NEXUS NOVUS™
Enabling Business in India

Waste free Himachal Pradesh

A Feasibility Study

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List of Abbreviations

AD	Anaerobic Digestion
BCC	Bangalore City Corporation
CDM	Clean Development Mechanism
CNG	Compressed Natural Gas
DGGF	Dutch Good Growth Fund
HDPE	High-density polyethylene
HPRP	Himachal Pradesh Reforestation Project
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
LFG	Landfill Gas
LPG	Liquefied Petroleum Gas
MOUD	Ministry of Urban Development
MRF	Material Recovery Facility
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
O&M	Operations and Maintenance
PNG	Piped Natural Gas
PPA	Power Purchase Agreement
TPD	Tonnes Per Day
ULB	Urban Local Bodies
VGF	Viability Gap Funding

Contents

LIST OF FIGURES

LIST OF TABLES

1 Executive Summary

The ecology of Himachal Pradesh is sensitive keeping in mind its sub-Himalayan mountainous terrain, and home to a wide variety of flora and fauna that is typical of the state. The state therefore, needs a tailor made comprehensive waste management approach which takes into account its terrain and practices of municipal solid waste management and the resultant environmental degradation. The approach to waste management would have to offer pragmatic key insights into the intrinsic value of waste as a resource, allowing local authorities to come up with a strategic business model to manage their waste.

The state needs to put in place the practise of collecting user charges from its citizens to augments its financial liquidity and provide them with funds to take up waste management and developmental activities. Payment of tipping fees at the waste management sites also ensure that the funds collected is put to the use of scientific waste management. Most waste management projects in India fail due to lack of funds and efficient planning. Excessive dependence of the ULBs on the state sponsored funds, and lack of collection of user charges has always hampered any waste management efforts of the municipalities, therefore ensuring full coverage of collecting user charges, would be an important step on the part of municipalities in achieving financial independence.

Our study found that the collection of waste in the cluster towns of cities of Sundernagar, Mandi and Ner Chowk do not have accurate records and statistics of their waste generation and characteristics. It is imperative for the municipalities to ensure that the data on waste generation is also up to date, to help take any decision on scientific waste management. Lack of data causes a hindrance in ensuring that the solution offered would be adequate for the city. The waste generated in the cluster is highly organic; however the side streams of waste generated by slaughter houses, agri-waste and hotels can also be added to the waste streams that are generated to be added to the biogas plant.

The introduction of underground bins in the cities of Sundernagar and Dharamshala would pave the way towards a cleaner environment and put the municipalities in good stead to be able to collect the already segregated waste. This opens up a plethora of options for the municipality to scientifically manage their waste, and derive waste from value. Underground bins have not been installed in any part of India; therefore this makes Himachal Pradesh stand out in India map for being on the forefront of waste management and paving the way towards a cleaner state.

Installing the biogas plant in Sundernagar, where the organics of the cluster cities would be taken to convert the waste into fuel would help the city augment its fuel requirements by using renewable energy. Along with supplementing fuel and reducing their dependence on fossil fuels, it will help the state manage their waste more efficiently thereby reducing the carbon footprint. The sanitary landfill to be constructed in Mandi district would be an ideal solution to seal away the inert waste in an isolated state. Both the bio-gas plant and the sanitary landfill would help Himachal Pradesh in getting one step closer to becoming a waste free state.

Himachal Pradesh as a state has taken concrete steps in getting closer to establishing a becoming a model state in terms of environmental awareness and zero waste.

2 Key Recommendations

a. Construction of a sanitary landfill at Mandi

The final disposal of all municipal waste in the cluster of Sundernagar, Mandi and Ner Chowk necessitates the sanitary landfill. Sanitary landfill isolates the inert waste, and does not pose any public hazard. Furthermore it minimizes pollution and other negative environmental impacts. This first step calls for the selection of appropriate sites to build sanitary landfills, from both the economic and social standpoints. The priority in MSW management with regard to treatment and final disposal should be the construction of sanitary landfills, since it is urgent to minimize the health risks for the population, and put a halt to environmental pollution and the deterioration of natural resources. There can be no doubt that this is the most critical activity of the whole municipal urban cleaning perspective. Mandi town is ideally placed from the other two towns to carry the inert to the sanitary landfill. The current landfill in Mandi, is an abandoned stone quarry having natural impermeable base and surroundings except from one side making it an ideal location for the sanitary landfill.

b. Construction of a biogas plant at Sundernagar

The city of Sundernagar has been a pioneer in many ways from implementing the segregation at source drive and the door to door collection of waste. This brings about a boost to waste management initiative in the state and a successful example for the rest of the state. Setting up the biogas plant in the town is a clear case of a decentralised waste treatment, generating waste to value and deriving energy for local consumption. The biogas can generate electricity or PNG for local consumption and thereby help the municipality save lakhs of rupees on fuel bills. Biogas plants also help reduce the global climate change which is imperative for the sensitive ecology of a state like Himachal Pradesh. The compost derived from the plant will also find application in a principally agrarian state. Therefore, setting up the biogas plant will reduce the waste footprint generation and find a way of deriving value from waste.

c. Implementation of waste segregation at source at Ner Chowk and Mandi

The implementation of segregation at source drives in Sundernagar district has been important step in the right direction towards zero waste initiative. The cities of Ner Chowk and Mandi would also have to follow suit and implement segregation at source as well as door to door collection of waste to truly help the cluster of Himachal Pradesh to become a pioneer in achieving zero waste. Training and awareness campaign to promote waste segregation at source can also be implemented in this aspect. The other districts can also be encouraged to initiate segregation at source drives, special provisions can be levied to ULB’s that have taken initiative for segregation at source.

d. Placement of underground bins every 100m

Sundernagar and Dharamshala are ideal for placement of bins at every 100 meters for both the cities. Pricing, location and waste stream analysis of the cities reflect that the waste generation of the cities are typically sporadic, organic and seasonal. Therefore to augment the requirements of the waste generation today and in the future, the bins would have to be placed in places that are strategic for current and future use.

e. Implementation of waste sorting centres to ensure only absolute inert/rejects go to the sanitary landfills

Setting up a waste sorting centre is essential to ensure that the dry waste that is generated can be further sorted for recyclables and plastics. This ensures that the plastics are moved to the cement factory, the recyclables to the recycling factory and only the absolute rejects are taken to the sanitary landfill. This would help getting as close as possible to the zero waste drive, as well as ensuring that only the complete inert go the sanitary landfill post sorting and the recyclables are derived of their value to also ensure the longevity of the sanitary landfill. This would be an important step in achieving the zero waste agenda. Alongside, the kabadiwalas can be hired for processing the waste at the waste sorting centre. This would also ensure that the kabbadiwalas are integrated into the waste management system, without stripping them of their means of livelihood.

f. Collection of waste generated from side streams

It has been determined from our research and study that none of the side streams of waste that are generated i.e. hotel waste, slaughter house waste, agri-waste are currently being collected. The side streams of waste generated as the ones mentioned are rich in organic content and would be a very useful feedstock for the biogas plant. Without integrating the collection of the side streams, the concept of zero waste cannot be achieved. Therefore, it is very highly recommended, that the ULB's take the steps towards ensuring that the side stream waste is also collected and taken as feedstock for the biogas plant.

g. Better user charges collection and gradual increase of tipping fee

The collection of user charges is an important step towards decentralization, as well as ensuring that the ULB's have sufficient liquidity to keep up with their governance operations. As per our findings we have observed that currently in India less than 50% of the user charges are collected. This induces a cash crunch for the ULBs' to take up developmental activities. The municipalities should therefore take stringent steps towards the collection of user charges for municipal solid waste management from the households as fees for the collection and management of waste. This would provide them with enough cash flow/liquidity to take up scientific waste management.

The municipality should also ensure that the tipping fee has to be levied for the management of waste. Currently Shimla is paying INR 150 per ton for the collection and management of waste at the Hanjer Plant. This is one of the lowest tipping fees paid as per industry average. Higher tipping fee provides motivation for the collection and management of waste. Therefore the ULBs can ensure that they collect 100% of their user charges, which can be in turn paid as tipping fee to ensure efficient and scientific management of waste.

h. PNG over electricity

The biogas generated from the plant can be used directly as piped natural gas or converted to electricity. Himachal Pradesh is an energy surplus state which is extremely rich in its hydroelectricity resources. The state is stated to have about twenty five percent of the national potential in this aspect. It has been estimated that about 21,244 MW of hydel power can be generated in the state by the construction of various hydel projects on the five perennial river basins no matter they are major, medium or small. Bearing this in mind generating electricity from the

Biogas plant would only be futile. Therefore to reduce the investment cost of electricity generators, the natural gas can be piped to the households as an alternative to LPG for cooking and for heating purposes.

Piped Natural Gas (PNG) ensures continuous and uninterrupted supply from the biogas plant once generated. It is easily available - once you get a connection, you will get it supplied to your house continuously through a pipeline. PNG is also absolutely safe with a pressure of just 21 mbar. The pressure of PNG is 200 times lesser than gas supplied through cylinders. Natural gas is lighter than air, in case of any leakage; it will instantaneously mix with air and evaporate. Therefore the choice of generating PNG would be very useful and help the city augment the use of PNG over government subsidized and highly volatile price of LPG as fuel for cooking.

i. Waste management drives

Training and awareness campaign to promote waste segregation at source can be implemented by the municipalities to spread awareness among the households. At the gate of Shimla a hoarding with instructions and rules of waste management can be put up to ensure strict adherence to rules. Penalties and fines for non-adherence of the rules can also be implemented which would ensure that the citizens abide by the instructions and the motive of efficient management of waste is achieved. Additionally, the schools can also be mobilized by conducting slogan competitions on keeping the city clean, along with spreading awareness among the young which will mobilize greater enthusiasm from the citizens.

Himachal Pradesh has been a pioneer in many ways by taking the first step towards efficient management of waste. By implementing the steps that it has taken, it would become a zero waste state following the lines of “Swachh Bharat” and become a model state in waste management.

j. Annual audit for biogas plant

The local team would need to conduct annual audits of the biogas plant. The training will be given by BBE at one of the digesters in Netherlands to the future operators of the plant to get acquainted with the daily technological and biological process. The training would have to be conducted before the commission of the plant, to ensure that the operations and performance of the facility is guaranteed from Day 1. BBE will also monitor the biology of the facility by standard lists (values of ph, FOS/TAC) that should be filled out by the local operators. The data will be used by BBE to give recommendations on feeding, temperature etc

3 Waste Stream Analysis

3.1 The state of Himachal Pradesh

Himachal Pradesh is one of the most dynamic hill stations in India which is high on human development. The resources of forests, fruits, minerals and Hydel Power hold great promise for the state. The state is called the apply belt of India, and its vast potential for Hydel Power generation due to its locational advantage has attracted the attention of the entire nation as a major resource awaiting full exploitation. Its physical diversity , its climate, and its peaceful environment can derive, high economic value from the development of the tourist Industry. Over the years, the economy of the state has kept pace with the economic environment in the country as well as across the globe. Gross State Domestic Product (GSDP) registered a growth of 6 % per annum between 1994–1995 and 1999–2000. This growth rate was higher than the growth rate achieved at national level. Himachal is extremely rich in hydroelectric resources. The state has about 25% of the national potential in this respect. It has been estimated that about 20,300MW of hydro electric power can be generated in the State by constructing various major, medium, small and mini/micro hydel projects on the five river basins.

The economy of the region is predominately agrarian as around 79% of the total population is dependent on agriculture and activities allied to it, for earning their livelihood. Agriculture contributes nearly 45% to the net state domestic product. It is the main source of income as well as employment in Himachal. About 93% of the state population depends directly upon agriculture. Cultivation of a wide variety of vegetables and pulses is common in the terrain. Fruit cultivation has led to its economic boom. Land husbandry initiatives such as the Mid-Himalayan Watershed Development Project, which includes the Himachal Pradesh Reforestation Project (HPRP), the world's largest clean development mechanism (CDM) undertaking, have improved agricultural yields and productivity, and raised rural household incomes

Industrialization in the state is a comparatively recent development. Due to the globalization and liberalization policies in the last two or three decades, industrial development has started taking shape. The state and central government policies of providing monetary and fiscal benefits in the form of subsidies and incentives, promoted private and public sector organizations to establish their industries in the state. In addition, better infrastructural facilities, in the form of ready-to-use plots, power, and better connectivity to big markets, have played a crucial role in the industrial development of the state

The state has 12 districts namely, Kangra, Hamirpur, Mandi, Bilaspur, Una, Chamba, Lahaul and Spiti, Sirmaur, Kinnaur, Kullu, Solan and Shimla. The state capital is Shimla, which was formerly British India's summer capital under the name Simla. Himachal Pradesh was the first state in India to ban the production, storage, use, sale and distribution of small polythene bags in June 2004. The state spread across valleys and 90% of the population lives in villages and towns and has achieved

100% hygiene and practically no single house without a toilet. The state of Himachal Pradesh is therefore a pioneer in many ways in the route towards waste management, pollution control, awareness about reducing hazadrous waste . With the initiative of making the state waste free, the Urban Development Department, Himachal Pradesh has taken another step towards scientific management of waste and creating eco-awareness.

3.1.1 Distinct characteristics of waste generated in Himachal Pradesh

a. Himachal Pradesh has many small and scattered dumpsites spread across the state, owing to its scattered population
b. The climate of Himachal Pradesh goes through several changes throughout the year, owing to its temperate climate. Starting from October till March, the state enjoys winter which includes snowfall. Therefore, the climate is far from tropical which is preferred for optimal gas extraction
c. Obsolete technology is currently being used in all waste management practises, starting from waste collection to its handling and management.
d. Hilly terrain with scarcity of flat land, makes it cumbersome to set up efficienct waste management practises
e. Highly organic fresh waste streams, throws up a plethora of options in gas production, composting etc in waste management
f. Varying degress of waste production due to high influx of tourists in the tourist season, requires specialised management during peak season

However, inspite of the innate characteristics of the waste, the hilly terrain of Himachal produces fresh organic waste, which is the most suitable for scientific management and valuable renewable energy production. Therefore, for sustainable development and waste management of this mountainous terrain, it is essential to study its various characteristics in detail and formulate plans that are suitable accordingly.

3.2 Municipal Solid Waste

Rapid industrialization and population explosion in India has led to the migration of people from villages to cities, which generate thousands of tons of MSW daily. The MSW amount is expected to increase significantly in the near future as the country strives to attain an industrialized nation status by the year 2020. Poor collection and inadequate transportation are responsible for the accumulation of MSW at every nook. Management of MSW is going through a critical phase, due to the unavailability of suitable facilities to treat and dispose of the larger amount of MSW generated daily in metropolitan cities. Unscientific disposal causes an adverse impact on all components of the environment and human health. Consequently, the management of the MSW needs to be revamped to accommodate the changes in the quantity and quality to ensure the longevity of the environment. Due to several legislative, environmental, economic and social constraints, the identification of most sustainable disposal route for MSW management remains an important issue in almost all industrialized countries.

Generally, MSW is disposed of in low-lying areas without taking any precautions or operational controls. Therefore, MSWM is one of the major environmental problems in India.

It involves activities associated with generation, storage, collection, transfer, transport, processing and disposal of solid waste. But, in most cities, the MSWM system comprises only four activities, i.e., waste generation, collection, transportation, and disposal. The management of MSW requires proper infrastructure, maintenance and upgrade for all activities.

Similarly in the hilly states of Himachal Pradesh, the same problem of waste management exists. For decades the hilly tourist location has seen an increase in population, developmental activities, and changes in socio-economic scenario and improved standard of living etc. The Increasing industrialization and rising income levels lead to greater use of resources which further leads to the increased MSW generation and more complex composition of MSW than earlier. Thus, waste quantities as well as composition are inextricably linked to the vibrancy of economic activity and resource consumption pattern of the society which generates the waste. Further, the technologies to be adopted for MSW management and processing predominantly depend upon MSW quantity, quality and range of variations.

