Reuse, Recover, Recycle and Remanufacture.

vii. Recognizing the role of kabadiwalas and rag pickers and incorporate this informal sector in IMSWM. IMSWM facilitates sorting of recyclable materials collected by informal sector and support recycling industry by permitting the informal sector to use that designated storage and transfer station facility for segregation of recyclables..

viii. Use of combination of factors such as the range of population, quantity and quality (% biodegradable) of wastes generated, the cost of setting up of processing plants, expected quantities of value added products and by-products generated to select suitable technologies.

ix. Ensuring all approvals including land, EIA clearance etc., are available with the municipal authority before initiating bidding process,

x. Creation of Special Purpose Vehicle (SPV) and a new PPP module.

In order to ensure efficient collection of segregated MSW following steps have been recommended:

A. Improved MSW collection system

Separate collection and transportation of domestic (including trade & institutional waste), inert wastes such as street sweepings, silt from surface drains and C&D wastes shall be ensured by the municipal authorities. Inert wastes should be kept away from biodegradable and recyclable wastes to facilitate smooth processing of MSW.

With the view to increase efficiency and sustainability of waste processing facilitates, all efforts should be made to collect biodegradable and recyclable materials from the door-step and delivered directly to the processing plants.

B. Optimum Utilization of All Components of MSW

Optimum utilization of all components of MSW in a cost effective manner by use by adoption of the “concept of 5-R” Reduce, Reuse, Recover ,Recycle and Remanufacture and appropriate technology mentioned in Chapters 3 to 5 and minimization of waste going to landfill shall be the matter of prime consideration for all urban local bodies in India. The ultimate objective should be zero waste going to landfills.

C. Strengthened Plastic Waste Management System

The municipal authorities should put in place plastic wastes management system as mandated in the “Plastic Waste Management and Handling Rules 2011” to facilitate plastic reuse, recycling and energy recovery.

The proposed framework of integrated MSW management depicting the four necessary streams of waste collection can be seen in **Figure A.**

2. Decentralized and Centralized Approaches for Waste Processing

Municipalities should make a judicious plan of establishing decentralized and / or centralized facilities in their respective cities taking into account /considering a) availability of suitable land, b) community support, c) availability of operator for the facility and d) environmental concerns.

Experts recommend a decentralized approach for segregation at source, transportation, pre-processing of wastes, biomethanation, conventional composting and vermi composting and centralized approach for processing methods such as incineration, pyrolysis, gasification, RDF production, mechanical compost, C&D waste processing and engineered sanitary landfill.

Decentralized Approach: Municipal authorities should make serious efforts to minimize the cost of collection and transportation of biodegradable MSW as well as prevent odour and public health issues by setting up decentralized waste processing facilities such as composting, and biomethanation within the community (colony, housing society, institution premises, local area etc) through Resident Welfare Association (RWA), Community Based Organization (CBO), Non Governmental Organization (NGO), Advanced Locality Management (ALM), Self-Help Groups etc.

Centralized Approach: The MSW generated in the areas where decentralized facilities could not be set up by the municipality along with the recyclables and residual wastes emerging from the decentralized facilities should be transported to a centralized MSW processing facility such as composting, RDF, incineration, gasification, biomethanation, plastics to fuel etc., as per the norms recommended for cities of different sizes.

3. Technological Options and Operational Models

The following technologies are identified and recommended for processing of MSW:

i. Biomethanation for wet biodegradable wastes
ii. Conventional microbial windrow/mechanized/vermi composting for wet biodegradable wastes
iii. Incineration / Gasification / Pyrolysis for dry high-calorific value combustible wastes
iv. Preparation of briquette/ pellets/ fluff as Refuse Derived Fuel (RDF) from dry high-calorific value combustible wastes as a feedstock to power plants, cement and metallurgical industry
v. Conversion of plastic wastes to fuel oil by catalytic conversion and pyrolysis
vi. Combinations of aforementioned technologies have been identified based on a range of population and quantity and quality (% biodegradable) of wastes generated. In addition, the cost of setting up of processing plants along with the

expected quantities of value added products and by-products were also considered. Choice of suitable technologies based on the above (five) criteria for various classes of cities as per census, 2011 is depicted in the **Table A.**

For successful application of the combination of technologies suggested, wet waste, dry recyclable waste and other inert waste should not be allowed to be mixed as it would necessitate expensive technology and machinery to segregate them at the processing facilities making the process very expensive or even un viable. Instead, improvements may be made in the primary collection system of MSW as suggested in the report.

A. Following recommendations are made for various classes of cities

i. For cities with population of 2 million and above, which generate more than 1100 TPD of MSW is suitable for setting up a standalone waste to energy plant based on thermal route. These cities should also setup, a combination of biomethanation, composting (VC/CC) plants besides setting up of W to E plants to optimally utilize biodegradable wastes. Conversion of waste plastic to fuel oil which is an emerging technology is also suggested as an option.

ii. For cities with population between 1-2 million, which generate more than 550 TPD of MSW are suitable for setting up a waste to energy plant based on thermal route only with the support of adjoining cities supplying RDF to make the W to E plant viable. These cities should also setup, a combination of biomethanation, composting (VC/CC) plants besides setting up of W to E plants to optimally utilize biodegradable wastes. Conversion of waste plastic to fuel oil which is an emerging technology is also suggested as an option.

iii. In respect of 415 Class I cities which has a population range of 1 lakh to 1 million and generate 30 to 550 TPD of MSW, the technological options are a combination of biomethanation, composting (VC/CC) plants to optimally utilize biodegradable wastes. However, these cities may set up a common /regional W to E plant after ensuring adequate availability of RDF on a regular basis from participating cities. Conversion of waste plastic to fuel oil is also suggested as an option. Hill stations are also included in this set of cities and local bodies will have to ensure that recommendations made for hill cities in respect of technological options be used for ensuring proper disposal of MSW.

iv. Towns below 100,000 populations which generate less than 30 TPD waste and have 45 to 65% of biodegradable fraction of MSW, a combination of biomethanation, composting (VC/CC) and RDF preparation is considered the most suitable technological option for management of MSW. These cities should segregate dry waste, prepare RDF and can supply RDF prepared as fuel to W to E plants established in cities above 1 million populations.

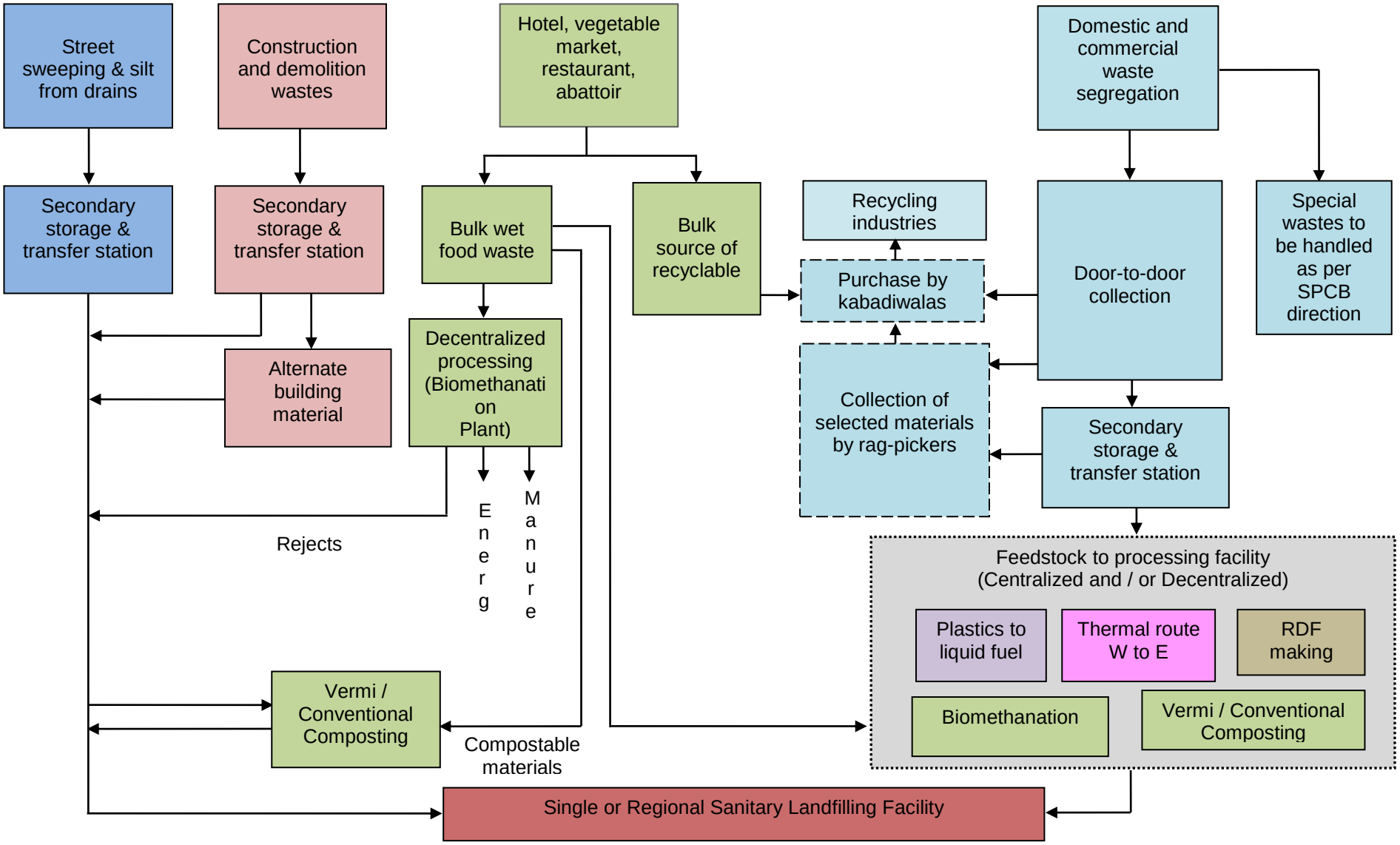


Figure A: General Framework for Integrated Municipal Solid Waste Management Scheme