3.3 Current state of Solid Waste Management in Himachal Pradesh

Efficient garbage collection, transportation and disposal are among the vital functions of Urban Local Bodies. Despite the fact that a large number of staff is employed by them to discharge this function and a substantial portion of their annual budget is spent only on garbage collection, transportation and disposal, the situation in the towns and cities remains far from satisfactory. There is no standard system of waste collection in our ULBs all over the state of Himachal. Some ULBs, during the recent years have started household level collection of waste but it is in un-segregated form.

As reflected in the table below the door-to-door collection of waste is existent in 14 out of the 20 districts of HP, but at varying degrees. Existence of door to door collection is also imperative to ensure that the residents do not casually dump or burn their waste which is hazardous to the environment. It also ensures maximum collection of waste for processing. Casual dumping of waste in the open in the long run aggravates pollution and can also ruin the landscape especially in a tourist friendly state like Himachal. Segregation at source is also practically negligent in the state. Although segregation at source drive is a relatively new phenomenon, it has its inherent advantages in helping provide a more holistic solution to waste management.

Table 1: Door to Door Collection in HP

Cities	Door to Door	Segregation at Source
Chamba	9%	-
Mehetpur	10%	-
Theog	14%	-
Solan	20%	-
Baddi	20%	-
Paonta	20%	-
Nahan	20%	-
Dharamshala	27%	27%
Una	30%	-
Mandi	38%	-
Hamirpur	45%	-
Parwanoo	55%	-

Shimla	90%	-
Manali	100%	-
Palampur	-	-
Jogindernagar	-	-
Kullu	-	-
Ghumarwin	-	-
Talai	-	-
Bilaspur	-	-

3.3.1 Operation cost per ton of waste managed

The ULBs/Nagar Panchayats have a varying degree of spending on solid waste management for a given amount of waste. As seen in the Figure 1, the districts of Palampur (INR 10,959) and Kullu (INR 10,275) have the highest spending per tonne of waste, while the Hamirpur (INR 548) and Paonta (INR 457) have the least spending per tonne of waste. The funds allotted to the ULBs/Nagar Panchayats are used for the purpose of collection of waste and managing solid waste. However they are usually faced with the problem of inadequate funding which can only be solved by the self-revenue generation model offered to ULB's in the form of property/sanitation taxes and user charges. Therefore, the ULBs have to put in utmost efforts in revenue collection to augment their funds for waste management.

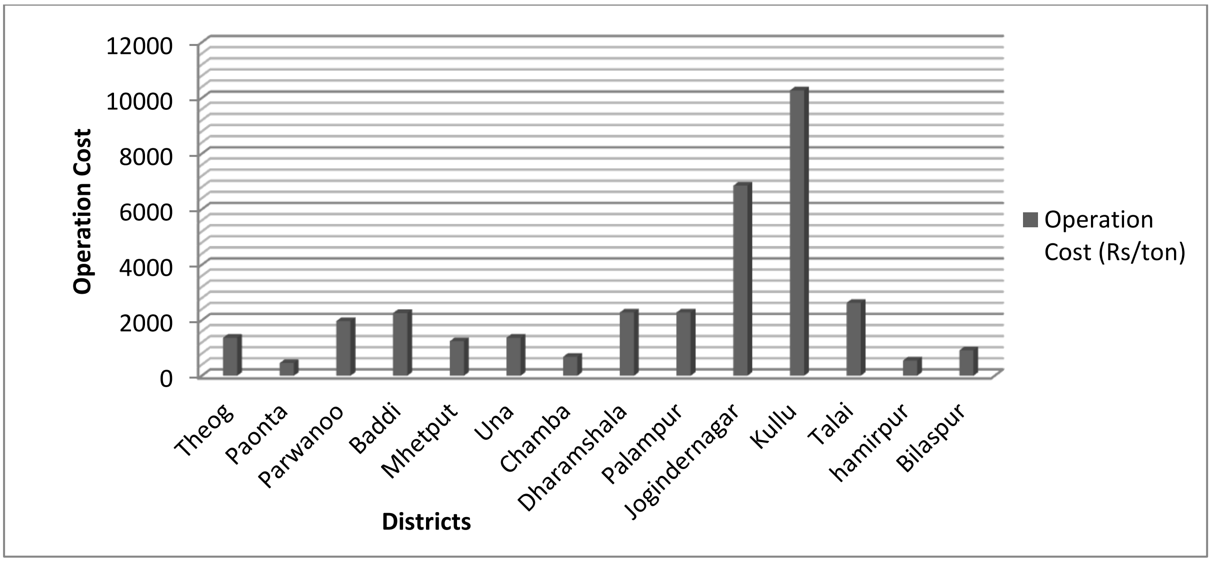


Figure 1: Operation Cost per Ton of waste managed

3.3.2 User charges

Funds are used by the ULBs/Nagar Panchayats are used for the purpose of collection of waste and managing solid waste. However they are usually faced with the problem of inadequate funding for the recurring and investment expenditure. There is a growing need to innovation and more scientific treatment of waste.

Considering the declining government financial support to ULB's it has become important for them to rationalize and collect User Charges for the services offered by them. Collection of User Charges for full cost recovery of services is mandatory key ULB level reform under JNNURM. Levying user charges for the purpose of full cost recovery of a service, which includes operational as well as capital costs, prevent the ULB from going through a cash crunch and using the funds to adapt better waste management practices. As reflected in the Table 2, below the user charges are collected by all cities in the range of INR 30/month. This provides sufficient liquidity to the ULB, if collected properly and also contributes to a significant amount of revenue, although it a very small amount per household. Therefore for the purpose of better finances for a more efficient management of waste, 100% collection of user charges would be very beneficial.

Table 2: User Charges in HP

	User Charges	Revenue Generation (₹/lakhs)
Shimla	30	188
Theog	30	5
Solan	30	34
parwanoo	30	14
Baddi	30	32
Paonta	30	21
Nahan	5	4
Mehetpur	40	7
Una	30	9
Chamba	30	17
Dharamshala	30	20
Palampur	30	5
Jogindernagar	30	7
Kullu	30	21
Manali	30	8
Mandi	30	32
Ghumarwin	30	13
Talai	30	2
Hamirpur	30	17
Bilaspur	30	18

3.4 Solid Waste Management in the cluster (Sundernagar, Ner Chowk and Mandi)

The cluster of Sundernagar, Ner Chowk and Mandi will be developed as an integrated waste management model. The pilot project will include setting up of a biogas plant and underground bins at Sundernagar and Dharamshala as well as setting up a sanitary landfill in Mandi District. The organics from all three areas will be brought to the Biogas Plant at Sundernagar, while the inert and rejects will be sent to the sanitary landfill to be constructed in Mandi.

The waste management initiative in the cluster will be a giant step by the HP government towards cleaning their state, and integrating a scientific waste management solution. The pilot project should be the first of a waste management revolution which will bring about waste management initiatives across the state.

Figure 2: SWM Cluster

a. Sundernagar

Sundernagar with a population of 24,329 is situated in the sub-hilly terrain of Himachal Pradesh. The city is the pioneer in bringing in door-to-door waste collection as well segregation at source drives. The city enjoys a salubrious climate and is well suited in terms of the support from the ULB and the enthusiasm of the citizens in bringing in a solution to their waste management. Sundernagar city would also be the pilot city for the installation of underground bins. The city is thus paving its way towards becoming a model city for waste management in Himachal Pradesh.

Sundernagar will be the location for setting up the waste to value biogas plant, to extract renewable energy from the organic/biodegradable waste generated in the city. This project has become feasible since the city has implemented segregation at source drives. With the installation of underground waste bins for segregated waste collection, the project will get further strengthened.

Table 3: Details of the waste generation at Sundernagar

Amount of Waste at current dumpsite	3033.75 m^3
Current size of Landfill	4045m^2 or 0.4045 hA
Daily waste generation in Sundernagar	11 Tonnes
	Biodegradables 57%
	Plastics - 20%
Daily Waste Composition	Dry Waste - 23%
Inert Waste	Approx. 18%
Density	0.37-0.400 tons per m^3
Sewage Generation	3.5 MLD

b. Mandi

Mandi town has a population of 26,422 and is a bowl shaped table land on the banks of river Beas, the town is surrounded by the high hill ranges of Gandharv Hills, Motipur Dhar, Rehra Dhar and Tarna Hill. Two small rivulets, Suketi Khad and Skodhi Khad join River Beas. Mandi is setting up an appropriate system of solid waste management for Mandi, looking into the various aspects, such as, storage at the point of generation, storage at community/municipal level, collection (primary as well secondary), transportation, treatment and disposal.

Mandi will be the location of setting up the sanitary landfill, to dump and seal the inert from the cluster cities of Sundernagar, Ner chowk and Mandi. The existing landfill and the proximity to the cities make it a feasible location for setting up a sanitary landfill. Once the segregation at source drive has been initiated in Mandi, the organics from the city can be brought to the biogas plant for gas production.

Table 4: Details of the waste generation at Mandi

Amount of Waste at current dumpsite	40000 m^3
Current size of Landfill	0.53 hA
Daily waste generation in Mandi	18 Tonnes
	Biodegradables 51%
	Plastics - 31%
Daily Waste Composition	Dry Waste - 18%
Inert Waste	Approx. 19%

c. Ner Chowk

Ner Chowk is a small hamlet with a population of 3,488 with 733 households and 700 Commercial Establishments. The waste generated at this town will also be transported to the sanitary landfill in Mandi and biogas plant in Sundernagar.

Table 5: Details of the waste generation at Ner Chowk

Daily waste generation in Ner Chowk	**1.5 Tonnes**
	Biodegradables 51%
	Plastics - 31%
Daily Waste Composition	Dry Waste - 18%

3.5 Side Stream Analysis

The side streams generated in Sundernagar, Ner Chowk and Mandi are currently not collected and estimated. However, the side streams of waste generated in the form of agri-waste, slaughter house waste and waste from hotels/restaurants are highly organic in content and could serve as a major source of organic feed for the biogas plant for biogas extraction. It is highly recommended that the waste that feeds into the biogas plant in Sundernagar contains maximum organic content to ensure the highest production of biogas gas.

3.5.1 Options for side streams

a. Slaughter House Waste

The waste generated in slaughter houses has similar chemical characteristics as those of domestic sewage but are considerably more concentrated in general as they are almost wholly organic. Open slaughtering of animals (87.5%) is a common practise in Himachal Pradesh, coupled with poor handling of carcasses. This gives rise to several cases of pollution and the possibility of disease. Therefore, organisation of private small butchers and the larger tanneries can be initiated for the collection of the waste and safe disposal. Organising them to collect and transport it to the biogas plant will ensure higher quality feedstock for the production of renewable energy

b. Agri-Waste

Agriculture is the main occupation of Himachal Pradesh with about 67 % of the population directly depending on agriculture for their livelihood. Due to hilly topographic condition, terraced cultivation is widely prevalent in the state. Small and marginal farmers comprise 80 % of the total holdings of the state. During the past three decades, due to ideal climatic condition, a well-diversified farm economy has developed in the state.

Different varieties of crops are being cultivated in the state. Among the cereals, wheat, rice, maize, and barley are important. The state also produces pulses and oilseeds, potato, ginger, tea, and peas. With a cropping intensity of over 175%, the state has an abundance of agri-waste which is being currently recycled for nutrients to the land. The agri-waste rich in organic nutrients can serve as a feed for the extraction of valuable renewable energy. The remaining sludge can also be used as high quality compost.

c. Organic food waste from hotels and restaurants

Tourism in Himachal Pradesh is one of its major contributors to the state economy and growth. Catering to the large influx of tourists are an umpteen number of hotels and restaurants that have sprung up across the length and breadth of the state. Food waste from these hotels can also be channelized towards the biogas plants, which are rich in organic content and thereby have high biogas generation potential.

The cluster cities of Sundernagar, Mandi and Ner Chowk should organize a method to pool together the waste arising from these sources to add to the organic feedstock for gas extraction.

3.5.2 Economic aspects of bio-methanation of slaughter house waste/agri waste and waste from hotels and restaurants

a. **Biogas:** Slaughterhouse waste is the very energy-rich waste stream of meat industry. The waste generated from slaughter houses are highly organic and therefore have the highest methane content leading to maximum production of biogas gas. Anaerobic digestion is the best option with production of biogas, reduced greenhouse gases and pollution control from slaughter house waste. Conversion of biogas to electricity, Bio-CNG or PNG helps in adding economic value to the biogas.

b. **Fertilizer:** The sludge can be used as a valuable fertilizer. Studies have shown that compost from slaughter house waste are valuable fertilizer having much higher content of N, P, Ca, Zn and Cu compared to farmyard manure. These materials could be used in crops having a larger fertilizer demand like sugar beet and also fibre crops or cereals. Residual effects of composts are pronounced

c. **Animal feed:** India ranks high in the world in livestock holding and has the potential to utilize primary sludge to partially meet the growing requirement of animal feed; the total requirement of animal feed has been estimated at 37 million tonnes. This includes 24 million tonnes of cattle feed (which as per the directive of the Department of Animal Husbandry, Government of India cannot have slaughter house waste material). Slaughterhouse waste material has the potential to partly replace 13 million tonnes of animal feed material. Slaughterhouse waste can be used as inputs to feeds for the poultry, fish and pets like dogs and cats.

4 Integrated Waste Management

4.1 Waste supply chain

In most cities, the municipal service for the collection and transportation of urban solid waste comprises three separate functions as follows:

a) Sweeping, curb side and domestic waste collection from garbage bins
b) Transportation by handcarts to large or road collection points, which may be open dumps.
c) Transportation by vehicles to the disposal sites

The Indian waste management system is starved of resources to tackle the increasing demands associated with growing urbanisation. Due to budgetary constraints, inadequate equipment and poor planning, house-to-house collection is very rare in India, particularly in certain low-income areas where waste is not collected at all. It is estimated that up to 30-40 per cent (UNCHS, 1994) of disposed solid waste are left uncollected. The areas, which are not serviced, are left with clogged sewers and litter which create serious health problems for the resident population.

4.1.1 Collection methods

In the state of Himachal Pradesh no standard system of waste collection is followed. Although the door-to-door collection has been initiated, the absence of segregation of waste puts all waste management practises in difficulty. We can see standard metal dustbins placed across towns, with no incentive for the citizens to throw their garbage in the bins. The ULBs have placed the big dustbins. Metal bins are placed at different locations without assessing the need, or doing any survey to identify the quantum of waste generation in different waste generating sources.

The citizens are not mobilized or informed of the need to segregate waste separately and to discard it scientifically. The ULB vehicles collect the waste from these large bins on an erratic basis, and most of the waste. Some people use the dust bins to dispose of their waste but in other cases where waste bins/dumpers are away from their location, they dispose of the waste at un-notified locations keeping in view their convenience. In fact the location of these dust bins have been found to be the dirtiest and stinking places in the town. Since the people have not been told about the use of these bins and there is no notice/sign board on or near the dust bins indicating the norms for the use of dust bins, they dispose of both biodegradable as well as the non-biodegradable waste in the same bins.

Figure 3: Waste Management in Himachal Pradesh

4.1.2 Waste collection system in India

a. Door to door collection: This system is used in narrow streets where a collection truck cannot reach individual houses. The house places the filled containers outside their doors when the waste collectors arrive. Some cities such as Chennai (Madras) and Chandigarh have implemented this in posh localities where influential people reside. On similar lines, Bangalore City Corporation (BCC) recently introduced door to door collection in some wards and management seems to be satisfactory. Himachal Pradesh should follow suit, and ensure that the pilot project of door-to-door collection initiated at Sundernagar is continued and the awareness spread across the entire state.

b. Curb side collection: This method is used in wider streets, where the collection trucks can pass through conveniently. The house owners leave the waste containers at the edge of the pavement. The waste collectors collect the waste from the curb side or empty the containers into the vehicle as it passes through the street at a set time and day and return the containers as practiced in Kanpur (UNCHS, 1994).

c. **Block collection:** The collection vehicles arrive at a particular place or a set day and time to collect waste from the households. Households bring their waste containers and empty directly into the vehicle (UNCHS, 1994).

d. **Community bins:** Community storage bins are placed at convenient locations, where the community members carry their waste and throw it. (These bins are also called Delhi bins, since it was introduced first time in Delhi)

The phenomenon of recycling by means of repair, reprocessing, and reuse of waste materials is a common practice in India. At the household level recycling is very common. Waste is accessible to waste pickers; they segregate it into saleable materials such as paper, plastics, glasses, metal pieces, textile, etc. Rag pickers/Kabadis segregate the waste directly from the dumps and bins with no precautions and they are exposed directly to harmful waste. The separated waste is sold to a small waste dealer, from where the waste is transferred to a medium sized dealer or wholesaler. All these activities are not regulated or monitored by any governmental organisation. Due to this informal segregation, volume reduction is achieved, while it ignores social, economic, environmental, and health aspects.

Figure 4: Bins currently being used at HP

4.1.3 Segregation of waste

Segregation as per Solid Waste (Management and Handling) Rules 2000 is now compulsory. Segregation in simple language means separation of waste into dry and wet, so that it is easier to handle it later. Whether it is collecting the waste through dumpers or we are collecting the waste from the source (door to door collection), it is in the un-segregated form in Himachal Pradesh. Due to this inherent problem of lack of segregation of waste, waste management has become a difficult task in the hilly state.

Segregation of waste ensures that the waste is split into organics, plastics, and others giving more room for safe and effective disposal of waste. The plastics and others can either be recycled or sent to cement factories as fuel, while the organics can be composted or used to extract renewable energy. Without segregation, waste becomes completely useless and void. It is therefore highly recommended that Himachal Pradesh starts to mobilize their municipalities and local authorities to initiate segregation at source drives. Fixing the problem at its root will not only ensure that the waste is segregated; it also throws up a myriad of opportunities for usefulness of waste.

Sundernagar District of Himachal has been the pioneer in implementing door-to-door waste collection and segregation of waste. Having implemented segregation of waste at source, the Sundernagar Municipality stands in good state to supply organics for setting up a biogas plant for extraction of renewable energy.

4.1.3.1 Why waste segregation is important

a. If the waste is not separated properly, it all gets mixed up in landfills. The dangers of this is that landfills leak after a period of time, resulting in leachate or toxic soup at the bottom, which can contaminate ground water and release combustible methane gas.

b. Methane is a greenhouse gas, which ultimately leads to climate change, extreme climates and droughts. We can see the impact already in the world.

c. Segregation protects health. When rag pickers put their hands into the waste to clean it up, it results in cuts that further lead to infections, resulting in deterioration of a rag picker's health. Hence, it becomes our responsibility to help these rag pickers by carefully segregating the waste that is generated at our homes.

d. When the waste is not separated properly it leads to less recycling because it is not easy to remove materials for recycling. This means many resources are wasted.

4.1.4 Storage of waste before final disposal is done at three levels

1. **At source:** Solid waste is often stored at the source until they are picked up by waste collectors (collection crew) or taken out to be thrown into an open space or a community bin.

2. **At community level:** Community bins are used in crowded and narrow market areas, which is a common feature of most developing countries. Because of the high cost of door to door collection many waste management authorities have introduced community bins.

3. **At transfer stations:** Transfer stations are established, for economic reasons in cities, which have long haulage distances to final disposal sites. Smaller collection vehicles bring in the waste collected at the source of generation or from the community bins and larger vehicles transport it away to final disposal sites. Transfer stations also serve as collection and sorting points for recycling materials.

4.1.5 Waste sorting centers

In the state of Himachal Pradesh, the current practise across the 50 ULBs and 6 cantonment boards with total of 7 lakh population has no standard system of sorting of waste. Currently the mixed waste is collected by the municipal vehicles and brought to the dumpsites where the waste is manually sorted for recyclables. This is a laborious and time consuming process which does not guarantee proper segregation.

Manual Segregation at Manali

Sorting Centre in Sundernagar

Figure 5: Waste sorting centres in Himachal Pradesh

4.1.5.1 Shortcomings of the manual waste sorting centers

The current waste sorting centres in Himachal Pradesh have inherent shortcomings which make manual sorting of waste difficult:

a. The current waste sorting is done manually. It is a violation of human rights and labour laws as it puts the labourers' into serious health hazards and risk.

b. Indian waste is highly organic and therefore the waste generated in India is *very sticky*. It mostly contains organics; it results in stench, diseases, generation of methane etc. The sticky waste makes it impossible to achieve proper segregation.

4.1.5.2 Solution for Segregation of Waste

a. Material Recovery Facility

A materials recovery facility (MRF), materials reclamation facility, is a specialized plant that receives, separates and prepares recyclable materials for marketing to end-user manufacturers. A materials recovery facility (MRF) accepts materials, whether source separated or mixed, and separates processes and stores them for later use as raw materials for remanufacturing and reprocessing.

The main function of the MRF is to maximize the quantity of recyclables, while producing materials that will generate the highest possible revenues in the market. MRFs can also function to process waste into a feedstock for biological conversion or into a fuel source for the production of energy.

- A clean MRF accepts recyclable commingled materials that have already been separated at the source from municipal solid waste generated by either residential or commercial sources.
- A dirty MRF accepts mixed solid waste stream and then proceeds to separate out designated recyclable materials through a combination of manual and mechanical sorting.

b. Trommels

Unsorted waste can be separated by way of capital intensive separation systems to produce the cleanest end-streams. Trommels are used to separate materials by size, separating the biodegradable fraction of mixed municipal waste or separating different sizes by means of rotation. These help in classifying the waste based on characteristics like size and thereby separating it for further treatment. They also allow dimensional sorting of incoming material into two or more fractions. They can be placed individually or cascading (primary and secondary screen) to obtain successive sorting refinements.

c. Extrusion Press

Extrusion press is a waste pressurizing machine designed to physically separate waste into two fundamental fractions, an organic wet fraction with hardly any non-organics and a solid dry fraction with almost total absence of organic substances. The separation process consists of a chamber with a very strong mesh, in which waste is compressed using as high a pressure as 1000Bar. This results in changing the structure of the organic material into fluid plasma, allowing it to be pressed through the mesh. This wet organic fraction can be treated in anaerobic digestion plants to generate biogas. The dry non-organic fraction contains mainly refuge derived fuel, but also some minerals and metals. After the dry fraction has undergone an additional separation process by sorting out these materials, only refuge derived fuel and recyclables remain.

Trommels

Extrusion Press

d. Segregation at Source

Household segregation at source is the first and easiest solution to the problem of waste in India. If the organics, plastics and dry waste is collected separately, it helps in scientific treatment of waste, which is otherwise not possible. Therefore, Himachal Pradesh should implement segregation at source drives across the state. The cluster of Sundernagar, Mandi and Ner Chowk which will feed organics to the biogas plant, would have to introduce segregation at source to be able to avail the benefit of fresh organics going into the biogas plant.

The renewable energy derived from pure organics is of higher quality, and the organic compost/fertilizer would also be able to avail a good market price. Segregation at source also ensures that the MSW produced is 100% treated. Therefore, scientific management of waste is only possible where segregation at source exists

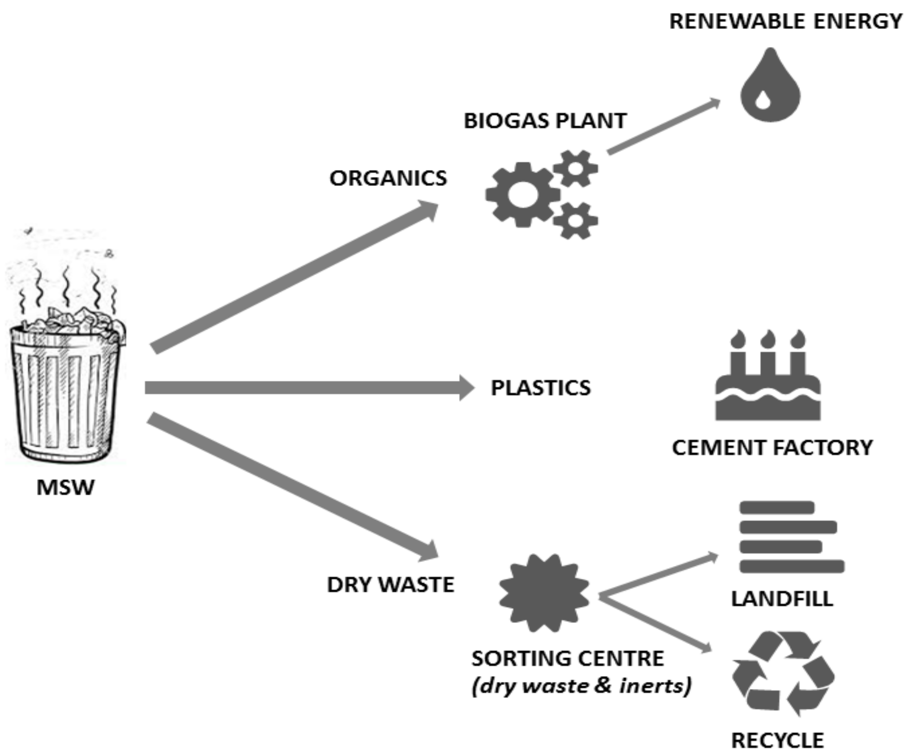


Figure 6: Ideal Waste Supply Chain for Himachal Pradesh

5 Collection and Transportation Process

5.1 Underground Bins

Underground waste bins are not a new world concept, as it has been incubated into the waste collections systems in the western world since the early nineties. Underground bins have made the collection of waste easier for residents to dispose of their waste. With increasing demands for more efficient and aesthetic recycling and waste collection methods, the underground system offers the most advanced method yet of storing waste. The reduced surface footprint helps create a feeling of open space whilst allowing more space as bin stores are no longer required thereby offering a positive contribution to the communities in which they are utilised. This self-contained unit also helps to prevent vermin infestation, reduces odours and creates a modern feel for users. The product also offers environmental and financial benefits; reduced manning levels and associated costs can create operational savings of a third against traditional lifting methods in the long run. Reduced collection frequency also offers a potential reduction in vehicle CO_2 emissions.

The features and advantages of underground bins are as follows:

- Aesthetically pleasing
- Reduced odour
- Reduced surface footprint and more open spaces
- Reduced environmental damage caused by littering

- Segregation of waste at source helping scientific treatment of waste
- Better waste management
- More efficient, faster and cost effective way of collection of waste
- Fewer resources need to be deployed to collect the waste from segregated bins

The collection of waste from underground bins makes the entire waste management process highly efficient. The waste collection and transportation is monitored and the estimation of waste generation is done scientifically. Therefore the waste is collected only when the bins are filled up, thereby reducing loss from unnecessary movement of vehicles and manpower deployed for the purpose. The entire process of waste collection is thus far more organised which makes the waste management process highly smooth.

Monitoring of the waste that is generated ensures that the data on waste is collected and observed. This ensures great flexibility in introducing waste management practises, since the amount of waste that will generated in regularly monitored. Therefore, collection and transportation process of waste on the whole takes a scientific shift – leading to highly organised, smooth and efficient waste management.

5.1.1 Description of Bins

The underground waste bins are from Western European quality and come with necessary certificates. All products are available from stock in the warehouse in Helmond, if necessary, to deliver within 24 hours for service purposes. All products are equipped with EN 13071 standard and their production process is ISO 9001 certified.

a. Fold Flooring

The Fold Floor is modular and suitable for all volume units of containers. The operation takes place by means of springs and mechanical interlocks. The Minimum load of 150 kg at any point is amply met by the mechanical lock. All sheet metal parts are fully welded and galvanized according to DIN / EN / ISO 1461 standards. The blow floors are equipped with sliding blocks in order to prevent minor damage to the container. The upper edge is provided with water -retaining edge, so that no rinsing water can run into the well. The folding floor includes adjusting profiles to accommodate the height of the pavement. The folding floor has a big edge search for the replacement of the container.

b. Containers

The Dimensions of containers are 1500x1500, 1650x1650, 1800x1800 and 1950x1950mm.

Containers are modular and can be easily converted to another unit volume and one, two or three chamber container. All the containers are to be supplied with a bottom flap, two or three bottom flaps. Containers can be performed with yoke construction or with chains. Yoke construction is mounted on the inside of the container, so that damage is prevented during unloading. Pull / push rods are round in shape, so do not waste lingers behind those links. The yoke construction is provided with lateral guide in order to obtain uniform opening of the bottom valves. Chains are standard certified and have a minimum working load of 5,000 kg. Glass containers can be supplied with sound insulation measurement according to 2000/14 / EU.

c. Throw-in column

Several throw-in column types are available and fit all containers. Throw-in column may be centrally placed on the container for an optimal degree of filling of the container. Every throw-in column is equipped with a self-supporting inner frame. This saves the column from external damages. External sheathing with screws mounted on the inner frame is available in all standard RAL colours. All coating processes meet the highest environmental standards with each column are equipped with an access door to clear any blockages. These doors are closed with a triangular/ hemisphere lock or key lock certified.

Other options available:

- All known electronic access locks
- Mechanical locks on all drums, hoppers, valves, paper and plastic ball in two sided throws
- Stainless steel cladding, cut or blasted execution
- New Year closures on all groups
- Filling level measurement systems
- If possible, all customers want integrated systems such as ashtray for cigarettes and logos
- License plates, etc. fraction entries

5.1.2 Specifications of the Bins

a. Specifications of underground Bins

- Volume $3.25m^3$
- Dimensions of 1455 x 1455 x 1670 (LxWxH)
- Hooks System, 1 2 or 3 hook shot possible
- Several Throw-in variations, Valves, Textile dampers, double-skin drum, round rubber ball, rectangle rubber, paper or plastic ball
- Parts of plate, 2mm with standard RAL colours with options such as anti-graffiti coatings or Hammer
- Bottom parts of galvanized steel, valves ± 3 mm waterproof 80 Litre frame v/d valves 4 mm galvanized steel. For trio glass content of the valves ± 60 Litre
- Lifting equipment, above the above-ground container can be provided with a yoke for the control valves, or be carried out with chains for glass containers

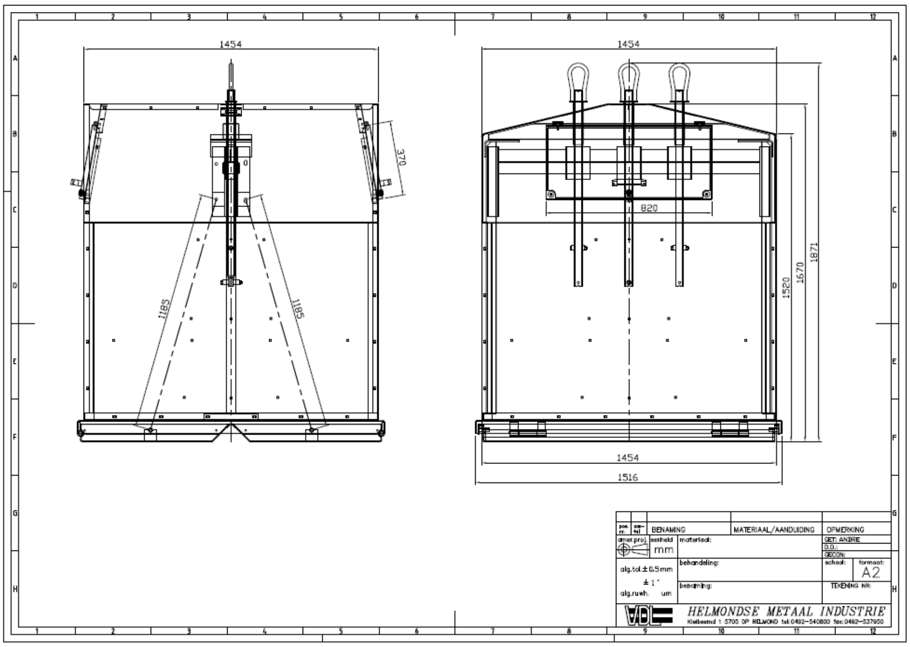


Figure 7: Aboveground Container

b. Specifications of semi-underground Bins

- Volume 4.5m^3
- 1455 x 1455 x 2375 (LxWxH) 2375 mm is ± 500 mm under the ground Hooks System , 1 2 or 3 hook shot possible
- Several Throw-in variations, Valves, Textile dampers, double-skin drum, round rubber ball, rectangle rubber, paper or plastic ball in
- Plate Parts 2mm with standard RAL colours with options such as anti-graffiti coatings or Hammer.
- Bottom parts of galvanized steel, valves ± 3 mm waterproof 80 Litre frame v/d valves 4 mm galvanized steel.
- Bottom Tray of 4 mm galvanized sheet steel.
- Lifting resources, the above-ground container can be provided with a yoke for the control valves, or be carried out with chains for glass containers.