Table-A Population based Technological options to Manage MSW in Towns and Cities

Sr. No.	Population range	Waste Gen.TPD	Composition	Technological options	Minimum requirements	Value added products	Approximate cost (excluding land cost)
1	Above 2 Million	>1100 TPD	Biodegradables 35 to 50 %	IWP comprising - BM +CC+ RDF W to E plant for power, based on: gasification , pyrolysis, incineration and mass burning. RDF to cement industry Plastic to fuel oil	Segregate wet wastes at source for BM and / or CC, dry wastes to be recycled or converted into RDF as feed stock for its own power plant / cement industry or any other power plant. Inerts to be land filled RDF must be burnt under controlled condition not below 850^{o} C	$75m^{3}$ of bio gas or 100 KW of electricity per 1 TPD of segregated wet wastes + 60 kg manure in case of BM , 200 kg per TPD vermi castings / CC per TPD 20 % RDF + 15 % compost. 1 MW power per 100 TPD of MSW.	Rs 5-7 Cr per 100 TPD of MSW composting + RDF Rs 15/20 Lakhs capital cost per 1 TPD for gas / electricity through Bio-methenation Rs 10 Cr per MW power plant. Rs 20 Lakh per 50kg capacity / shift catalytic conversion technology plastic waste to liquid fuel. Rs 16 Crore per 10 tonne of plastic (pyrolysis technology)
2	1 M to 2 Million	550 to 1100 TPD	Biodegradables 40 to 55 %	IWP comprising - BM +CC+ RDF W to E plant for power, where wastes exceeds 500 TPD based on: gasification , pyrolysis, incineration and mass burning. RDF to cement industry Plastic to fuel oil	Segregate wet wastes at source for BM and / or cc, dry wastes to be recycled or converted into RDF as a feed stock for large power plant and landfill the inerts RDF must be burnt under controlled condition not below 850^{o} C	Likely output from BM, as above. 20 % RDF + 15 % compost. 1 MW power per 100 TPD of MSW.	As above

Sr. No.	Population range	Waste Gen.TPD	Composition	Technological options	Minimum requirements	Value added products	Approximate cost (excluding land cost)
3	1 Lakh to 10 Lakh	30 to 550 TPD	Biodegradables 40 to 55 %	IWP-BM, CC + RDF as feed stock to power plant / cement industry. Plastic to fuel oil	Segregate wet wastes at source for BM and / or CC, dry wastes to be recycled or converted into RDF as a feed stock for large power plant / cement industry and inerts to be landfilled	As above for BM + CC and RDF to be used as feed stock for power plants / cement industry likely output: (20 % RDF + 20 % Compost). 25 to 40 Litres from 50kg plastic wastes	Cost for BM, CC and RDF as above Rs 20 Lakh per 50kg capacity / shift catalytic conversion technology for plastic waste to liquid fuel. Rs 16 Crore per 10 tonne of plastic (pyrolysis technology)
4	50,000 to 1 Lakh	10 to 30 TPD	Biodegradables 45 to 60 %	BM, VC or CC RDF	Segregate wet wastes at source for BM and / or VC / CC, dry wastes to be recycled or converted in to RDF as feedstock for power plants and landfill the inerts.	As above for BM +25 to 40 Liters liquid fuel from 50kg plastic wastes	Rs 15/20 Lakhs capital cost per 1 TPD for gas / electricity through Bio-methenation Rs 7- 10lakhs per TPD for VC/CC
5	Less than 50,000	Less than 10	Biodegradables 45 to 65 %	BM VC / CC and RDF	Segregate wet wastes at source for BM, /CC, dry wastes to be recycled or converted into RDF as a feed stock and inerts to be landfilled	As above for -BM	As above
6	Hill towns	State capitals	Biodegradables 30 to 50 %	BM, CC / RDF as feed stock. Plastic to fuel oil	Segregate wet wastes at source for BM / CC, dry wastes to be recycled and landfill the inerts. Dry wastes to be recycled or converted into RDF as a feeder stock. Plastic waste can be converted to liquid fuel and inerts to be landfilled	As above for BM + CC and RDF to be used as feed stock likely output: (15 to 20 % RDF + 15 % compost).	As above Rs 20 Lakh per 50kg capacity / shift catalytic conversion technology for plastic waste to liquid fuel Rs 16 Crore per 10 tonne of plastic (pyrolysis technology)

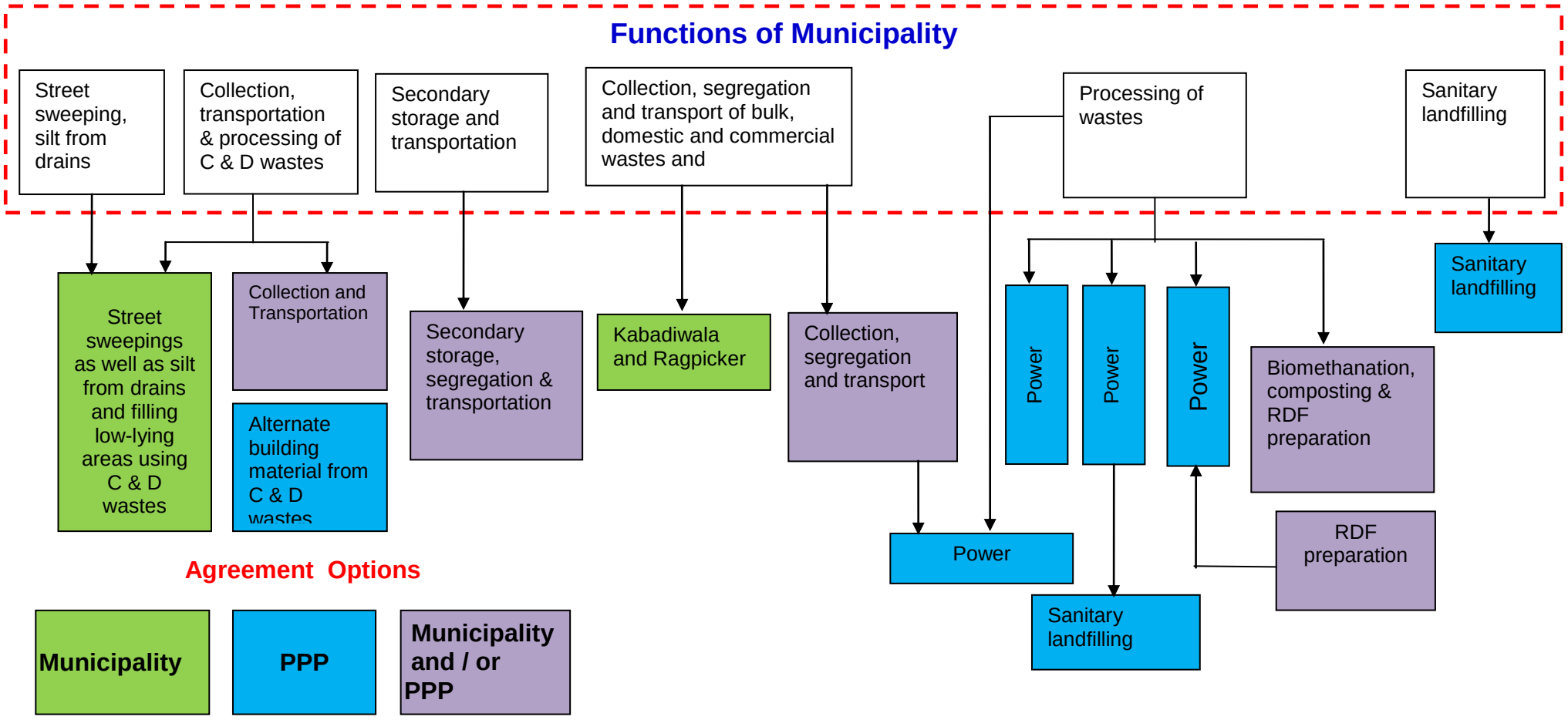


Figure B: Framework of PPP options for integrated MSW management

4. Framework for Public Private Partnership

Public private partnerships (PPP) may be encouraged in Solid Waste Management sector by the state governments through a policy framework on PPP and development of standard RFP documents including concession agreements clearly outlining the roles and responsibilities of private sector and the municipal authorities. A simple workable mechanism to resolve disputes that may arise between the concessionaire and the municipal authority during the concession period may be provided by the state to avoid long drawn litigations. PPP may be encouraged in providing services that are not currently provided by the municipal authorities ,as well as for setting up waste processing and disposal facilities. PPP projects will facilitate, putting private money into public projects (Ahluwalia, 2014) and pave way for infrastructure development. Through this mode of procurement, the government/municipal authority will be able to tackle serious problems of municipal waste management by combining the respective strengths of the public and the private sector. The municipal authorities may be fully apprised of the concept of PPP and the benefits they can derive through PPP mode of service delivery.