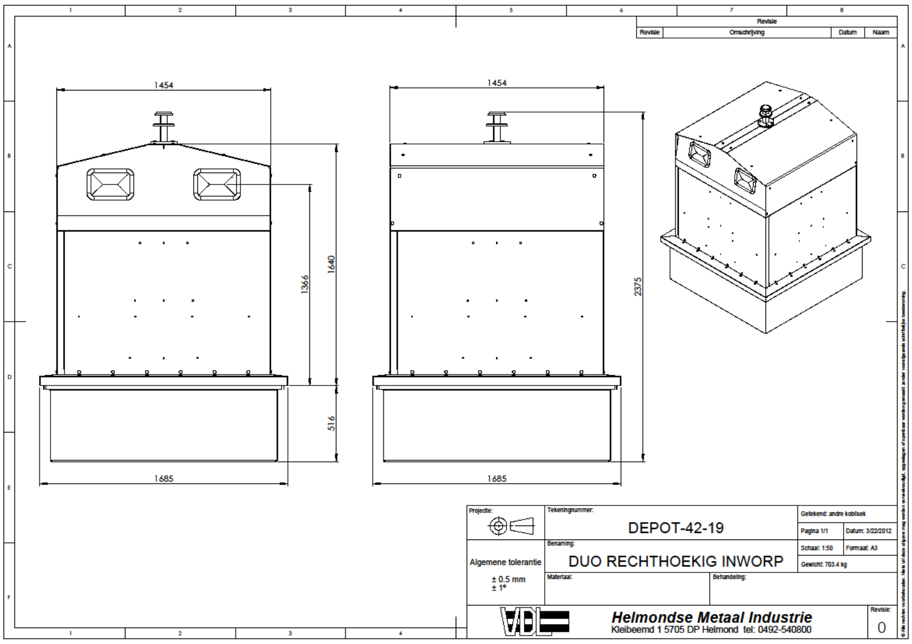


Figure 8: Semi-underground Bins

Figure 9: Semi underground Bins

5.1.3 Steps in the Placement of Underground Bins

a. Dig a hole, suiting the dimensions of the underground bins, deep enough to fit the base

b. Placement of underground concrete structure (into which the bin will be placed subsequently) which provides an outer layer of protection and covering

Figure 10: Underground concrete structures

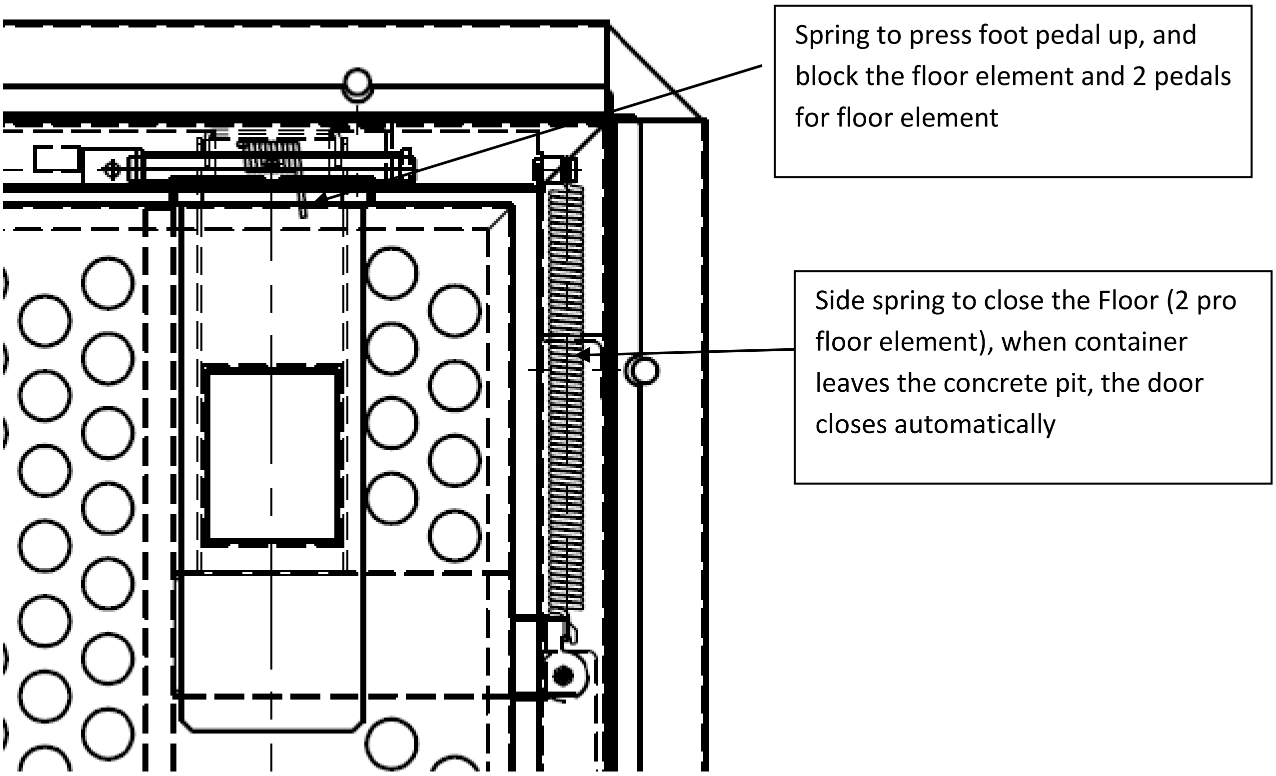
c. Placement of steel frame, with safety floor, on top of the concrete structure. The underground stainless steel bin will push the levers on the safety floor and the safety floor will open.

Figure 11: Underground stainless steel bin

5.1.4 Additional features of the underground bins

a. Safety Floor

The bins are supported with additional safety issues spring floor. The device is equipped with double springs on the side and each Red pedal is equipped with a spring. The springs have the force to close the system by itself. If one spring should break the safety floor will still function and still guarantee a safe situation.



If there is in any case any waste stuck underneath the safety floor you can open the safety floor with a Special handle. But take the necessary safety guiding that no one will fall into the concrete Pit. The special handle is pushed inside the red pedals. When you press the tool down on the bar the paddle will unlock the floor part. You press the Special handle to the side off the concrete pit and there you can block the special handle inside the frame off the safety floor. If there is water inside the concrete pit there is a special sized hole to put a hose trough and suck the water out of the pit. The diameter of this hole is 100 mm.

5.2 Estimation of current and future waste production and collection - Sundernagar

Sundernagar district has a total of 13 wards, generating on average close to 11 Tonnes of MSW a day. The waste generated in Sundernagar is sporadic and highly organic while the generation of plastics and inert are relatively much lower.

Table 6: Sundernagar Waste and Population Data

	Waste Per Ward	Number of Households in Ward	Population	Average Waste Generation	Waste Generation
	TPD		2011 Census	Kg/Ward	m^3/ward
Ward 1	5	320	1457	655.65	1.77
Ward 2	10	456	1845	830.25	2.24
Ward 3	8	398	1656	745.20	2.01
Ward 4	10	628	2582	1161.90	3.14
Ward 5	10	457	1723	775.35	2.10
Ward 6	5	354	1553	698.85	1.89
Ward 7	5	326	1315	591.75	1.60
Ward 8	12	363	1659	746.55	2.02
Ward 9	20	360	1582	711.90	1.92
Ward 10	5	427	1794	807.30	2.18
Ward 11	10	428	2027	912.15	2.47
Ward 12	5	653	2400	1080.00	2.92
Ward 13	5	852	2736	1231.20	3.33
Total	**11.80**	**6022**	**24329**	**10948.05**	**29.59**

In the table 6, the waste generation characteristics of Sundernagar are reflected. The amount of waste generated per ward was collected from the Municipality of Sundernagar, which deviated from the total waste production in town; therefore the assumption of 450 grams (national per person waste generation) average was used to calculate the average waste generation kg/ward. The average waste generation kg/ward was thus used to estimate the amount of cubic meters (m^3/ward) of waste generated in each ward of Sundernagar. As reflected in the table above a total of 29.59 m^3 of waste is generated in Sundernagar everyday on average.

Below we have worked out several options for the following configuration:

- 2 bins per pick-up location
- One for wet organics
- One for plastics and other dry waste (the bin is split into two compartments)
- The bins will be $3m^3$ in volume

5.2.1 Mapping of Underground Bins at every 200 Meters in Sundernagar

Figure 12: Mapping of Underground Bins at every 200 Meters in Sundernagar

The map reflects the placing of bins in Sundernagar at every 200 meters distance. A total of 52 bins (26 Bins of organics of $3m^3$ and 26 bins of half capacity each for dry waste and plastics of $3m^3$) can be placed in the various locations of the city, to ensure maximum coverage and easy access to the citizens. A person would have to walk a maximum of 200 meters in one direction to able to locate an underground bin where they can trash their waste.

5.2.2 Option 1: Underground Bins at every 200 meters ($3m^3$)

Table 7: Underground Bins at every 200 meters ($3m^3$)

Number of bins locations	Amount of Waste (TPD)	Bins	Type	Utilization	Pick up frequency
Organics	6.31	26	$3m^3$	22%	4.57
Plastics	2.21	26	1/2 $3m^3$	15%	6.51
Dry	2.54	26	1/2 $3m^3$	15%	6.51
Total	**11.08**	**52**			**5.86**

The amount of waste generated in across the wards of Sundernagar differs based on the population served by them. The amount of organics in the bins will fill up on an average in a day to 22% for $3m^3$ bins and 15% for $3m^3$ bins of half capacity for plastics and dry waste when the bins are located at a distance of 200 meters. This would mean that the bins would require to be cleared every 5-6 days for $3m^3$ on an average.

5.2.3 Option 2: Underground Bins at every 100 meters (3m³)

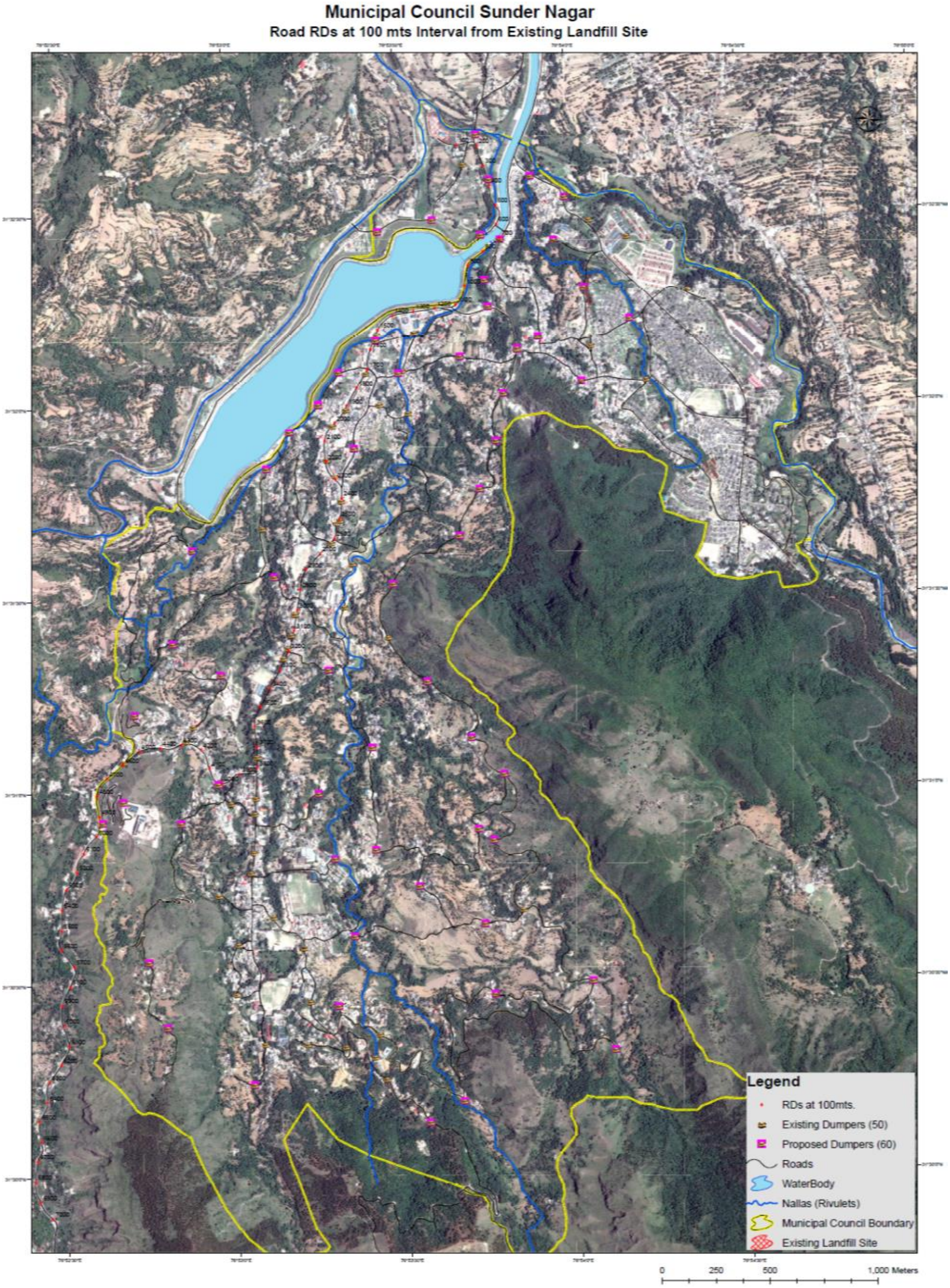


Figure 13: Mapping of Underground Bins at every 100 meters in Sundernagar

The map reflects the placing of bins in Sundernagar at every 100 meters distance. A total of 104 bins (52 Bins of organics of $3m^3$ and 52 bins of half capacity each for dry waste and plastics of $3m^3$) can be placed in the various locations of the city, to ensure maximum coverage and easy access to the citizens. A person would have to walk a maximum of 100 meters in one direction to able to locate an underground bin where they can trash their waste.

Table 8: Underground Bins at every 100 meters ($3m^3$)

Number of bins locations	Amount of Waste (TPD)	Bins	Type	Utilization	Pick up frequency
Organics	6.31	52	$3m^3$	11%	9.14
Plastics	2.21	52	1/2 $3m^3$	8%	13.02
Dry	2.54	52	1/2 $3m^3$	8%	13.02
Total	**11.08**	**104**			**11.73**

The amount of waste generated in across the wards of Sundernagar differs based on the population served by them. The amount of organics in the bins will fill up on an average in a day to 11% for $3m^3$ bins and 8% for $3m^3$ bins of half capacity for plastics and dry waste when the bins are located at a distance of 100 meters. This would mean that the bins would require to be cleared every 11-12 days for $3m^3$ on an average.

5.2.4 Option 3: Underground Bins at every 50 meters (3m³)

Figure 14: Mapping of Underground Bins at every 50 Meters in Sundernagar

The map reflects the placing of bins in Sundernagar at every 50 meters distance. A total of 212 bins (106 Bins of organics of $3m^3$ and 106 bins of half capacity each for dry waste and plastics of $3m^3$) can be placed in the various locations of the city, to ensure maximum coverage and easy access to the citizens. A person would have to walk a maximum of 50 meters in one direction to able to locate an underground bin where they can trash their waste.

Table 9: Underground Bins at every 50 meters (3m3)

Number of bins locations	Amount of Waste (TPD)	Bins	Type	Utilization	Pick up frequency
Organics	6.31	106	$3m^3$	5%	18.63
Plastics	2.21	106	1/2 $3m^3$	4%	26.55
Dry	2.54	106	1/2 $3m^3$	4%	26.55
Total	**11.08**	**212**			**23.91**

The amount of waste generated in across the wards of Sundernagar differs based on the population served by them. The amount of organics in the bins will fill up on an average in a day to 5% for 3m^3 bins and 4% for 3m^3 bins of half capacity for plastics and dry waste when the bins are located at a distance of 50 meters. This would mean that the bins would require to be cleared every 24 days for 3m^3 on an average. Although the placement of bins at every 50 meters ensures maximum coverage, it would not be necessary for a city like Sundernagar.

Recommendation: *The ideal placement of bins at Sundernagar would have to at every 100 meters. A total of 104 Bins, 52 bins of organics of 3m^3 capacity and 52 bins of half capacity of 3m^3 each for dry waste and plastics. This ensures maximum coverage of the area for the citizens to dispose trash while also giving sufficient bandwidth for growth in waste for the next many years.*

5.2.5 Option 1: Estimation of Future Waste Production - Underground Bins at every 100 meters (3m3) – 2025

Table 10: Estimation of Future Waste Production - 2025

Number of bins locations	Amount of Waste (TPD)	Bins	Type	Utilization	Pick up frequency
Organics	7.37	52	3m^3	13%	7.83
Plastics	2.59	52	1/2 3m^3	9%	11.15
Dry	2.98	52	1/2 3m^3	10%	9.70
Total	12.94	104			9.56

Keeping in mind a population growth of 1.2% annually, the next 10 years, the population of Sundernagar would be 28,751, with the waste production also estimated to be growing at the same rate. The daily waste generation 10 years from now is likely to be 12.94 TPD. With the growth in population and waste the utilization would be 13% for organics, 9% for plastics and 10% for dry waste. For the given growth of population, the bins of 3m^3 located at every 100 meters would be ideal to cover for the waste generation for the next 10-20 years and beyond.

5.2.6 Transportation and Pick Frequency

The below frequency for pick up are calculated based on a standard milk-route system, without applying smart technology reporting back the utilization status of bins (which would allow a truck to only go pick up waste from full bins). The utilization calculation is used to see how many trucks will be required for waste collection and if it will be feasible to complete within the given time when the bins are placed at every 100 meters.

Table 11: Sundernagar Transportation and Pick Frequency for organics

Input	Short code	Amount	Measure	Notes
Ton/Day total	TPD	11.08	Tonnes/Day	
Ton/Day Plastic	TPD_P	2.216	Tonnes/Day	Assumption
Ton/Day Organic	TPD_O	6.3156	Tonnes/Day	Assumption
Ton/Day DW	TPD_DW	2.5484	Tonnes/Day	Assumption
# of bins	Bins	52	#	Calculated
Trucks	Numbers	8	#	Given
Tonnage/truck	Tonnes	6	Tonnes	Given
Speed estimation	Speed km/hr	10	km/hr	Assumption
Pick-up/bin	Time_bin	5	minutes	

To and fro	Time_TF	20	minutes	
Dumping time	Time_DP	30	minutes	
Distance between bins	Distance	100	Meters	
Working hours	Working	8	Hours	

The table 11 reflects the amount of organics, plastics and dry waste generated in Sundernagar and the waste collection process, time and speed estimations. The frequency has been calculated for an estimation of 52 bins placed at a distance of 100 meters.

a. Organics

Table 12: Pickup Frequency for Organics - Sundernagar

Formulas	Short code	Formula	Value	Measure
Trips required- Organics truck	TR_O	TPD_O/Cap	1.05	#
Avg. bin/trip	Avg B/T	Bins/TR_O	49.40	#
Travel time	TrT_O	Avg B/T*Dist/1000/Speed	0.49	hour
Pick-up time	PU_O	Avg B/T*Time_bin/60	4.12	hour
Dumping and traveling	D+T	(Time_DP+2xTime_TF)/60	1.17	hour
Total time required per trip	TTpT_O	TrT_O+PU_O+D+T	5.78	hour
Total time required	TT_O	TT_O*TR_O	6.08	hour
Utilization Organics	U_O	TT_O/Working	0.76	%

The table no. 12 reflects the travel time; pick up time and the total time required per trip for the collection of the organics that are generated. Therefore, the total time utilization for organics is 76% and the total time required for a complete pickup of organics per trip would be 6.08 hours.

b. Plastics

Table 13: Pickup frequency for Plastics - Sundernagar

Formulas	Short code	Formula	Value	Measure
Trips required- plastics truck	TR_P	TPD_P/Cap	0.37	#
Avg bin/trip	Avg B/T	Bins/TR_P	140.79	#
Travel time	TrT_P	Avg B/T*Dist/1000/Speed	1.41	hour
Pick-up time	PU_O	Avg B/T*Time_bin/60	11.73	hour
Dumping and traveling	D+T	(Time_DP+2xTime_TF)/60	1.17	hour
Total time required per trip	TTpT_P	TrT_P+PU_P+D+T	14.31	hour
Total time required	TT_P	TT_O*TR_P	5.28	hour
Utilization plastics	U_P	TT_O/Working	0.66	%

The table no. 13 reflects the travel time; pick up time and the total time required per trip for the collection of plastics that are generated. Therefore, the total time utilization for plastics is 66% and the total time required for a complete pickup of plastics per trip would be 5.28 hours.

c. Dry Waste

Table 14: Pickup frequency for Dry Waste - Sundernagar

Formulas	Short code	Formula	Value	Measure
Trips required- Organics truck	TR_DW	TPD_DW/Cap	0.42	#
Avg. bin/trip	Avg B/T	Bins/TR_DW	122.43	#
Travel time	TrT_DW	Avg B/T*Dist/1000/Speed	1.22	hour
Pick-up time	PU_DW	Avg B/T*Time_bin/60	10.20	hour
Dumping and traveling	D+T	(Time_DP+2xTime_TF)/60	1.17	hour
Total time required per trip	TTpT_DW	TrT_DW+PU_DW+D+T	12.59	hour

Total time required	TT_DW	TT_DW*TR_DW	5.35	hour
Utilization Dry Waste	U_DW	TT_DW/Working	0.67	%

The table no. 14 reflects the travel time; pick up time and the total time required per trip for the collection of the dry waste that are generated. Therefore, the total time utilization for dry waste is 67% and the total time required for a complete pickup of dry waste per trip would be 5.35 hours.

5.2.7 Waste Sorting at Sundernagar: Plastics and Dry Waste

Sundernagar district produces 11.8 Tonnes of waste a day. Out of the waste generated, 6.3 tonnes are organics while the remaining 2.2 tonnes are plastic and 2.5 tonnes are dry waste. With 43% of the waste that includes dry waste and plastics, Sundernagar would have to set up a waste sorting centre where the segregated dry waste comes for further sorting, as people will always make mistakes in placing the specific type of waste in the right bin. The plastics resorted would go to the cement factory, the dry waste for recycling and the ultimate rejects to the sanitary landfill.

Figure 15: Sundernagar Dumping Site

Reflected in the below figure 16 is the replication of the sorting centre that would need to be set up in Sundernagar. The sorting centre would further sort the dry waste into recyclables and plastics. Setting up the sorting and waste processing centre is mandatory to extract recyclables and saleable plastics from dry waste and ensure that only the ultimate rejects are sent to be deposited at the sanitary landfill in Mandi district.

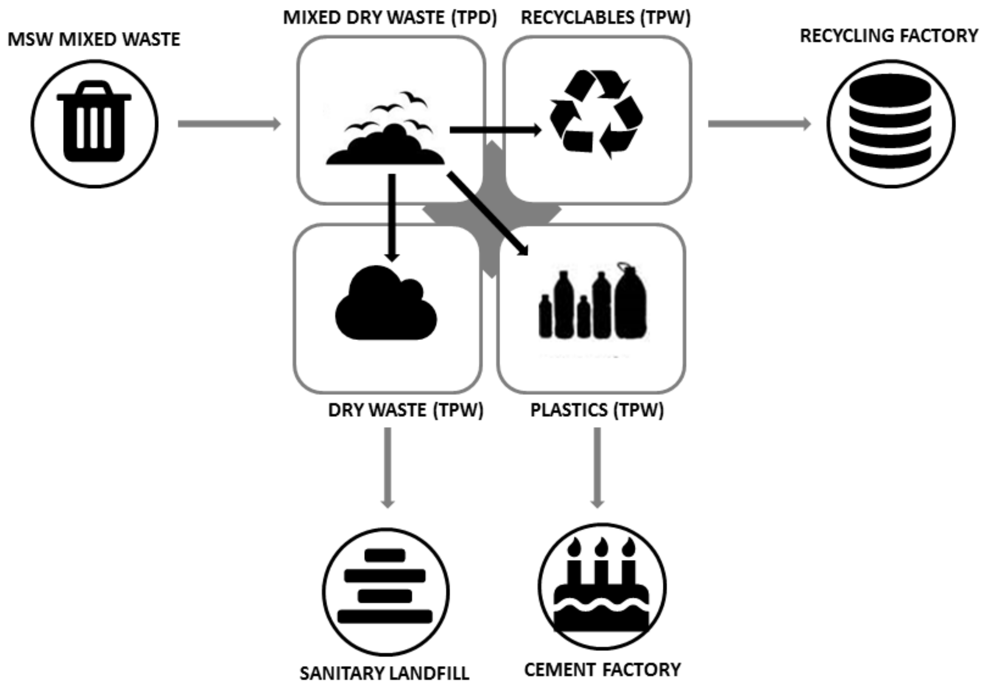


Figure 16: Flow of Dry/Mixed Waste

5.3 Estimation of current and future waste production and collection – Dharamshala

Dharamshala district has a total of 11 wards, generating 16 Tonnes of MSW a day. The waste generated in Dharamshala much like the waste in all of Himachal Pradesh is sporadic and highly organic as well as variable owing to the influx of tourists during season.

5.3.1 Option 1: Underground Bins at every 100 meters

Table 15: Dharamshala Waste and Population Data

	Waste Per Ward	Number of Households in Ward	Population	Average Waste Generation	Waste Generation
	TPD		2011 Census	Kg/Ward	m^3/ward
Ward 1	1.45	290.75	1163	523.35	1.41
Ward 2	1.45	1068.25	4273	1922.85	5.20
Ward 3	1.45	1347.75	5391	2425.95	6.56
Ward 4	1.45	483.75	1935	870.75	2.35
Ward 5	1.45	447	1788	804.6	2.17
Ward 6	1.45	405.5	1622	729.9	1.97
Ward 7	1.45	238	952	428.4	1.16
Ward 8	1.45	293.25	1173	527.85	1.43
Ward 9	1.45	281.25	1125	506.25	1.37
Ward 10	1.45	288.5	1154	519.3	1.40
Ward 11	1.45	502.5	2010	904.5	2.44
Total	16.00	6022	22586	10163.7	27.47

In the Table 15, the waste generation characteristics of Dharamshala are reflected. The amount of waste generated in Dharamshala was collected, and since the ward waste characteristics was not available, the total waste generated (16 TPD) was assumed to be equally generated by all 11 wards (1.45 TPD) for the purpose of calculation and analysis. The average waste generated per ward was calculated by using the national per person waste generation average of 450 grams. The average waste generation kg/ward of was thus used to estimate the amount of cubic meters (m^3/ward) of waste generated in each ward of Dharamshala approximately. As reflected in table above approximately 27.47 m^3 of waste is generated in Dharamshala everyday on an average.

Dharamshala being a tourist town also sees a huge influx of tourists in the tourist season of March to August. A floating population of about 30 Lakh tourists visit Dharamshala every year. During this time the waste produced by Dharamshala is approximately 50 TPD. The waste generated by tourists would be more plastics and less organics, the below mentioned plan of placing bins at every 100 meters would accommodate the excess plastics generated by tourists during the season.

5.3.2 Option 1: Estimation of Waste Production - Underground Bins at every 100 meters ($3m^3$)

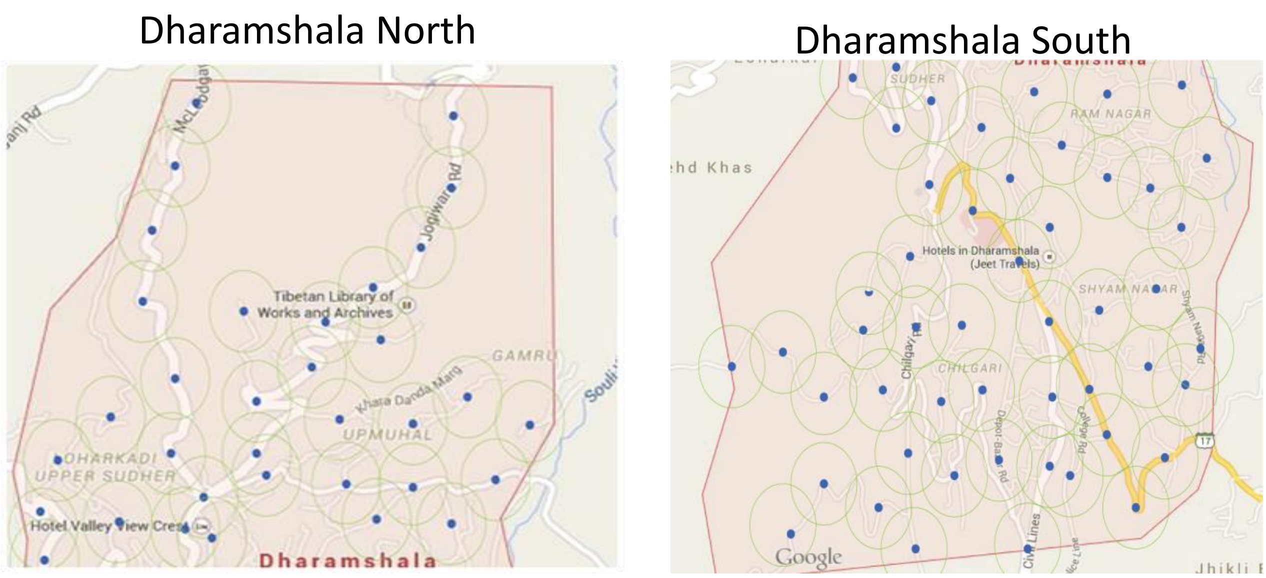


Figure 17: Mapping of Underground Bins at every 100 meters in Dharamshala

The map reflects the placing of bins in Sundernagar at every 100 meters distance. A total of 172 bins (86 Bins of organics of $3m^3$ and 86 bins of half capacity each for dry waste and plastics of $3m^3$) can be placed in the various locations of the city, to ensure maximum coverage and easy access to the citizens. A person would have to walk a maximum of 100 meters in one direction to able to locate an underground bin where they can trash their waste.

Table 16: Underground Bins at every 100 meters ($3m^3$)

Number of bins locations	Amount of Waste (TPD)	Bins	Type	Utilization	Pick up frequency
Organics	9.12	86	$3m^3$	10%	10.47
Plastics	3.2	86	1/2 $3m^3$	7%	14.92
Dry	3.68	86	1/2 $3m^3$	7%	14.92
Total	**16**	**172**			**13.43**

The amount of waste generated in across the wards of Dharamshala differs based on the population served by them. The amount of organics in the bins will fill up on an average in a day to 10% for 3m3 bins and 7% for $3m^3$ bins of half capacity for plastics and dry waste when the bins are located at a distance of 100 meters. This would mean that the bins would require to be cleared every 13 days for $3m^3$ on an average.

During the peak tourist season Dharamshala generates about 25 TPD of MSW. The waste bins located at every 100 meters can sufficiently accommodate all the extra waste during the peak season of March to August.

5.3.3 Transportation and Pick Frequency

Table 17: Transportation and Pick-up frequency - Dharamshala

Input	Short code	Amount	Measure	Notes
Ton/Day total	TPD	16	Tonnes/Day	
Ton/Day Plastic	TPD_P	3.2	Tonnes/Day	Assumption
Ton/Day Organic	TPD_O	9.12	Tonnes/Day	Assumption
Ton/Day DW	TPD_DW	3.68	Tonnes/Day	Assumption
# of bins	Bins	86	#	Calculated
Trucks	Numbers	4	#	Given
Tonnage/truck	Tonnes	6	Tonnes	Given
Speed estimation	Speed km/hr	10	km/hr	Assumption
Pick-up/bin	Time_bin	5	minutes	
To and fro	Time_TF	20	minutes	
Dumping time	Time_DP	30	minutes	
Distance between bins	Distance	100	meters	
Working hours	Working	8	hours	

The table 17 reflects the amount of organics, plastics and dry waste generated in Dharamshala and the waste collection process, time and speed estimations. The frequency has been calculated for an estimation of 86 bins placed at a distance of 100 meters.