Keeping in view the current status of MSW management, three types of MSW management models are envisaged:

1. The functions that could be best performed by the municipal authority only (green box in Figure B)
2. The functions that could be performed by the municipal authority and / or private sector (purple box in Figure B)

iv. The functions that could be best performed by the private sector only (blue box in Figure B

In all three scenarios the municipal authority shall remain accountable for efficient delivery of service.

The municipal authorities are advised to follow recommended models (**Figure B**) on a PPP mode as detailed in the report.

PPP Scheme to avail Viability Gap Funding.

Municipal authorities with a population above 2 Million and where large W to E projects have been recommended should consider adopting the PPP scheme drafted by the planning commission and detailed in Chapter 6

A. Setting up of Processing and Disposal Facilities through PPP: The municipal authorities are not well equipped, either financially or technically, to process MSW and set up plants for conversion of waste to electricity / energy or compost nor do they have the in house capabilities to set up sanitary landfills for disposal of inerts and residual waste from the processing facilities. Hence, public private partnerships in this sector to set up waste to energy projects to generate power from the segregated high calorific value MSW or RDF, set up compost plants or biomethanation plants to process bio degradable fraction of

municipal solid wastes and setting up sanitary landfills for safe disposal of waste is recommended. .

Under this framework, it is further recommended that the processing of MSW involving setting up of W to E, RDF, biomethanation and composting technologies and for processing of C & D wastes and disposal of wastes at sanitary landfill should be entrusted to private sector partner on a PPP mode. If found necessary, the PPP contracts could to awarded for a group of activities (partial or complete) to facilitate integrated waste management as shown in **Figure B**.

B. Waste to Energy Plant: PPP projects may be promoted and supported for setting up viable waste to energy plants where the high calorific value dry municipal solid waste should be processed and output in the form of energy generated. The concessionaire should be responsible for setting up the waste to energy plant and process the waste by adopting an appropriate technology.

Waste to energy technology mainly consists of incineration, gasification and pyrolysis. For adopting any of these technologies, the minimum capacity of the plant should be about 300 tonnes of segregated waste per day (TPD) to make it commercially sustainable.

C. Waste to compost / Biomethanation Plant.: Projects in this area need to be encouraged and supported for setting up viable biomethanation and /or waste to compost plants where the wet biodegradable component of MSW be processed and output in the form of biogas (fuel or energy) or compost may be generated. The concessionaire should be responsible for setting up the Biomethanation or vermi/microbial compost plant and process the waste by adopting an appropriate technology.

D. Such plants could preferably be community based (maximum 20 TPD) or decentralized in various parts of the city and in the absence of suitable land or local acceptance, centralized plants may be set up. Centralized compost plants should preferably be under 300 TDP capacity. **Sanitary landfill construction:** Setting up of sanitary landfills for disposal of inert wastes and residual waste from the processing plants should be facilitated through a PPP mode. Projects must be of large capacity designed for a period of 25 - 30 years with initial cell capacity to handle waste not less than 100 TPD of inerts and residual waste for 5 years to ensure economic viability and professional management. This should imply that such individual facility can be supported in cities above 1 million population or regional /common facilities for a group of cities/towns having a total population above 1 million people.

E. Issues to be addressed in PPP Models :-Based on the observations of failures of PPP projects in MSW sector; the following recommendations are made to address the issues:

a. Municipal authorities should treat the PPP concessionaire as their partner and seriously work towards successful service delivery.

b. The Municipal authority should ensure supply of committed quantity / quality of waste and absence of inerts such as street sweeping, silt and construction and demolition wastes while delivering at the processing plant.

c. Municipal authorities should undertake the responsibility of collection of user fees and should not link the recovery with the payment to the concessionaire

d. The tariff structure should adequately cover the risk of steep increase in the fuel price and wage structure to ensure viability of the project

e. ESCROW account mechanism should be created to avoid delay in release of payment to the concessionaire

f. Supervision of the performance of concessionaire should be done through professionals and supervision by multiple agencies should be avoided

g. Selection of appropriate site and all necessary clearances (such as EIA, Consent to Establish etc) should be ensured by the Municipal Authority before the bidding process

h. Dispute resolution mechanism must be a part of the contract Agreement clearly binding both the parties for resolution of dispute through a mutually agreed arbitrator.

i. While imposing penalty on the concessionaire the reasons for failure need to be carefully ascertained.

5. Financing the projects

The Government of India, through various schemes extends financial support for introducing appropriate solid waste management systems and for setting up processing and disposal facilities.

The municipal authorities and respective State Governments must avail the existing grants and assess the gap if any in putting the entire system in place as recommended. The gap could be bridged partly, by levying user charges/taxes and the remaining gap could be bridged through the additional grants from the central and state governments as detailed out in this report.

The municipal authority should endeavour to involve private sector in providing services and setting up waste processing and disposal facilities on a PPP basis.

The municipal authority through respective State Governments may request the Government of India, Ministry of Finance to extend support in the form of viability gap funding in capital investments and/or performance based Operation and Maintenance (O&M) grants to the operator for ensure the commitment of the operator of the facility to run the project efficiently and to reduce the tipping fee burden on the local authority. The Government of India may consider formulating a policy of gradually replacing the initial capital subsidy by outcome based subsidy to meet the viability gap in O&M of the project.

Support may also be extended to all municipal authorities to revive existing non-functional/partially functional waste processing plants funded earlier under various schemes of Government of India or State Governments.

A. Proposed Support for Capital Investments and O&M Costs

Under JnNURM all cities and towns are eligible for Grants, under UIG component or under UIDSSMT schemes. The current UIG support covers only 65 cities, it is proposed that efforts should be made to widen the coverage and to extend financial support to at least 468 class 1 cities which will cover over 70% of the urban population. It would not be difficult for the Central Government to look at the needs of these cities critically and even monitoring their performance. The remaining 7,467 small local authorities including 3894 census towns (urban centres) not covered under such schemes may also be given financial support through state agencies to put their MSW management systems in place to ensure that MSW systems improve in all small towns and large cities simultaneously: The support to census towns other than municipalities can be rooted through respective state agencies.

A.1 Segregation, Collection and Transportation: The capital investment required for these activities may be shared as under:

i. 35% grant from central government
ii. 35% grant from state government
iii. 30% investment from the municipal authority from its internal sources and / or through equity from private sector

A.2 Centralized Processing Plants

i. 40% viability gap funding for capital investment from the Government of India or 20% viability gap funding each for capital investments and O & M costs linked to performance.
ii. 10% support from the State Government towards O&M expenditure. Minimum 30% to be invested by private sector.

A.3 Decentralized Processing Plants

i. 40% from the Central Government towards capital investment or 20% viability gap funding each for capital investments and O&M costs linked to performance.
ii. 20% from state and/or ULB's as a viability gap for O&M Costs based on performance.
iii. 40% investments from private sector

A.4 Support to existing defunct/partially functional processing plants

The municipal authority a may consider inviting private sector to operationalize defunct plants earlier funded by Central or State grants/schemes. Funding support may be extended as under:

Capital Subsidy

i. 50 % from government of India

ii. 20% state government

iii. 30% investment by private operator

A.5 Construction and Demolition Waste Plants

i. 30% grant from central government

ii. 20% grant from state government

iii. 50% to be borne by private sector

B. Common Regional Sanitary Landfill Facility (SLF) for Disposal of Inerts

Cities above one million populations generating over 100 TPD residual wastes for disposal should set-up their own landfill and permit all cities and towns within 50km periphery of the city to use that facility for disposal of their waste. Common regional facilities may be constructed for rest of the 7,882 cities, towns and urban centres by forming clusters within 50 km radius with a population of at least one million. Only in special cases, where, the distances between the cities are large the cluster size may be brought down suitably to handle at least 50 TPD of residual waste. For smaller cities, common / regional facilities are recommended as individual facilities are both neither economically viable nor can be managed sustainably. Construction of SLF's and common SLFs can be financially supported as under:

i. 33% grant from Central Government of India limited to Rs 2 crore

ii. 33% from the State Government authority limited to Rs 2 crore.

The Government grants for SLF's and CSLF may be 33% limited to 2 crores of the cost per 1 million populations. If the landfill covers larger population the support could be proportionately increased. As a pre-condition to aforesaid grant, suitable land for SLF should be made available by the ULB/State Government to the concessionaire with all necessary clearances.

C. Rehabilitation and Capping of Dumpsites

Rehabilitation and Remediation of abandoned landfills including capping of dumpsites should be initiated on priority in the cities where water table is generally high and the amount of waste being deposited is large. Scientific assessment of contamination of soil and groundwater should be undertaken and extent of damage and possibilities of remediation may be ascertained. Based on the outcome and cost implications, a strategic decision regarding remediation and or capping should be taken. Capping should be planned to minimize further damage and release of the part of the land by scraping and accumulating scattered waste and using it for sanitary landfills or putting it to a profitable use. Remediation to release precious land is therefore recommended.

Financial support to the extent of 50% of the cost by the Central Government and 20% cost by the State Government may be considered.

(The operation and maintenance cost of primary collection and transportation of waste in an efficient manner may be met by ULBs through levy of user fees as per paying capacity and waste generation rates of the users as recommended in this report and ensuring its recovery by timely billing and efficient collection. Municipality may meet the gap in the O&M cost by levy of sanitation tax. The basic principles to be considered by Local Bodies while prescribing norms for levying user/service fee for MSW services include: polluter pays principle, proportionality and capacity to pay.)

D. Viability Gap Funding Support

Viability of waste processing technologies on PPP mode is a matter of great concern. It is considered essential to bridge the viability gap through financial support from government of India, state government and municipal authorities. After carefully examining the viability gap, it is felt that private sector may be given viability gap funding to the extent of 40% towards capital expenditure by the central government upfront or 20% viability gap funding each for capital investments and O&M costs linked to performance and another 10% by the state governments for the sustainability of such projects.

The total VGF should be the bidding parameter and should be determined by competitive bidding. The private entity which seeks lowest viability fund will be selected to execute the project.

Such support can be linked to performance of the plant. In that case, viability gap funding may be given per unit of electricity produced or per tonne of compost produced, for a fixed period of 3-5 years. Support may also be extended in setting up common regional sanitary landfill for cluster of cities, remediation/capping of dumpsites as well as for supporting door to door collection, secondary storage and transportation of waste to ensure that the processing plants get committed quantity and quality of waste. The municipal authorities should facilitate private sector in availing viability gap funding and avail themselves the support for improving collection and transportation on the lines recommended in the chapter on public private partnership (PPP).

E. Cost Implications

The Task Force has recommended a framework for technological options leading to optimum utilization of all components of wastes and to extend financial support for setting up MSW processing facilities in all cities and towns including urban centres declared as census towns and regional landfills. The preliminary estimates indicate that 88 W to E power plants generating 439 MW power from the combustible non-recyclable fraction of waste can be set up in large cities preferably in 1 million + cities. Besides large power plants, biomethanation and compost plants (@ 1 plant in each urban centre and about 200 large and 300 medium size regional sanitary landfills(in all 500) to cover all 7935 urban centres are required to be set up. All small towns need to segregate combustible waste and supply as feed stock in the form of RDF to power plants /cement plants to facilitate utilization of such waste

With a view to facilitate the GoI in determining the financial support to the ULBs; a cost estimate has been prepared (**Table B)** for setting up waste processing plants including W to E plants, preparation of RDF, biomethanation, composting and vermin-composting facilities. The estimated capital investment works out to be approximately Rs. 11,951 crore.

The ball-park cost estimates for procurement of tools, equipments and vehicles for meeting the capital costs for collection and transportation of MSW as well as for setting up of engineered sanitary landfills have been estimated. The preliminary estimates indicate that the capital costs for collection and transportation of MSW and for setting up of approximately 500 engineered sanitary landfill facilities (SLF) worked out to be approximately Rs. 10,740 crore (**Table C).** This includes provision of mechanized sweeping as advised by MoUD in one million plus cities at a cost of Rs. 208 cr. This amount may have to be spent over a period of 3 years at the rate of 3,580 crore per year. The central government and state government could support this cost by giving grants as recommended in the report.

The report also estimates the total investment required for the sector and the share of Government of India, State Government and private partner for the various activities to be undertaken in a PPP mode including revitalizing the defunct MSW processing plants set-up through government grants, remediation and capping of dumpsites and C&D waste processing. Total investment required is Rs. 24,691 crore assuming availability of assets worth 20% with the municipal authorities, the total investment works out to be Rs.20, 153 crore. As detailed earlier and as depicted in the **Table D,** the cost share of GoI, State and the private partner varies from activity to activity and works out as under:

I. Government of India share Rs. 7,670

II. State Government share Rs. 4,302

III. Public partner share Rs. 8,181

Apart from these, it is estimated that Rs 600 crore will be required to set up the proposed Centre of Excellence in IITs in the four regions of the country for R & D in technology for MSW management and recycling.

With a view to facilitate smooth disbursement of funds MoUD should be designated the single point of support. The support of Ministry of Agriculture, Ministry of New and renewable energy, CPCB etc could be channelized through MoUD in a well coordinated manner.

6. Institutional mechanism and management structure

The following institutional arrangement at central, state and municipal levels is proposed

A. Central Government

i. Establish an Authority or Mission on Solid Waste

ii. Set up a Special Technical Cell under the Authority. This cell could guide the states on appropriate technologies on processing and disposal of waste in consultation with CPCB.

iii. Allocate funds to states/ ULBs for improving MSW systems and setting up waste treatment and disposal facilities.

iv. Support programmes of training and capacity building.

v. Central and State Governments may consider giving Tax holidays /incentives to waste processing and recycling industries for at least 10 years.

vi. The Central and State Agencies may provide training to young entrepreneurs in setting up and operating and maintaining such plants

Table B: Tentative Capital cost estimates for processing various fractions of MSW

Sr. No.	Classif-ication of Cities	No of Cities	Population, % of Total Urban population & GPCD*	Quantity of waste Generated TPD	Waste to be treated (65%)** TPD	I Waste for W to E		II Waste for Bio-Methanation		III Waste to Compost		Cost I (10/12** *Cr per 75 TPD)	Cost II (15 Cr per 100 TPD)	Cost III Rs 5 Cr per 100 TPD)
						TPD	in %	TPD	in %	TPD	in %			
1	More than 1 M	53	160 M, 42.4% & 550 gm	88,000	57,200	22,880	40	5,720	10	28,600	50	3,050	858	1,430
2	0.1 to 1 M	415	105 M, 27.9% & 450 gm	48,000	31,200	7,800	25	6,240	20	17,160	55	1,248	936	855
3	Below 1 lakh	7467	112 M, 29.7%, 300 gm	34,000	22,100	2,210	10	6,630	30	13,260	60	354	995	665
	Total		377 M, Average 450 gm	1,70,000	1,10,500	32,890		18,590		59,020		4,652	2,790	2,950
												# Grand Total approx. Rs 10,392 Cr		
Add 15% on account of likely price rise during procurement over a period of 3-5 years												**1,559 crore**		
TOTAL												**11,951 crores**		

Note: The total cost can be reduced by about 15-20% by deducting the cost of existing operational plants

The cost figures are tentative and hence the estimates could be ± 15% .

* GPCD is grams per capita per day

** This does not include 17,000 TPD (10%) recyclable wastes collected by rag pickers and 42,500 TPD (25%) of inert waste

*** 2 crore per100 TPD addition amount is proposed for segregating RDF in smaller towns

Table C: Cost estimates for procurement of vehicles, tools and equipments for MSWM and SLF

Item	Numbers Required	Unit cost (in Rs.)	Total cost (in Rs.)
Door to door collection vehicles @ 1 vehicle per 10,000 population	37,700	5.5 lakh	2,073 crore
Containerized Tricycles for door to door collection from narrow lanes and low income settlements (20% areas)	75,400	16,000	121 crore
Handcarts for street sweepings @ 2 per 1000 population	7,54,000	8,000	603 crore
Mechanical road sweepers @ 2 for One Million plus cities	320	65 lakh	208 crore
Secondary Storage containers (1.1 m^3) for street sweepings and inerts only (30% waste)	1,80,000	20,000	360 crore
Compactors for transportation	4,875	31 lakh	1,511 crore
Transfer stations for 50% waste	250	4 crore	1,000 crore
Common Sanitary Landfills for 25% waste for 5 years capacity	about 500 for disposal of 42,500 TPD	500 per tonne/day for 5 years	3878 crore
TOTAL			9754 crore Or 9760 crore
10% increased on account of likely price rise during procurement over a period of 3 years			10736 Or 10,740 crore

Note: The total cost can be reduced by about 15-20% by deducting the cost of existing vehicles tools, and equipments

Table D: Recommended cost sharing for MSWM activities

Sr. No.	MSWM Activity	Total Investments (Rs in Crores)	Required Investment (80%) (Rs in Crores)	GoI Share (%) (Rs in Crores)	State Share (Rs in Crores)	PPP Share (%) (Rs in Crores)
1	Collection, Storage and Transportation *etc*	6,862	5,490	1,922 (35%)	1,922 (35%)	1647 (30%)
2	MSW processing	11,951	9,561	3824 (40%)	956 (10%)	4,780 (50%)
3	C&D Waste Processing	500	500*	150 (30%)	100 (20%)	250 (50%)
4	Support to Non-Functional Plants	500	500*	250 (50%)	100 (20%)	150 (30%)
5	Support to Regional Common Sanitary Landfills	3,878	3,102	1,024 (33%)	1,024 (33%)	1,054 (34%)
6	Remediation of Dump Sites /Capping	1,000	1,000*	500 (50%)	200 (20%)	300 (30%)
	Total	24,691	20,153	7,670	4,302	8,181

Note: * Budget provision suggested

B. State Government

i. All State Governments may set up solid waste management authority with experts on various aspects of MSW, including contracting and financial management.

ii. The authority should be responsible for assessing: the correct status of MSW, setting up processing and disposal facilities, regional sanitary landfill, detailed project reports (DPRs) for obtaining Central Government assistance, appointing transaction advisors for bid process management, guide ULB in obtaining necessary clearances / authorizations and oversee the construction, operation and maintenance of waste processing and disposal facilities.

iii. Support programmes for training and capacity building.

iv. The State Agencies may provide training to young entrepreneurs in setting up and operating and maintaining such plants.