Table 18: Pickup frequency Organics - Dharamshala

Formulas	Short code	Formula	Value	Measure
Trips required- Organics truck	TR_O	TPD_O/Cap	1.52	#
Avg bin/trip	Avg B/T	Bins/TR_O	56.58	#
Travel time	TrT_O	Avg B/T*Dist/1000/Speed	0.57	hour
Pick-up time	PU_O	Avg B/T*Time_bin/60	4.71	hour
Dumping and traveling	D+T	(Time_DP+2xTime_TF)/60	1.17	hour
Total time required per trip	TTpT_O	TrT_O+PU_O+D+T	6.45	hour
Total time required	TT_O	TT_O*TR_O	9.80	hour
Utilization Organics	U_O	TT_O/Working	1.23	%

The table 18 reflects the travel time; pick up time and the total time required per trip for the collection of the organics that are generated. Therefore, the total time utilization for organics is 123% and the total time required for a complete pickup of organics per trip would be 9.8 hours.

Table 19: Pickup frequency plastics- Dharamshala

Formulas	Short code	Formula	Value	Measure
Trips required- Organics truck	TR_P	TPD_P/Cap	0.53	#
Avg. bin/trip	Avg B/T	Bins/TR_P	161.25	#
Travel time	TrT_P	Avg B/T*Dist/1000/Speed	1.61	hour
Pick-up time	PU_P	Avg B/T*Time_bin/60	13.44	hour
Dumping and traveling	D+T	(Time_DP+2xTime_TF)/60	1.17	hour
Total time required per trip	TTpT_P	TrT_P+PU_P+D+T	16.22	hour
Total time required	TT_P	TT_P*TR_P	8.65	hour
Utilization plastics	U_P	TT_O/Working	1.08	%

The table 19 reflects the travel time; pick up time and the total time required per trip for the collection of the plastics that are generated. Therefore, the total time utilization for plastics in Dharamshala is 108% and the total time required for a complete pickup of plastics per trip would be 8.65 hours.

Table 20: Pickup frequency dry waste - Dharamshala

Formulas	Short code	Formula	Value	Measure
Trips required- Organics truck	TR_DW	TPD_DW/Cap	0.61	#
Avg. bin/trip	Avg B/T	Bins/TR_DW	140.22	#
Travel time	TrT_DW	Avg B/T*Dist/1000/Speed	1.40	hour
Pick-up time	PU_DW	Avg B/T*Time_bin/60	11.68	hour
Dumping and traveling	D+T	(Time_DP+2xTime_TF)/60	1.17	hour
Total time required per trip	TTpT_DW	TrT_DW+PU_DW+D+T	14.25	hour
Total time required	TT_DW	TT_DW*TR_DW	8.74	hour
Utilization dry waste	U_DW	TT_DW/Working	1.09	%

The table 20 reflects the travel time; pick up time and the total time required per trip for the collection of the dry waste that are generated. Therefore, the total time utilization for dry waste is 109% and the total time required for a complete pickup of dry waste per trip would be 8.74 hours.

5.4 Investment in C&T

The investment in collection and transport systems would be varying based on the number of bins that would be eventually installed. For the purpose of clarity and choice, we propose 3 options of investment.

Below we have worked out the following options for estimation of pricing

- Investment in underground bins of $3m^3$ for organics at a distance of 100 m, $5m^3$ for plastics and $5m^3$ for Dry waste within a distance of 500 meters
- Investment in aboveground bins of $3m^3$ for organics at a distance of 100m, $5m^3$ for plastics and $5m^3$ for Dry waste within a distance of 500 meters
- Investment in underground bins at a distance of 100m of $3m^3$ for organics, and underground bins of $3m^3$ of half capacity of plastics and dry waste

The below options 1 and 2 are suggestions for underground bins made by the Waste to Value Consortium team after studying the waste generation patterns and requirements of Himachal Pradesh. Option 3 investments are the suggestion of Nexusnovus based on the findings and study of the waste characteristics of Himachal Pradesh.

5.4.1 Option 1: Investment in Underground Bins

Table 21: Option 1 - Underground Bins

	Number of bins $3m^3$ Underground Bins	Number of bins $5m^3$ Underground Bins	Number of bins $5m^3$ Underground Bins
	Distance max 100 m.	Distance max 500 m.	Distance max 500 m.
	Organics	Plastics	Dry recyclables
Sundernagar	48	6	6
Dharamshala	83	9	9
Total bins	**131**	**15**	**15**

Table 22: Option 1 - Investment in Underground Bins

Pricing	Quantity	Per Unit Price (EUR)	Total Price (INR)
Nr of bins $3m^3$ underground	131	**2800**	366800
Underground container		1200	
Above ground unit/pillar		900	
Frame		200	
Safety floor (option)		500	
Nr of bins $5m^3$ underground	30	**2800**	84000
Underground container		1200	
Above ground unit/pillar		900	
Frame		200	
Safety floor (option)		500	

Transportation Ship (20 complete units per 40ft container)	161	150	24150
Total Investment in Bins			**474950**
Import duties (30%) (*exemptions on Duty during for Government purchase*)		0.3	**142485**
Transportation Truck Mumbai – HP	161	150	24150
Concrete casing/pit 3m^3	131	600	78,600
Concrete casing/pit 5m^3	30	914	27,429
Total cost to get the bins to HP			**130179**
Local preparation activities (estimates)			
Digging hole	161	20	3220
Placing concrete casing	161	20	3220
placing underground bin and installation/roadwork	161	20	3220
Total cost for installation of bins			**9660**
(estimates for purchase in India)			
Truck for collection	2	30000	60000
Crane for emptying bins into collection truck	2	20000	40000
Total trucks and cranes			**100000**
Total cost of Underground Bins (EUR)			**857,274**
Total cost of Underground Bins (INR)			**6 Crores**

The table above reflects the total investments for the installation of 131 underground bins of bins for organics (48 Sundernagar and 83 Dharamshala) of 3m^3 and 15 plastics and 15 dry underground bins of 5m^3 (6 each in Sundernagar and 9 each Dharamshala). The cost includes the price of a truck for waste collection of INR 60,000 and crane for emptying the bins into the trucks of INR 40,000. The total investment for the 161 bins inclusive of installation, transportation, truck and crane is approximated to INR 6 crores.

5.4.2 Option 2: Investment in Underground (Organics) and Aboveground Bins (Plastics and Dry Waste)

Table 23: Option 2 – Underground and Aboveground Bins

	Distance max 100 m.	Distance max 500 m.	Distance max 500 m.
	Organics	Plastics	Dry recyclables
Sundernagar	48	6	6
Dharamshala	83	9	9

Table 24: Option 2 - Investment in Underground and Aboveground Bins

Pricing	**Quantity**	**Per Unit Price (EUR)**	**Total Price (INR)**

Nr of bins 3m³ underground	131	**2300**	301300
underground container		1200	
above ground unit/pillar		900	
Frame		200	
Nr of bins 5m³ above ground	30	**2000**	60000
Transportation Ship (20 complete units per 40ft container)	161	150	24150
Import duties (30%) (*exemptions on Duty for Government purchase)*		0.3	**115635**
Transportation Truck Mumbai - HP	161	150	24150
Concrete casing/pit 3m³	131	600	78,600
Local preparation activities (estimates)			
Digging hole	131	20	2620
Placing concrete casing	131	20	2620
Placing underground bin and installation/roadwork	131	20	2620
Estimates for purchase in India			
Truck for collection	2	30000	60000
Crane for emptying bins into collection truck	2	20000	40000

The table above reflects the total investments for the installation of 131 underground bins of bins for organics (48 Sundernagar and 83 Dharamshala) of $3m^3$ and 15 plastics and 15 dry aboveground bins of $5m^3$ (6 each in Sundernagar and 9 each Dharamshala). The cost includes the price of a truck for waste collection of INR 60,000 and crane for emptying the bins into the trucks of INR 40,000. The total investment for the 161 underground and aboveground bins inclusive of installation, transportation, truck and crane is approximated to INR 4.98 crores.

5.4.3 Options 3: Underground Bins at every 100 meters distance

Table 25: Option 3 - Underground Bins at every 100 metres

	Number of Bins of 3m³	**Number of Bins of 3m³ ½ to Dry Waste ½ to plastics**
Sundernagar	52	52
Dharamshala	86	86

Total Number of Bins	138	138

Table 26: Option 3 - Investment in Underground Bins at every 100 metres

Pricing	Quantity	Per Unit Price (EUR)	Total Price (INR)
Bins $3m^3$ underground	276	2800	772800
underground container		1200	
above ground unit/pillar		900	
Frame		200	
Safety floor (option)		500	
Transportation Ship (20 complete units per 40ft container)	276	150	41400
Total Investment in Bins			**814200**
Import duties (30%) (*exemptions on Duty for Government purchase)*		0.3	244260
Transportation Truck Mumbai - HP	276	150	41400
Concrete casing/pit $3m^3$	276	600	1,65,600
Total cost to get the bins to HP			**207000**
Local preparation activities (estimates)			
Digging hole	276	20	5520
placing concrete casing	276	20	5520
placing underground bin and installation/roadwork	276	20	5520
Total cost for installation of bins			**16560**
Estimates for purchase in India			
Truck for collection	2	30000	60000
Crane for emptying bins into collection truck	2	20000	40000
Total trucks and cranes			**100000**
Total cost of Underground Bins (EUR)			1382020
Total cost of Underground Bins (INR)			**9.67 Crore**

The table above reflects the total investments for the installation of 138 underground bins for organics (52 Sundernagar at every 100 meters and 86 Dharamshala at every 100 meters) of $3m^3$ and 138 underground bins for plastics and dry waste (52 Sundernagar and 86 Dharamshala) of half capacity each for dry waste and plastics of $3m^3$. The cost includes the price of a truck for waste collection of INR 60,000 and crane for emptying the bins into the trucks of INR 40,000. The total investment for the 276 bins underground bins inclusive of installation, transportation, truck and crane is approximated to INR 9.67 crores.

Note:

The import duty rate of 30% on the bins would receive exemption, since the purchase will be made by a *government body*. The application for exemption would have to be submitted during collection of the shipment of bins at the port on behalf of the municipal authority.

5.5 Web based monitoring systems

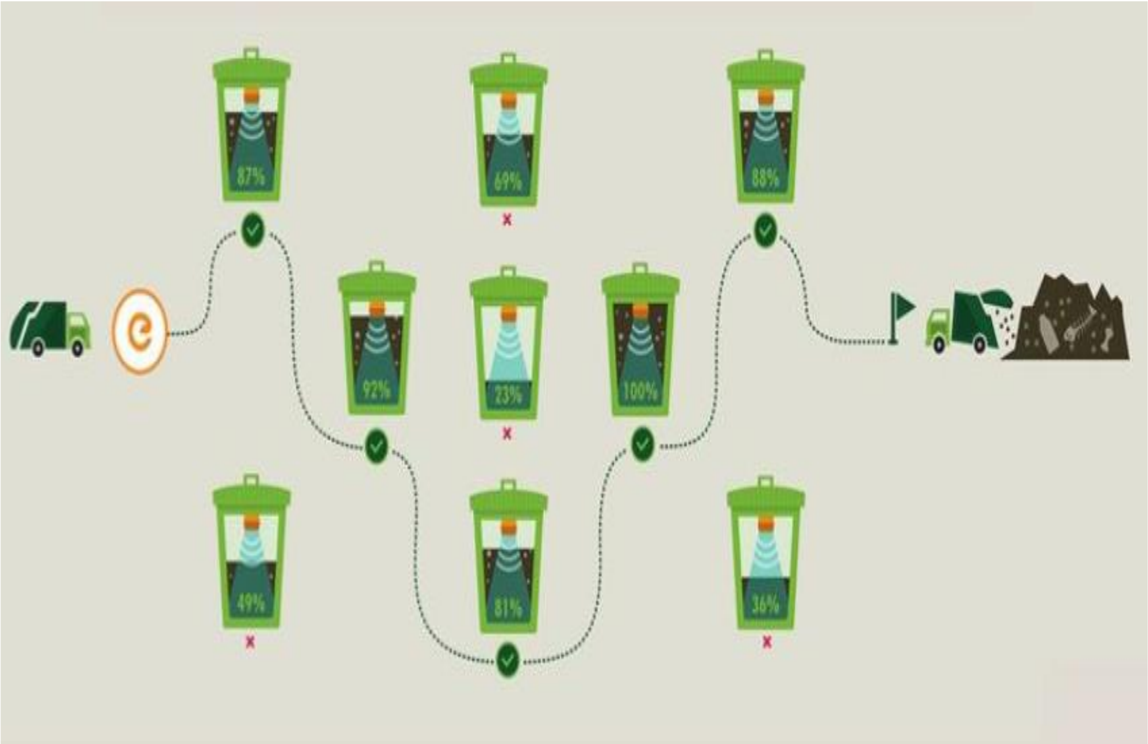
Web-based monitoring system for bins allows real-time, remote wireless inventory management of stored material and gets update on when the bin gets filled up from any computer connected to the Internet anywhere in the world.

Monitoring systems eliminates the need to manually check bin levels which saves time, money and manpower and improves the efficiency of waste collection. The system is highly scalable and is able to monitor one or a hundred bins and grow as operations expand.

5.5.1 Enevo – Digital Collection Intelligence System

Enevo assists in understanding when and where to collect waste containers. It uses wireless sensors to measure and forecast the fill-level of waste containers and generates smart collection plans and the most cost efficient collection routes.

Web based monitoring



I. Advantages of installing web based digital collection intelligence system

a. It provides direct cost savings and gives you a transparent window into every container. The service eliminates unnecessary collections of half-empty containers and radically improves your fleet utilization
b. It automatically generates dynamic routes based on accurate forecasts. It then uses an extensive set of parameters to determine which route is the most cost efficient.
c. Big Savings in side-costs e.g. clean-up costs, bags in small litter bins etc.
d. Increased service quality: no overflow – no complaints

e. Reduced emissions and litter in the surrounding area, high level green performing.

The system works by way of not only looking at the current situation but considering the future outlook as well. It considers operation costs and restrictions and selects the most cost efficient plan for execution.

II. Technology overview of the systems

It uses Wireless 2G and 3G with global roaming, with Ground breaking signal processing algorithms to detect fill-levels using ultrasonic sensors and highly accurate temperature, tilt and accelerometer sensors

III. **Features**

a. Continuously monitors fill level and automatically detects container collections
b. Container movements and even fire
c. Can easily be retrofitted or pre-installed into any type of container
d. Can measure any type of collection stream, solid or liquid
e. Easy installation
f. Zero maintenance
g. Totally independent with internal power
h. supply lasting for 10+ years*
i. Wireless communications and alarming
j. Wireless configuration and remote software updates
k. Data access from anywhere via the Internet through the Enevo ONE web interface
l. Submersible robust IP-66

6 Biogas Plant: Sundernagar

6.1 Biogas Plant: Introduction and technology Options

Biogas in India is being used by Communities and households. The use of Biogas Technology in India is seen more on domestic levels, rather than large scale productions in Industries which generate liquid and solid organic waste are installing gas engines and waste digesters for generating power.

India ranks second in biogas utilization and the total biogas potential, in terms of electrical Power, is estimated at ~1,300 MWe with the major industries generating biogas being Distillery, Sugar, and Starch. These three, together, account for 3/4th of the total biogas potential of India. The other major industries are Pulp and paper, Milk processing, Slaughter house, and Poultry. These industries are exploring biogas options to deal with waste management problems that currently exist.

6.1.1 The key drivers for biogas Industry in India

- Higher electricity and LPG prices
- Due to rise in waste management crisis, organizations are showing interest in biogas
- Availability of scrubbers in India
- On – grid connectivity (at location of feedstock production)

- Energy scarcity
- Black-outs (thus local generators which can run on diesel or biogas or LPG)
- Large availability of feedstock

6.1.2 Biogas in India – Scope for Growth

Going for renewable energy resources is an excellent workable option. In fact, it could be the only way going forward. Indian government has taken cognizant of the fact, and you can expect more and more attractive incentives being offered for producing energy with the help of renewable resources. They are also taking steps to bring about more awareness among the public, about the benefits of using sustainable energy resources.