C. Municipal level

i. All municipal corporations should have a MSW Management Department and other municipal authorities should have a MSW Management Cell and minimum technical and supervisory staff as per the yard stick prescribed by the State MSW Authority to ensure efficient MSW service delivery.

ii. Municipal authorities to carefully read through the report, implement the recommendations of the Task Force to avail the Viability Gap Funding (VGF) and grants.

iii. Municipal authorities should ensure the implementation of the integrated MSW management system as recommended by the Task Force - which consists of the following four streams of wastes namely, 1) street sweepings, scattered wastes and silt from drains 2) construction and demolition (C & D) wastes 3) single source bulk wastes collected from market yards, restaurants and canteens, slaughter houses, etc., 4) wet biodegradable and recyclable fraction from households, institutions and commercial establishments.

iv. Municipal authority may facilitate setting up of decentralized and centralized processing as elaborated in recommendation 2.

v. Municipal authority should purchase power from the concessionaire at a rate approved by the regulatory authority.

7. Policies, Strategies, Legislation and Program

A. Policy

i. The MoUD should come out with a national policy outlining the country's intentions about handling waste of all types and clearly demarcating the role of central government, states and local authorities. The national goal should be clearly stated, specifically indicating what will be achieved by the end of each Plan.

ii. A National Policy on “Recycling, Resource Conservation and Preventive Environmental Management” be notified.

iii. A performance based viability gap funding for waste processing projects.

iv. A performance based incentives in the field of environment and waste management for rewarding excellence be initiated and implemented.

v. An action plan to implement specific recommendations made regarding this sector in the NEP be actively pursued. Details are in chapter-1.

D. Strategy

i. There should be a national strategy as to how the problems of municipal solid waste management will be handled including what type of funding and support will become available.

ii. Each state should come out with its own policy and strategy keeping in view the national policy and strategy as envisaged in the draft MSW rules, 2013.

iii. There should be a national standing task force/committee of eminent persons and experts to oversee the progress and report independently on the progress made by the states and the shortcomings that need to be addressed.

iv. National Recycling Programme (NRP): The NRP should be an overarching framework to create and mainstream the organized waste management and recycling industry. Structured frameworks and guidelines for recycling industry should be developed under the NRP to integrate it with the existing waste management rules & guidelines. Industry and sector specific recycling standards, including recycled product standards be developed under the NRP.

v. Preparation of “model DPR”, RFPs including concession agreements for PPP contracts, guidelines on setting up common and regional Sanitary Landfill Facility (SLF) and waste management in hill towns and the north east region should be undertaken by MoUD with the help of appropriate expert consultation.

vi. Evolving a mechanism at state level for capacity building and handholding, where necessary, of municipal authorities and make sure that all the local bodies implement the rules in a given time frame and achieve the service level benchmarks prescribed by MoUD and adhere to national sanitation policy in place

E. Legislation

i. MoEF should consider re-introducing a reasonable time frame for the implementation MSW Rules and Plastic Waste (Management and Handling) Rules 2011, by all the local bodies in the country.

ii. The State governments should be mandated to identify suitable lands to set up MSW processing facilities and for construction of sanitary landfills for large cities and regional landfills for group of small cities/towns where suitable lands are not available with the urban local bodies.

iii. The town planning departments of respective States should be directed and authorized to reserve from time-to-time suitable parcels of land for setting up MSW storage, processing and disposal facilities while preparing development plans/ land use plans for cities and towns.

iv. In 1 million plus cities metropolitan planning authorities should have at least two experts on municipal waste management who could advise on reservation and selection of appropriate land for setting up waste processing and disposal facilities for large cities from time to time and also for setting up waste storage and transfer station facilities within large cities. Similar arrangement need to be made in district planning committee for addressing the issues of solid waste management in municipal authorities having population below 1 million.

v. Mandate citizens/waste generators to segregate the three major components of wastes namely biodegradable waste, non-biodegradable waste and domestic hazardous waste at source.

vi. Make it mandatory for municipal authorities to have at least three streams of waste collection namely

d. Biodegradable and combustible wastes stored at households, shops and establishments and collected from the door step to be directly delivered at the processing facility.

e. Inert waste such as street sweeping and silt from the drain to be collected and transported separately and taken directly to waste disposal site without mixing with waste collected from the door step.

f. Construction and demolition waste to be collected separately and utilized for making bricks, paver blocks, aggregate or any other useful product and for filling in low lying areas, bio-engineering works for mosquito breeding prevention *etc*.

vii. Mandate preparation of an action plan at state level to ensure municipal authorities implement the rules in a given time frame.

viii. Specify the most appropriate and viable waste processing technologies for small, medium and large cities in the country.

ix. In respect of sanitary landfills the rules should specify the minimum size of the sanitary landfill and encourage setting up of regional landfills for small cities and towns.

x. Separate provisions should be made for management of municipal solid waste (MSW) in Hill Areas.

8. Research and Development in MSW Sector

It is recommended that Indian Institute of Technologies (IITs) and leading scientific institutions be encouraged to take up research projects and programmes in the MSW sector, including recycling and W to E technologies. At least four institutions, be identified - one each in north, south, east and west; where ***Centre of Excellence*** can be set up with Government of India support. This support may be extended for a period of 10 years and budgetary provision of Rs.150 crore per institution (total Rs 600 crore) could be made to support research and development. These institutions may also undertake R&D

activities on the various processing technologies in vogue, their suitability in Indian conditions in addition to developing new technologies, products, and management practices.

The government of India and the state governments should play a major role in dissemination of information on the outcomes of R&D conducted by centres of excellence, on the recommendations contained in this report as well as other relevant reports and provide adequate training support to the municipal authorities in achieving the desired objectives

9. Smart Waste Management

i. The use of Information Communication Technology (ICT) in MSW management is recommended as it will reduce manual effort and enhance the efficiency of collection, transportation, and identification of dumping site, manpower management, resource management and addressing citizens' complaints.

ii. Use of technology in synchronization of waste vehicle tracking and quality monitoring should help to ensure better performance of the system.

iii. A Pilot SM-WMS project should be initiated and systems /equipment be standardized enabling cost reduction and easy replication.

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Annexure I-A

State wise generation, collection and treatment of MSW

Sr. No.	State	Quantity Generated (TPD)	Collected (TPD)	Treated (TPD)
1	Andaman & Nicobar	70	70	05
2	Andhra Pradesh	11500	10656	9418
3	Arunachal Pradesh	181	181	-
4	Assam	650	350	100
5	Bihar	1670	-	-
6	Chandigarh	340	330	250
7	Chhattisgarh	1896	1704	168
8	Daman Diu & Dadra	85	85	Nil
9	Delhi	7500	4500	2500
10	Goa	183	182	182
11	Gujarat	8336	7378	116
12	Haryana	3490	3440	570
13	Himachal Pradesh	1370	280	160
14	Jammu & Kashmir	1792	1322	320
15	Jharkhand	4450	1889	71
16	Karnataka	9500	5700	2000
17	Kerala	1576	1072	434.
18	Lakshadweep	21	-	-
19	MP	5079	4298	802
20	Maharashtra	17000	14900	4700
21	Manipur	176	125	-
22	Meghalaya	268	199	98
23	Mizoram	552	276	Nil
24	Nagaland	270	186	18
25	Orissa	2383	1986	30
26	Puducherry	495	495	Nil
27	Punjab	3853	3853	365
28	Rajasthan	5037	2491	490
29	Sikkim	40	25	25
30	Tamil Nadu	14532	14532	1607
31	Tripura	360	216	40
32	Uttar Pradesh	19180	-	-
33	Uttrakhand	1251	1235	Nil
34	West Bengal	8674	7196	1415
	Total	**133760**	**91152**	**25884**

Annexure I-B

The original order for constitution of the "W to E Task Force"

N-14070/08/2013-Infra
Planning Commission
(PPP & Infrastructure Division)

Yojana Bhawan, New Delhi,
Dated June 05, 2013.