The trend of private investments is more likely to be picked up by many organizations that specialize in renewable Energy Power generation. With the FDI (Foreign direct Investment) being lenient and conducive to international investors, we can only expect more international companies planning to invest on Biogas energy in India. India is going big on renewable energy and biogas sector is one of those that will see nascent growth in the coming decade.

A biogas plant is an anaerobic digester that produces biogas from waste. Biofuels are liquid, gaseous, or solid fuel made from live or recently dead organic material known as biomass, as opposed to fossil fuels, which are composed of ancient biological materials. Biogas is a type of biofuel created via anaerobic, or oxygen-free, digestion of organic matter by bacteria.

A biogas plant is composed of a digester and a gas holder. The digester is an airtight container in which the organic waste is dumped and decomposed, and the gas holder is usually a double membrane roof on top of the digester tank where the biogas is stored. Bacteria within the digester tank breaks down the waste and, as it decomposes, gases such as carbon monoxide, methane, hydrogen, and nitrogen (together referred to as ‘biogas’) are released. The biogas is stored and pressurized under the double membrane roof, from where it will be combusted, or reacted, with oxygen to create an energy source for such processes as heating and vehicle propulsion.

6.1.3 Construction of a biogas plant

Construction of a biogas plant may vary depending on the amount of gas needed, the amount of waste at hand, and whether the digester is designed for batch feeding or continuous feeding. A biogas plant may be constructed either above or below ground, with advantages and disadvantages to both models. An above ground biogas plant is easier to maintain and benefits from solar heating, but takes more care in construction because it must be built to handle the internal pressure of the digester. A below ground biogas plant is cheaper to construct and easier to feed, but is more difficult to maintain. In an attempt to neutralize the slurry, more acidic carbon dioxide, which is a desired gas, will be created. The slurry within the tank must also be frequently stirred to prevent a hard crust from forming on top of the waste. A crust can trap the gases within the slurry and impede the machinery’s ability to harness the gases.

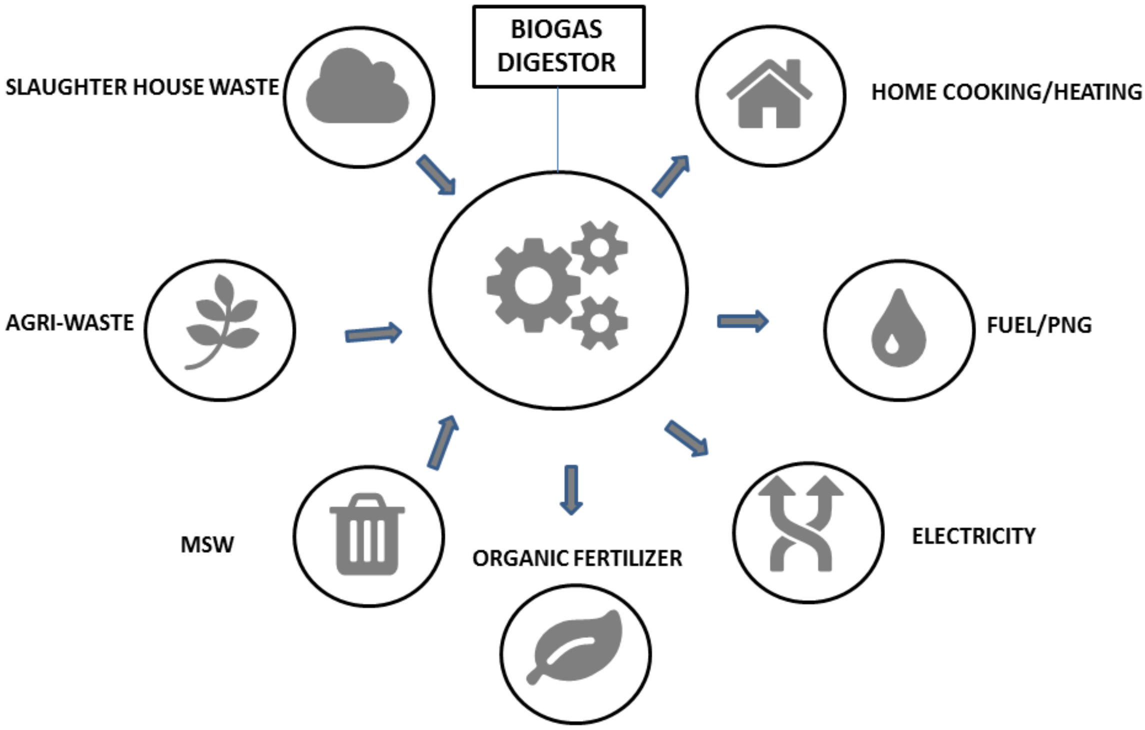


Figure 18: Biogas Model

6.1.4 Mesophilic and Thermophilic anaerobic digestion for biogas production

Anaerobic digestion is the most widely used method of organic waste disposal due to its high performance in volume reduction and stabilization and the production of biogas that makes the process profitable. However, biological hydrolysis, which is the rate-limiting step for the anaerobic degradation has to be improved to enhance the overall process performance and to reduce the associated cost. Several mechanical, thermal, chemical, or biological pre-treatment methods have been considered to improve hydrolysis and anaerobic digestion performance. These pre-treatments result in the lysis or disintegration of cells and release of intracellular matter that becomes more accessible to anaerobic micro-organisms, thus improving anaerobic digestion. Anaerobic fermentation significantly reduces the total mass of waste, generates solid or liquid fertilizer and yields energy. It can be maintained at psychrophilic (12-16°C, e.g. in landfills, swamps or sediments), mesophilic (35-37°C, e.g. in the rumen and in anaerobic digester) and thermophilic conditions (55-60 °C; e.g. in anaerobic digesters or geothermal heated ecosystems). Disadvantages of thermophilic anaerobic fermentation are the reduced process stability and reduced dewatering properties of the fermented sludge and the requirement for large amounts of energy for heating, whereas the thermal destruction of pathogenic bacteria at elevated temperatures is considered a big advantage. The slightly higher rates of hydrolysis and fermentation under thermophilic conditions have not led to a higher methane yield reported no significant change in the total methane yield from organic matter for fermentation temperatures ranging from 30°C to 60°C.

There are three ranges of anaerobic degradation temperature: degradation at ambient temperature (psychrophilic range), mesophile degradation at 33-40° C and thermophilic degradation at 50-60° C.

It is typical of the temperature ranges that at higher temperature decomposition take place quickly. Thermophilic anaerobic degradation is also up to 8 times faster and more efficient than mesophile degradation. Thermophilic digestion is 4 times more intense and therefore yields more gas.

Table 27: Difference in biogas production under thermophilic and Mesophilic temperatures

Details	Mesophilic	Thermophilic
TPD	1 Tonne	1 Tonne
Biogas	$40m^3$	$120m^3$
Methane%	60%	60%
Methane	$24m^3$	$72m^3$

6.1.5 Waste Stream Analysis - Biogas Plant

a. Waste - Organics

The daily waste generated in the cluster of Sundernagar, Mandi and Ner Chowk is 30.5 tonnes which comprises of roughly 57% organics. The average daily organics generation is therefore 17.38 tonnes. Based on estimations the total production of organics in the cluster for a week is 121.69 tonnes and for a year is 6345.52 tonnes.

Table 28: Organics Waste Generation

Cluster	Total Waste generation (tonnes/day)	Percentage Organics	Daily Organics Waste generation (tonnes/day)	Weekly Inert Waste Generation (tonnes/week)	Yearly Inert Waste Generation (tonnes/year)
Sundernagar	11	57%	6.27	43.89	2,288.55
Mandi	18	57%	10.26	71.82	3,744.9
Ner Chowk	1.5	57%	0.855	5.985	312.07
Total	**30.5**	**57%**	**17.385**	**121.695**	**6,345.52**

With the population growth rate 1.2% (national average) and the per capita daily waste generation of 450 grams the generation of organic waste will also grow at 1.2% annually. The daily organic waste generation will grow from 17.38 tonnes/day to 19.36 tonnes/day of waste generation as reflected in Figure 19 below.

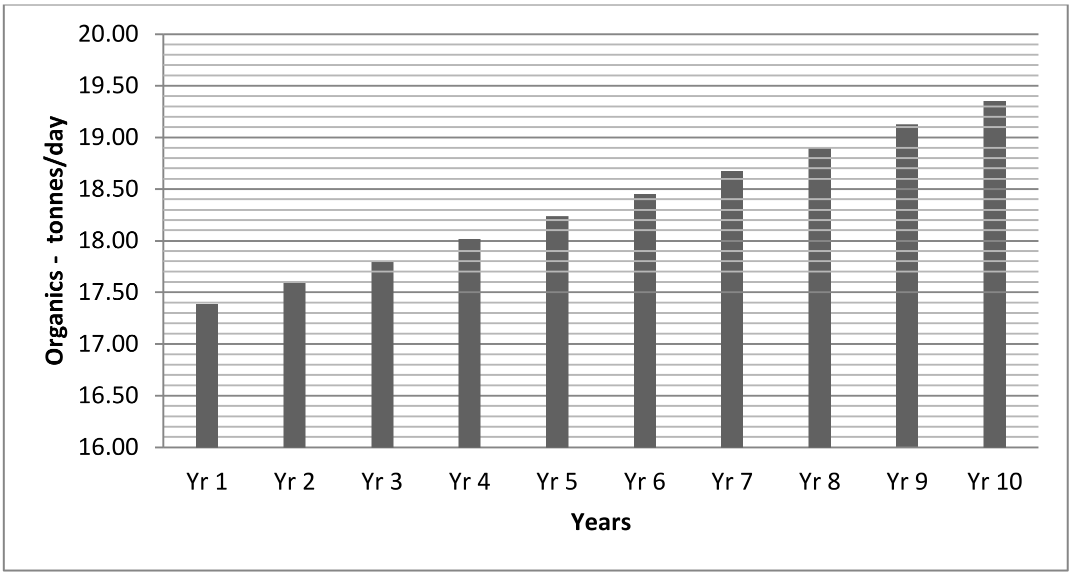


Figure 19: Growth of organic waste generation in the cluster

b. Map of Sundernagar dumpsite – Site for the Biogas Plant

Figure 20: Sundernagar Dumpsite

Sundernagar, dumpsite is located at latitude 31°32'42.41"N and longitude 76°53'37.53"E.

6.2 Production inputs

a. Organics

Sundernagar generates about 11 tonnes of waste per day, out of which 57% are organics. The organics fraction therefore amounts to 6.3 tonnes a day which would be fed into the biogas plant. The organics from the Ner Chowk and Mandi would also be flowing into the Sundernagar Biogas plant once the segregation at source has been implemented to separate the organics from the rest. Organics with high levels of organic dry matter are the best feedstock for a biogas plant.

b. Sewage

There are BBMB sewerage treatment plants of 5.00 MLD (Million Litre Daily) and I&PH sewage treatment plants of 3.50 MLD, currently in Sundernagar. A total of 8.5 MLD of sewage is generated in Sundernagar; the sewage sludge can be fed into the biogas plant and treated by using CSTR technology. Sewage water itself contains low amounts of organic dry matter and is therefore normally not suitable for anaerobic digestion projects using CSTR technology, unless it is used for liquefying waste streams with high amounts of dry matter.

c. Agri-waste

Agricultural waste of 1 tonne per day would be an additional source of feedstock that may feed into the biogas plant. Agri-waste is rich in organics; therefore the fresh feedstock from Sundernagar's agri-belt can be a methane rich input for the biogas plant.

d. Mixed waste

Non-Source separated MSW from Mandi consists of 9.18 TPD of organics and 0.7 TPD of organics from Ner chowk. The waste can be sorted and removed for organics by using mechanical segregation methods like Extrusion Press.

Table 29: Climatic conditions of Sundernagar

Temperature				Precipitation
Months	**Normal**	**Warmest**	**Coldest**	**Normal**
January	12.8°C	18.9°C	6.7°C	2
February	14.8°C	21.0°C	8.5°C	3
March	19.4°C	26.0°C	12.8°C	4
April	26.7°C	34.6°C	18.8°C	1
May	31.1°C	38.8°C	23.3°C	2
June	33.0°C	39.6°C	26.2°C	4
July	30.5°C	34.9°C	26.1°C	11
August	28.8°C	32.9°C	24.8°C	9
September	28.5°C	33.4°C	23.4°C	4
October	24.9°C	32.0°C	17.7°C	0
November	19.0°C	26.4°C	11.6°C	1
December	14.1°C	20.7°C	7.4°C	2

The climatic conditions of Sundernagar are temperate with moderate rainfall, thereby the climate cannot be considered optimal for mesophile generation of biogas. The given temperature variation, would result in a severe fall in the production of biogas during the winter season owing to the temperature fall, which can be nullified by sufficient insulation of the digestor. Therefore, thermophile gas production would be the preferred method for biogas production to ensure that the gas production is not interrupted during the winter season.

6.2.1 Biogas generation model

Based on the feedstock that goes into the model, Biogas is generated by the breakdown of organic matter in the absence of oxygen. Biogas is primarily methane (CH4) and carbon dioxide (CO2) and may have small amounts of hydrogen sulphide (H2S), moisture and siloxanes. The gas methane derived is a valuable renewable energy, which can be used as a cheaper alternative to fossil fuels.

6.2.2 Biogas Composition and Properties

Biogas generally comprises of 60% methane, 40% carbon dioxide, 0.5-1.0% hydrogen sulphide, rests of water vipers etc. Biogas is non-toxic, colour less and flammable gas. It has an ignition temperature of 650 – 7500C. Its density is 1.214kg/ m^3 (assuming about 60% Methane and 40% CO2). Its calorific value is 20 MJ/m^3 (or 4700 kcal.). It is almost 20% lighter than air. Biogas, like Liquefied Petroleum Gas (LPG) cannot be converted into liquid state under normal temperature and pressure. It liquefies at a pressure of about 47.4 Kg/cm^2 at a critical temperature of -82.10 c. Removing carbon dioxide, Hydrogen Sulphide and moisture upgrades biogas into Bio-CNG and compressing it into cylinders makes Bio-CNG easily usable for transport applications & also for stationary applications. Already Bio-CNG technology has become easily available and therefore, Bio-CNG which is nearly same as CNG as per ISO Standards can be used for all applications for which CNG is used. Purified biogas (bio-methane or Bio-CNG) has a high calorific value in comparison to raw biogas.

6.3 Biogas model

6.3.1 Revenue from biogas plant

A biogas plant takes in feedstock from varied sources which could include organics from MSW, slaughterhouse waste, Agri-waste, hotel waste, cow dung etc. Besides the renewable energy that it generates which can be used as an alternative to fossil fuels, the setting up of a biogas plant has the environmental effect of replacing conventional fuels like kerosene and firewood, and thereby saving the negative effects on the environment. The plant once established can also be made profitable by earning revenues from various sources as below:

a. Tipping Fee/Gate Fee

Gate Fee also known as tipping fee is the price paid to the waste processing companies by the Municipal authority or vice versa. Tipping Fee Model, in which municipalities pay private MSW, companies a tipping fee for every ton of waste collected, processed and dumped, is the most prevalent model in India. The Municipal authority decides the gate fee based on the tendering document of the waste processing company being awarded the project. In the Western & Southern part of India, it is being observed that the municipal authority primarily pays the fee to the waste processing companies. However, the rate differs based on location and tender document of the respective waste handling company. The fee is finalized based on mutual understanding between Municipal authority and the waste processing company. The fee can be charged per load, per tonne, or per item depending on the source and type of the waste.

Some cities still do not pay tipping fee, however the fee provides a great incentive to avail funds to process the waste. The average tipping fee in India is around INR 500/MT. In large waste to value projects, the tipping fee received will be a small fraction of the total earnings possible from renewable energy extraction. The fee however should serve for the purpose of waste sorting and processing. Not levying gate fee to waste that is already sorted can add as an incentive to initiate segregation at source drives.