OFFICE MEMORANDUM

Subject: Constitution of Task Force on Waste to Energy Projects

Increasing urbanisation and changing lifestyles of people has given rise to generation of large quantities of wastes leading to increased threats to the environment. In recent years, technologies have been developed that not only help in generating energy from the waste but also in reducing the quantity of waste for its safe disposal.

2. To examine the technological aspects of Waste to Energy projects, it has been decided to constitute a Task Force as under:-

Chairman

i) Dr. K. Kasturirangan, Member, Planning Commission

Members

ii) Secretary, Ministry of Urban Development
iii) Secretary, Department of Atomic Energy
iv) Secretary, Ministry of Power
v) Secretary, Ministry of New and Renewable Energy.
vi) Adviser to Deputy Chairman, Planning Commission
vii) Dr. Indrani Chandrasekharan, Consultant, Planning Commission

Experts

viii) Prof. S. Dasappa, Centre of Sustainable Technologies, Indian Institute of Science, Bangalore
ix) Mr. Amit Kumar, Director, Energy Environment Technology Division, The Energy Research Institute (TERI), New Delhi

3. The Chairman shall co-opt two more technical members to the Task Force.

4. The Task Force would submit its report within a period of three months.

5/6/13

(Ch.P.Sarathi Reddy)
Director (Infra)
Tele: 011-23096747

To
As per list enclosed

1

Annexure I-C

Decision Support Matrix

Rationale behind suggesting scores for each unit operations in MSW management.

Segregation at Source: Ghantagadi system of door-to-door collection of MSW in segregated fashion is seen as a difficult thing to set up in most of the ULBs. However, it is not often recognized that the transportation and segregation of putrified garbage at a centralized location is no mean task! No wonder there exists any successful centralized segregation facility where work is being carried out with the help of machines successfully. The work force will be more unhappy handling waste that emanates foul odour and is a health hazard.

Transportation: Transportation is a modular activity and therefore there is no advantage on account of "economy of scale".

Pre-processing of Wastes: Pre-processing of wastes may be not be a difficult task in the case of a decentralized system as the quantity of waste that is needed to be handled will be less. In case of a centralized system, the quantity of waste to be pre-processed will be more and will be less efficient.

Biomethanation: Segregated wet waste is required as feedstock along with water as the other input. Suitable for both centralized and decentralized system of waste handling specifically for source segregated waste from kitchens, canteens, institutions, vegetable markets *etc*. Biomethanation can be used for handling 1 TPD to 20 TPD segregated wet biodegradable wastes.

Conventional Composting: Segregated wet waste from apartments, companies, government offices can be used to conventionally compost in a decentralized manner. However, in a centralized manner it is a difficult task to achieve conventional composting as it is more time consuming and requires larger area and there is limited market for the compost that is generated.

Vermi-composting: Vermi-composting can be used for a segregated wet waste degradation in a decentralized manner. The advantages of vermi composting in decentralized manner is handling of biodegrade waste or cast becomes easy as quantity of wastes in decentralized system will be relatively less and fouling chances are less as waste transportation distance is minimized. The atmospheric conditions such as temperature, humidity, moisture content *etc*., can be controlled to some

extent in a decentralized system whereas it is difficult to achieve these in centralized system of MSW management.

Mechanical Composting: It can be used for a segregated wet waste degradation in a decentralized manner with the help of small machine (mechanical composter) in case of a restaurant, hotel kitchen, canteens, departmental store, housing society, bus stand, railway station, individual bungalow, school, resort or any small quantity generator of MSW. Also, the technology at decentralized scale and the machinery is indigenously developed and available from Indian service providers. Mechanical composting has also been practiced for centralized large scale applications in the developed world. Manure produced in the process can be used in organic farms or gardens. The centralized systems of composting require very large tracts of land and market for compost is low. One of the issues with mechanical composting is that it calls for capital cost investment to purchase a machine.

Refuse Derived Fuel (RDF): RDF is typically that portion of MSW which is incinerable or suitable for furnaces or boilers to generate heat or steam. For ease of handling, storing, transporting and derivation of energy, RDF is converted into dry non compacted burnable fluff or with the help from high energy liquid waste fuels as well as by blending other solid residues including farm residues, sawdust, scrap wood, biomass like rice husk, sugarcane baggas or coconut shells and coirs may be mixed with MSW fluff in appropriate proportions or made into pellets or bricks using mechanical force. Such pellets or briquettes have higher density hence better burning rates and thus may prove to be superior to modern boilers. It should, however, be remembered that equally high quality burning and heat generation rate is possible in modern boilers by directly charging dry fluff into burning zone. Production of fluff or bricks or pellets can be conveniently made from MSW using small machines in case of decentralized system. These fluff or bricks or pellets can easily be transported to the nearby industry as a boiler feed or furnace for generating heat or steam. The centralized system can produce RDF using large equipments at one place. The transportation of MSW to the RDF production plant may add up to the cost.

Incineration: Incineration is the oxidation of the combustible materials contained in the MSW. Incineration is used as a treatment for a very wide range of wastes. This process can reduce the waste volume up to 90% and the capital cost of this process is lower than the cost of biomethanation process. This will work out best in a centralized system.

Pyrolysis / gasification: Gasification is the incomplete combustion of wastes (biomass, automotive shredder residue, coal, plastics,

polyvinyl chloride, sludge, tires and organic waste generated from the MSW), in the presence of limited oxygen supply to generate syngas. Pyrolysis is combustion of wastes in absence of oxygen at higher temperature generate products in the form of solid (coke) and liquid (tar and oil). This method can reduce the volume of MSW by 50–90%.

Plasma arc gasification: Plasma is often called the fourth state of matter containing a significant number of electrically charged particles. A plasma arc torch increases the temperatures in the reactor gasification vessel to as high as 3,300–6,000 ^{0}C and even as high as 15,000 ^{0}C. The two process gasification *i.e.* by means of partial combustion with oxygen followed by gas turbine combustion with sufficient oxygen to produce high energy output from MSW. This technology is new and requires huge capital to set up. In addition, handling this system require trained worker.

Engineered Sanitary Landfill: In India, more than 90% of MSW in cities and towns are directly disposed off on land in an unsatisfactory manner. Sanitary landfilling is an acceptable and recommended technique for final disposal of MSW. It is a necessary component of MSW management, since all other options generate some residues that must be disposed off through landfilling. This is well suited for centralized system.

The basis for scoring was attributes such as technical feasibility, managerial, social acceptance, operation and maintenance advantage, capital cost and recycling potential. The "average scores along with the standard error" is mentioned in Appendix II.

Decision Support Matrix: Statistical Summary of Opinion of the Experts

S. No	Unit Operation or Step in MSW Management	Technical Feasibility		Managerial Feasibility		Social acceptability		Low Capital Cost Advantage		Low O & M Cost Advantage		Recycling Potential	
		C	D	C	D	C	D	C	D	C	D	C	D
1	Segregation at Source	6±0.76	6.9±0.98	6.2±0.57	6.4±0.78	7.3±0.45	5.4±.64	6±0.56	6.3±0.65	5.7±0.45	5.7±0.76	5.2±0.70	6.6±0.86
2	Transportation	6.5±0.64	7.8±0.77	6.7±0.50	7.3±0.86	6.9±0.46	6.5±0.79	5.5±0.64	6.8±0.71	5.6±0.58	6.5±0.65	6.6±0.48	6.8±0.77
3	Pre-processing of Wastes	6.5±0.56	6.3±0.86	6.3±0.68	5.9±0.86	6.7±0.56	5.8±0.76	5.3±0.60	6.6±0.78	5.6±0.52	6.6±0.67	5.5±0.60	6.6±0.73
6	W to E: Bio-methanation	3.6±0.67	6.9±0.77	4.1±0.82	6.8±0.79	6.1±0.48	6.3±0.84	4.9±0.64	6.6±0.67	5±0.60	6.7±0.62	5.2±0.68	6.9±0.77
5	W to E: Con. Composting	6.5±0.48	5.5±0.72	6.6±0.54	6.1±0.77	6.5±0.52	5±0.58	5±0.71	5.8±0.68	4.9±0.66	5.5±0.50	5.1±0.64	6.4±0.65
6	Vermi-Compostiing	7.1±0.31	5±0.68	6.7±0.37	5.1±0.67	7.5±0.31	6.1±0.64	6.3±0.47	5.3±0.62	6.1±0.38	5.2±0.66	6.5±0.54	5.9±0.59
7	W to E: Mechanical Composting	8.7±0.26	3.4±0.62	8±0.42	3.8±0.59	6.3±0.79	4±0.49	6.1±0.62	3.9±0.46	6.6±0.43	3.5±0.54	6.4±0.83	3.7±0.84
8	W to E: RDF Production	7.6±0.48	4.6±0.62	6.6±0.48	4±0.58	6.4±0.64	4.2±0.42	5.5±0.58	3.5±0.45	5.8±0.53	3.2±0.44	6.4±0.88	4.5±0.86
9	W to E: Incineration	5.9±0.72	2.8±0.65	5.4±0.76	3±0.65	6.6±0.48	3.6±0.69	4±0.84	3±0.83	4.4±0.73	3.4±0.82	6.4±0.91	3±0.73
10	W to E: Pyrolysis / Gasification	6.9±0.59	4.8±0.70	6.4±0.45	5.2±0.71	6.4±0.50	4.8±0.55	6.3±0.40	5.2±0.61	6.4±0.62	5±0.56	5.2±0.70	4.5±0.73
11	W to E: Plasma Arc Gasification	8.7±0.42	3.6±0.62	7.9±0.41	3.5±0.54	7.6±0.73	3±0.60	6.9±0.57	4.3±0.80	6.7±0.65	4.1±0.77	3.6±1.05	2.3±0.72
12	Disposal of Road Sweeping & C&D	4.7±0.65	7.7±0.50	4.7±0.50	6.1±0.66	5.8±0.51	6.3±0.63	4.9±0.81	7.6±0.78	5.7±0.52	7.6±0.40	5.6±0.56	7.8±0.73
13	Engineered Sanitary Landfill	7.2±0.68	8±0.56	7.6±0.64	7.3±0.68	7±0.42	6.8±0.59	5.2±0.80	6.8±0.53	5.2±0.53	6.8±0.53	4.4±0.70	6.2±0.96

Annexure I-D

SWOT matrix to be used by the customer and provider of technology for management of MSW

S.No.	Technology	Opportunities driven by internal strengths	Opportunities compromised by internal weaknesses	Threats minimized on the basis of internal strengths	Threats aggravated due to internal weaknesses
		+ +	+ -	- +	- -
1	Mass Burn	No segregation at source or segregated transportation required Storage for longer duration not needed Can be located relatively closer to the city, minimizing the cost of waste transport.	Incineration of mixed waste leads to wastage of energy on account of moisture content in the waste and thus results into lower net energy production. Mixed waste has low calorific value. Therefore, W to E is not economically feasible Auxiliary heat (fuel) may be required to sustain the process Consistency in temperature need to be maintained during the operations Air emissions include acid gases, dioxins and furans, nitrogen oxides, sulphur dioxide, particulates, cadmium, mercury, lead and hydrogen sulphide	Putrification of wet wastes and odour problems get minimized due to possibility of charging the mixed waste into incinerator relatively sooner. Transmission of disease is minimized as no pre-processing and direct contact with waste is required.	Poor management leading to foul odour and environmental pollution Waste of energy on account of charging wet non-homogenized wastes Seasonal variability of waste composition and moisture will lead to poor performance of the incinerator
2	Pyrolysis and Gasification	Production of fuel gas / oil, which can be used for a variety of applications Gasification and pyrolysis technologies are able to recover	Segregation of MSW is necessary. This necessitates additional land, Infrastructure and O & M cost Consistency in temperature need	High energy recovery due to use of well-segregated and controlled feedstock	Excessive moisture in wastes leads to waste of energy as well as air pollution control technology requirement add-up to increase in

S.No.	Technology	Opportunities driven by internal strengths	Opportunities compromised by internal weaknesses	Threats minimized on the basis of internal strengths	Threats aggravated due to internal weaknesses
		much more value from waste compared to mass burn incineration Syngas generated in the process can be converted into energy through use of a gas engine, whereas incineration can only generate energy through use of steam turbines which are less efficient. Compared to incineration, control of atmospheric pollution can be dealt with in a superior way, in techno-economic sense Use of dry waste and RDF enhances the energy efficiency of the plant	to be maintained during the operation Net energy recovery may suffer in case of wastes with excessive moisture leading to corrosion High viscosity of fuel oil through pyrolysis may be require further processing to meet the standards Additional investment for filtration of fuel oil to remove particulate manner This Technology has much highe capital and operational cost compared to mass burn incineration. Higher technical expertise is required to operate this plant compared to mass incineration Enhanced safety requirements		installation cost of this technology Carbon monoxide (CO) and molecular hydrogen (H_2) are toxic and hazardous gases. Further, threat is compounded by the fact that the syngas needs to be cleaned before used as fuel
3	Bio-methanation	High energy recovery (60-90 Nm^3 biogas per 1 TPD segregated wet wastes) with production of high grade (60-80 kg per TPD) manure slurry which can be used as a fertilizer in city gardens and in farm.	Segregated wet waste if not used as a feedstock will adversely impact the performance of the plant. Hence, there is a need for obtaining waste with desired composition (wet waste from kitchen, vegetable markets,	The variability in daily composition of feedstock does not typically affect the composition of gas produced from the plant by the virtue of longer	Technology has limited application as it can handle only biodegrade wastes and thus can only be a part of an integrated facility for waste processing.

S.No.	Technology	Opportunities driven by internal strengths	Opportunities compromised by internal weaknesses	Threats minimized on the basis of internal strengths	Threats aggravated due to internal weaknesses
		The biogas typically contains v/v 65 to 75% methane and v/v 35 to 25 % CO_2. Returns the nutrients back to the farm ecosystem Suitable for application in small towns and as decentralized facilities in larger urban settlements (1 to 20 TPD of segregated wet waste) Enclosed system enables all the gas produced to be collected for use either for public utilities such as street lights or for domestic fuel-gas as well as controls GHG-emissions and helps in following Kyoto protocol. This technology is more suitable for handling segregated biodegradable (wet) waste as compared to any Minimum waste transportation cos as it can be potentially located within the city limits	institutions', canteens, hotels, slaughter house waste, *etc.*) Efficiency of plant is directly dependent on the degree of segregation and quality of biodegradable wet waste as the feedstock Water / sewage is required to run the process Biological processes are time consuming hence energy generation rates are low Uncertainty in marketing the slurr / utilization	retention times of reactor. Can accept a variety of biodegradable waste ranging from kitchen wastes, market wastes, garden wastes to slaughter house wastes There is no need of adding any external chemical or culture as a catalyst to maintain the process Does not require skilled man power to operate	

S.No.	Technology	Opportunities driven by internal strengths	Opportunities compromised by internal weaknesses	Threats minimized on the basis of internal strengths	Threats aggravated due to internal weaknesses
4	Refuse Derived Fuel (RDF)	RDF is a segregated dry waste having high calorific value (2500-3500 Kcal/Kg on dry basis) This can be easily produced in the form of fluff, pallets or briquetts and can be profitably used as a feedstock for power plants, cement plants or steel plants. Suitable for processing dry wastes in towns and cities having population range of 50,000 to 1 Million or in cities where MSW generation is below 500 TPD	If MSW is not adequately segregated into wet and dry wastes it will adversely impact the performance of the plant. Hence, there is a need for obtaining dry waste with desired composition and higher calorific value Efficiency of plant is directly dependent on the degree of segregation and quality of non-biodegradable dry waste as the feedstock Can be a feedstock only for power plant, cement or steel plant and cannot be used in furnaces operating at less than 850^{o} C	Setting up of small power plants is economically viable. Therefore, small cities generating less than 500 TPD wastes can set up RDF plants only for utilization of high volume dry wastes as a feedstock for W to E plants Can handle and convert high volume dry waste into feedstock to W to E plants RDF and biomethanation / composting technology can be adopted in an integrated waste management system by gainfully utilizing all components of MSW.	MSW if not segregated into dry and wet wastes, it can adversely impact the performance of the W to E plant. Efficiency of W to E plant is directly dependent on the degree of segregation and quality of RDF Uncertainty in marketing of RDF
5	Plastic waste to Fuel Oil	Direct and high rate (97%) of conversion of plastic waste to fuel. This technology will enable the conversion of plastic wastes not otherwise considered suitable by recycling industry. Small and large plants can be set up to process plastic wastes	Currently, no system exists to collect the plastic waste discarded by kabadiwalas and rag-pickers and is disposed off at dump-sites. Plastic wastes, if not properly segregated, will adversely impact on the production and quality of the fuel oil.	Separate collection system can be established to collect plastic wastes as per the Plastic Waste Handling Rules and use as a feedstock Plant can be set up both as decentralized and	Special catalyst is required which is prohibitively expensive and regeneration is limited to few cycles. Catalytic conversion is exothermic in nature and therefore run away reaction, local overheating, reactor

S.No.	Technology	Opportunities driven by internal strengths	Opportunities compromised by internal weaknesses	Threats minimized on the basis of internal strengths	Threats aggravated due to internal weaknesses
		ranging from 50 kg to 1000 TPD Readily available marker for use o the fuel produced	Conversion rate is low for metalized plastic wastes	centralized manner It is possible to operate the plants with the help of trained man power	melting and potential hazard cannot be ruled out.
6	Vermi Composting and Conventiona Windrow Composting	Biodegradable matter and plant matter is processed to produce a rich plant nutrient / soil enricher and improves the soil health, porosity of soil and moisture retaining capacity. Technology is simple, proven and does not require highly skilled mar power Cost of treatment is relatively low as compared to thermal technologies Carbon footprint is low in case of composting technology	segregated biodegradable wet waste as feedstock is required The feedstock for the vermin pits must be free from toxic materials for the survival of earthworms Requires large area of land (5 acres per 100 TPD) The process cycle is long (45-60 days) Open compost plant pose a problem during mansoon including odour Vermi composting requires constant monitoring of moisture and temperature levels to support earthworm life including regular harvesting of vermin-castings	Low cost soil conditioner Minimizes high volume biodegradable wet wastes disposal into sewage / landfill	
7	Plasma pyrolysis and gasification	This technology not yet proven for handling MSW. It is very expensive and unaffordable for treatment of MSW	No information was found on industrial plasma pyrolysis facilities processing MSW or RDF.	This technology not yet proven for handling MSW It is very expensive and unaffordable for treatmen of MSW	This technology not yet proven for handling MSW. It is very expensive and unaffordable for treatment of MSW

S.No.	Technology	Opportunities driven by internal strengths	Opportunities compromised by internal weaknesses	Threats minimized on the basis of internal strengths	Threats aggravated due to internal weaknesses
		Different kinds of organic wastes, varying from plastic and used tires to agricultural residue and medical waste, can be subjected to plasma pyrolysis. plasma pyrolysis produces a combustible gas and a carbonaceous residue (char). plasma pyrolysis offers potential for carbon black recovery from used tyres (material recovery) The high temperature conditions in plasma gasification result in the decomposition of organic compounds into their elemental constituents, forming a high-energy synthesis gas, In contrast to conventional gasification processes tar, char and dioxins are broken down, resulting in a synthesis gas The inorganic fraction (glass, metals, silicates, heavy metals) is melted and converted into a dense, inert, non-leaching vitrified slag The synthesis gas can be used for efficient production of electricity and/or heat, or second generation liquid (bio)fuels	Technique is very much scientific It is costlier than conventional pyrolysis. Mixture of hydrogen, oxygen and hydroxide radicals leads to strong electrode erosion Gas plasma technologies for waste treatment use electricity as energy source		

Annexure I-E

Recommendations on Public Private Partnerships (PPP) in Waste to Energy Projects (Report of Task Force on Waste to Energy)

Following are the recommendations on Public Private Partnerships (PPP) in Waste to Energy projects.

1. The ULBs lack the financial and institutional capacity necessary for integrated management of municipal solid waste which requires investments, especially for Waste to Energy projects. In such projects, it is appropriate to transfer the commercial risks to the private sector in order to ensure an efficient system for collection, transportation and processing of waste for generation of electricity. The Task Force, therefore, recommends that integrated Waste to Energy projects may be set up by the ULBs on public private partnership (PPP) basis.

2. The Waste to Energy projects should be structured and awarded on the basis of standard bidding documents. The Model Request for Qualification (RFQ) and Model Request for Proposal (RFP) published by the Ministry of Finance may be used for conducting the bidding process for award of such projects. The Feasibility study for these projects may be undertaken through consultants selected on the basis of the Model RFP for selection of Technical Consultants, as published by the Finance Ministry.

3. The projects should be based on a Model Concession Agreement (MCA) for Waste to Energy projects. Planning Commission has already commenced the drafting of the MCA. The Committee recommends that the same may be evolved in consultation with the principal stakeholders and finalised within three months.

4. The Committee noted that in the Budget Speech for 2013-14, it was proposed to support municipalities that will implement Waste to Energy projects through different instruments such as viability gap funding, repayable grant and low cost capital. The Committee recommends that as a special dispensation, the Central Government may grant Viability Gap Funding (VGF) of up to 40 % (forty per cent) for Waste to Energy projects. Alternatively, the Central Government may give a VGF Grant of 20% as per the existing scheme and also provide an interest-free loan equal to 30% of the Project cost.

5. The State Governments may also provide an additional 20% by way of VGF or interest free loan with a moratorium of five years from commencement of commercial operation and a repayment period of 10 years. However, the total grant and soft loans from the Central Government and State Governments should not exceed 60% of the project cost with the remaining 40% to be financed by the PPP Concessionaire.

6. The State Electricity Regulatory Commissions (SERCs) should be approached to specify electricity tariffs for Waste to Energy power stations at par with the tariffs currently payable for solar energy.

Annexure I-F

Institutional Mechanism for MMSW in Municipal Authorities

Small towns (under 100000 population)

a On getting intimation of selection of PPP partner (concessionaire) from the MSW authority, Executive officer (EO) to allocate land free from encumbrances to the concessionaire for processing and disposal facility.
b Get all necessary clearances from pollution control board.
c Conduct fortnightly review meeting on the performance of the concessionaire.
d Inspect once in a month the facility operated by the concessionaire and take corrective measure.
e Ensure that payments are released to the concessionaire as per the schedule.
f Take punitive measures if concessionaire fails to perform

Sanitary inspector/ supervisor to

a verify whether staff and vehicles have reported as scheduled and supervise the work of door to door collection and transportation by random check .Record the observations and submit to EO / HOD
b supervise the work of street sweepers
c inspect weekly the processing / disposal facility if contracted out Or daily if carried out departmentally. Report the observations to EO /HOD and propose corrective measures.
d scrutinize monthly invoice of the contractor if received within 7 days and recommend release of payment
e Chief Sanitary inspector in towns above 50000 population if any, , should oversee the performance of concessionaire and. SI / supervisor and recommend the payment to the concessionaire and take punitive measure if contractor fails to perform.
f if municipal councillors have any complaint, they should take up the matter with EO who should look into the matter on merits and take corrective measures. The concessionaire should not be subjected to interaction with councillors on his performance as it can lead to multiple controls.
g if payment due to the concessionaire is delayed beyond the period mutually agreed to, the concessionaire should be given interest @ 12% on the delayed payment and this interest should be recovered from the person / persons responsible for delayed payment.

In cities between 100000 to 1 million population

The municipal authority should appoint minimum technical and managerial staff in MSW department as recommended by state MSW authority and assign them specific duties. In cities with population of 2 lakh and above there should be an engineer, preferably an environmental engineer, in charge of MSWM.

The municipal authority should also appoint an independent engineer qualified in the subject to supervise the work of the concessionaire. He should be responsible to supervise the performance of the concessionaire and recommend the payments. The municipal authority should release payment in the prescribed time not later than 15 days from the date of submission of invoice. If payment due to the concessionaire is delayed beyond the period mutually agreed to, the concessionaire should be given interest @ 12% on the delayed payment and this interest should be recovered from the person / persons responsible for delayed payment.

Any person having complaint against the concessionaire should only report to municipal EO who in turn should pass on the complaint to the independent engineer. The independent engineer will look into the merit or otherwise of the complaint and report to the municipal authority i.e. EO/ commissioner who should act on such report

The municipal officers and supervisory staff should supervise the work of the concessionaire as per duty assigned and as suggested for towns under 50000 population but it will be subject to reporting to the HOD and through HOD to the independent engineer whose will give considered opinion to the EO / Municipal commissioner. The elected members being very large in number should not have access to the concessionaire. They should register their complaint with chief executive and only the concessionaire will be answerable to the independent engineer and the chief executive only or to the officer specially designated by the chief executive,

In cities above 1million

The cities above 1 million population should have adequate technical and managerial staff well conversant with MSW and contracting mechanism. Generally for every 1million population, there should be an executive engineer and twice the number of asst. engineers to assist the executive engineer in looking after technical aspects and functioning of processing and disposal facilities. There should be a dedicated officer responsible to oversee the performance of each plant / facility. In cities above 2 million, there should be a superintending engineer in charge of MSW dept and in cities above 5 million, there should be chief engineer to head the MSW department. In large cities, the engineering staff should have mixed expertise such as environmental engineers, civil engineers and mechanical engineers so that they can address all the issues related to MSW.

Such cities must have independent engineers having a team of subject experts to supervise the performance of the concessionaire and maintain records of each inspection. The independent engineer should report to the chief executive or to another senior officer designated by the chief executive.

The independent engineer should be responsible to recommend the payments. As per the work done, the municipal authority should release payment in the prescribed time not later than 15 days from the date of submission of invoice. If payment due to the concessionaire is delayed beyond the period mutually agreed to, the concessionaire should be given

interest @ 12% on the delayed payment and this interest should be recovered from the person / persons responsible for delayed payment. If the contractor fails to perform, the reasons should be looked into and he should be given time to take corrective measure if reasons are justifiable.

The private sector participation in MSW sector is new and emerging. The management should take pragmatic view while initiating action against the concessionaires and make efforts to build the sector to promote healthy competition and sustainable partnership.

On any dispute arising between the municipality and concessionaire, the municipality should remember that this is a dispute between the partners and it should be resolved amicably subject however to protecting the public interest.

The municipality should desist from imposing its will upon the concessionaire and should involve a third party such as commissioner / director of municipal administration to mediate to find a fair solution to the dispute and resort to arbitrator or courts as a last resort.