Table 30: Tipping fee charged by some of the Municipalities and Waste Management Companies across India

Cities	Tipping fee (INR/MT)
Pune	300
Mumbai	525
Delhi	550
Bangalore	315-420
Hyderabad	1500
MGM	550
Raipur	1000
Ahmedabad	No Fee
Bhopal	No Fee
Kanpur	No fee

There is however an increasing trend of the governments in India demanding royalties for garbage. Most of the new requests for proposal do not therefore find applicants. This is causing an issue of lack of parties to collect and dispose waste and tenders don't get fulfilled and projects fail. Royalty can be in the form of compost for the waste that is provided free of cost, or a share in the profit on waste treatment. However, this has led to several disputes and litigations and has taken the focus away from providing a solution to waste. Therefore, ULBs should abstain from demanding royalty as it defies their statutory obligations.

Payment of Tipping fees to the waste management companies ensures the motivation levels for the waste management companies, and provides financial liquidity to help them invest in waste management projects and derive value from waste. Renewables and recyclables alone are not sufficient to make waste management projects viable. Himachal Pradesh should pay tipping fee to the companies, therefore providing them with leverage for managing the waste efficiently. However, tipping fee requires processing of waste, as it is really *processing fee* for waste.

Tipping fee serves as an additional incentive to collect and process the waste. The fee thus collected can be used for operations of the waste treatment facilities such as incinerators, biogas plant facilities or composting plants. The fee offsets the operation, maintenance, labour costs, capital costs of the facility along with any profits and final disposal costs of any unusable residues.

b. Bio-CNG/PNG

India's expanding population and growing economy has led to a huge demand of coal, oil and natural gas – with a CAGR of 6% putting a huge strain on India's current account deficit. There exists higher demand for natural gas than ever before, with the demand constantly rising.

Commercial LPG is the costliest fuel and thus, replacement of commercial LPG with Bio-CNG makes for a profitable business mode since Bio-CNG production is very cost effective. Bio-CNG is one of the cheapest fuels in India which has the potential to be the future of renewable fuel because of the abundance of biomass in India. Bio-CNG has wide applications, where is can be used for transportation, industry application, heating, cooking, air conditioning etc. With the increasing demand for energy, and the deficit of fossil fuels, there is a lot of incentive to explore ways to develop renewable energy.

The below table reflects the revenue potential for 1 m^3 of methane when sold as CNG equivalent (compressed) for various price levels of CNG in the market.

CNG price in INR	Revenue per 1 m^3 methane
30	19.90
40	26.53
50	33.17
60	39.80
70	46.43

- **Benchmarking of CNG price with equivalents**

CNG generally replaces LPG as an energy carrier and with a lack of a well-established CNG or PNG network in India LPG prices should be used as benchmarks.

Fuel	Type	City	Price	Ratio*	CNG equivalent
LPG	Subsidized	Mumbai	40.00	2.26	90.37
	Commercial	Mumbai	71.00	2.26	160.40
	Commercial	Delhi	68.00	2.26	153.62
	Commercial	Bangalore	75.00	2.26	169.44
CNG	Subsidized	Mumbai	40.00	1	40.00
	India	India	60.00	1	60.00
PNG	Commercial	Ahmedabad	29.00	1.43	41.43
	India	Ahmedabad	29.00	1.43	41.43

CNG at INR 60 offered to industrial users is at a significant discount as compared to LPG. Therefore, users if given a choice would chose CNG over LPG due to its price competitiveness

***Ratios considered for benchmarking**

Fuels	Volume to kg	Caloric value*	Ratio
LPG	0.51	1.15	2.26
PNG	0.7	1	1.43
CNG	1	1	1.00

**Caloric value LPG to CNG ratio*

LPG	**46**	**MJ/kg**
CNG	53	MJ/kg
Ratio	1.15	

Conversion ratio for LPG to CNG: LPG is 1.15 times less energy dense as CNG

Generating Bio-CNG/PNG from waste will therefore has immense potential in India where a great amount of municipal waste is generated in its cities/towns, which can be used profitably to generate renewable energy. The biogas plant in Sundernagar can also generate the upgrade the biogas and pipe it to household's commercial establishments where the PNG can replace fossil fuels. Fossil fuels such as LPG are heavily subsidized in India, the price of which is prone to the vagaries of the economy. Therefore, having a constant source of energy would provide Sundernagar without a self-sufficient alternative to LPG in the form of PNG.

c. Electricity

Electricity generated from biogas can be sold to the grid or used by the municipality for captive usage, either for lighting the streets or for domestic consumption in heating. Sundernagar can use the electricity for street lighting thereby augmenting the ULB electricity consumption. It could mean a lot in cost savings in the long run. There is an option of selling electricity to third parties thereby earning revenue from the sale. Agreements entered into with another party for the sale of electricity is called a Power Purchase Agreement.

- **Power Purchase Agreement (PPA)**

It is a contract between two parties, one who generates electricity for the purpose and one who is looking to purchase electricity. The PPA defines all of the commercial terms for the sale of electricity between the two parties, including when the project will begin commercial operation, schedule for delivery of electricity, penalties for under delivery, payment terms, and termination.

Table 31: PPA agreements across India

	PPA (INR)	Details
₹/kWh	3.5-8	Kanjur Contract
₹/kWh	4.04	Andhra Pradesh
₹/kWh	2.83	Delhi
₹/kWh	6.80	Gujarat
₹/kWh	4.15	Karnataka
₹/kWh	4.88	Maharashtra
₹/kWh	2.89	Uttar Pradesh
₹/kWh	5.10	West Bengal
₹/kWh	2.77	Bihar
₹/kWh	2.55	Kerala
₹/kWh	4.40	Orissa
₹/kWh	5.32	Punjab

- **Bio-CNG revenues corresponding to different PPA values**

The table 32 reflects the revenue earning potential from 1m^3 of methane (Biogas with 60% methane) for different PPA's ranges. It reflects the amount of revenue that a Bio-CNG at 60% methane can yield at different PPA levels. E.g.: at INR 3.5 PPA the revenue earning potential from 1 m^3 of Bio-CNG is INR 11.20.

Table 32: Bio-CNG revenue and PPA comparison

PPA (INR/kWh)	Revenue per 1 m^3 methane (INR)
3.5	11.20
4.5	14.40
5.5	17.60
6.5	20.80
7.5	24.00
8.5	27.20
9.5	30.40
10.5	33.60
11.5	36.80
12.5	40.00

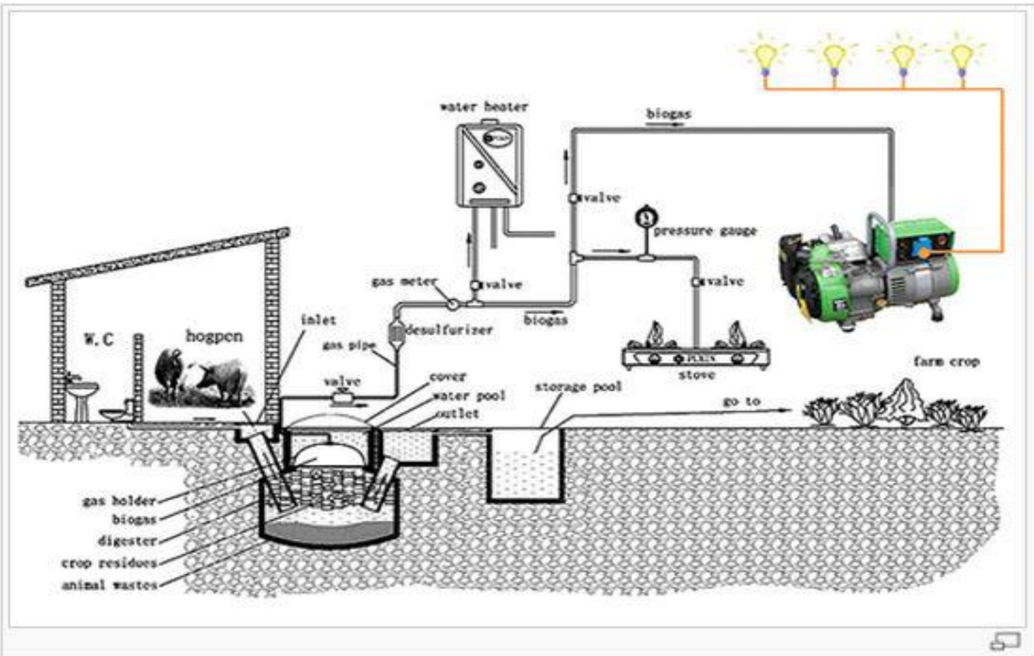


Figure 21: Schematic of a biogas plant used for power generation

d. **Compost** is a by-product of biogas production. The process of anaerobic digestion of municipal waste often includes the separation of liquid from both organic input material and anaerobic digestion residues. The separation improves biogas productivity and generates organic solid manure for aerobic treatment before and after anaerobic digestion. The solid residue is commercially available as residue. Therefore biogas plant is a suitable tool not only for renewable energy production but also for obtaining organic fertilisers. Composting is the biological decomposition of the biodegradable organic fraction. Organic Compost sells at INR 2000-2200 a tonne, based on the quality grading. Organic compost thus derived from a biogas plant is a fertilizer which would have great demand in the agrarian economy like Himachal Pradesh.

6.3.2 Laboratory Test of MSW

a. MSW test protocol for Biogas plant

MSW would have to be tested to confirm its chemical and physical characteristics and to check if it meets the basic requirements and feasibility for biogas production. The characterisation must be representative of the waste physical and chemical properties and consider any variability in the waste stream. The Basic Characterisation must also be representative of each individual load sent to the disposal site. Hence, it is usually preferred to take four/five samples from each of 3 dumping sites located within the scope of the feasibility study.

Laboratories usually require relatively small quantities of sampled materials to perform all of the characterisation tests. The laboratory is unlikely to have information regarding the waste and its heterogeneity. Therefore, someone with knowledge of the objectives of the waste producer's 'sampling plan' and the nature of the waste must design and manage the initial sampling programme at the waste source site.

Table 33: Some of the important parameters that MSW should be tested

Physical analysis	Chemical analysis
➢ Composition of dry/ wet waste, ➢ Composition of biodegradable/ non-biodegradables, ➢ Composition of Recyclables/ non-recyclables, ➢ Bulk density, ➢ compostable, ➢ Inert and ➢ Volatile Organics	➢ pH, moisture content, N, P, K, S, loss on ignition, carbon content, C/N ratio, calorific value etc. ➢ Heavy metals: Cd, Cr, Cu, Mn, Pb, Fe, Ni, Zn etc. ➢ Methane and Carbon Dioxide emissions

Protocol for biomass sampling and lab test required before setting by a Biogas Plant

a. Pre-treatment of porcelain cups

b. Pre-dry porcelain cups (100ml) at 100°C for 24 h.

c. Store cups in vacuum desiccator over KMnO4 crystals until use (at least one hour).

Dry weight Determination

a. Carefully weigh Pre-dried cups to 5 decimal places.
b. Fill the cup with sample and weigh again to 5 decimal places
c. Dry at 100°C for 48h and then place in vacuum desiccator over KMnO4 overnight.
d. Weigh cup containing sample to 4 decimal places.

Dry weight (DW) = (weight of cup plus sample) - (weight of cup)

Organic Dry Weight (Ash-free dry weight) Determination

a. Take cups including the dried sample from above dry weight determination and ash at 520°C for 24 h.
b. Cool cups in a vacuum desiccator over KMnO4 overnight.
c. Rapidly and carefully weigh cup to 4 decimal places.

Ash Free dry weight (AFDW) = Dry Weight - Weight after ashing

6.3.3 Electricity Business Case

The generation of electricity from biogas is one method of converting the biogas generated to valuable energy. In principle, the chemical energy of the combustible gases is converted to mechanical energy in a controlled combustion system by a heat engine. This mechanical energy then activates a generator to produce electrical power. The most common heat engines used for biogas energy conversion are gas turbines and combustion engines. Combustion engines can be either internal combustion engines or external combustion engine.

a. Advantages of generating electricity from Biogas

- Generation of renewable, green electricity
- Low operating costs
- Underground construction minimizes land use
- Long life span
- Reduces greenhouse gases
- On site use of heat

6.3.3.1 Estimation of Investment and Revenue: Electricity

If Sundernagar decides to go with electricity, the below calculations reflect the generation and revenue potential from electricity generation.

- **Electricity Metrics**

Methane gas	1	m^3
Calority of methane gas	32	MJ/Nm^3
Kw per MJ	3.6	kw-MJ
Energy production from methane gas	8.89	kW/Nm^3
Efficiency generator	40%	%
Utilization	90%	%
Ratio	3.20	kwH per 1 m^3 methane

- **Feedstock**

Availability of feedstock	**Organic fraction MSW**	
	Sundernagar only	**Entire district (after implementation of segregation at source)**
Quantity (TPD)	10	20
Conversion rate	100	200

Biogas production in m^3	1,000	2,000
Methane production in m^3	600	1,200
Note: organic fraction is 57% of total waste coming in		

- **Revenue from Electricity**

The feedstock for Sundernagar biogas plant is estimated for 10 TPD with 60% methane capacity for electricity generation.

Revenue from Electricity	Value	Units
Production capacity	120	kWh
Daily production	1920	kWh/day
Daily revenue	15,360	INR
Annual revenue (lakhs)	56.06	INR

For the continuous production capacity of 120 kWh of electricity, the daily revenue for a given PPA of INR 8 is INR 15,360 which totals to INR 56.06 a year of revenue.

- **Revenue from other sources**

Feedstock	Organic fraction MSW (10 TPD)
Gate fee (per tonne)	300
Value – Daily revenue (10 TPD)	**3000**
Compost (per tonne)	2000
Value – Daily Revenue (20% or 2TPD)	**4000**

Revenue from other sources	Value (INR)
Gate fee (300 for 10 Tonnes)	3,000
Compost (2 Tonnes)	4,000
Total	7,000
Annual revenue (INR - lakhs)	25.55

For a given gate fee of INR 300, the daily revenue from gate fee for the 10 TPD organics that come into the plant is INR 3000. 10 TPD of Organics produces 2 tonnes of compost, therefore at a price of INR 2000 for compost; we get INR 4000, daily revenue from compost. Therefore the total revenue from other sources annual is INR 25.55 Lakhs.

- **Total annual revenue potential from Electricity**

Total Revenue	Value (INR)
Energy	15,360
Compost	4,000
Gate fee	3000
Total Daily Revenue	**22,360**
Annual revenue (INR - Lakhs)	**81.61**

Therefore, the total annual revenue potential from electricity generation is INR 81.61 Lakhs.

- **Model variations**

Model variations	Option 1	Option 2	Option 3	Option 4
Feedstock	10	10	20	20
PPA	4	8	8	4
Compost price (INR)	2000	2000	2000	2000
Tipping fee (INR)	150	300	300	0
Total annual revenue (INR)	**53**	**92**	**185**	**85**

At various PPA's the revenue potential from the generation of electricity differs. A PPA as low at INR 4 for 10 TPD fetches INR 53 Lakhs revenue which increases to INR 92 lakhs with INR 8 PPA. With a higher amount of feedstock, the revenue earning potential also substantially increases as reflected in the table above. Higher feedstock would need higher capital investment which will yield exponentially high revenue from higher amount of biogas production.

6.3.4 PNG Business case

The biogas generated from the biogas plant can be supplied to its destination via pipes without compression. Compression of Biogas becomes necessary when the gas would have to be transported along long distances. If the gas generated would be used in Sundernagar to supply it to households for cooking or heating purposes, compression of the gas would not be required. The gas can be used for cooking, water heating, space heating, air conditioning, refrigeration and other domestic purposes.

Sundernagar is situated in a hilly terrain not surrounded by industrial locations. Therefore, the biogas generated can be efficiently used to heat homes during winter and for domestic cooking purposes. By the use of renewable gas generated from the biogas the town can rely less on the fossil fuel LPG.

6.3.4.1 Estimation of Investment and Revenue: PNG

If Sundernagar decides to go with PNG the below calculations reflect the generation and revenue potential from generation of natural gas.

- **CNG Metrics**

CNG metrics	
Methane m^3 to kg conversion rate	0.7
Compression loss	10%
Applicable conversion rate meso	63%
Gas used for heating inflow	5%
Applicable conversion rate meso	60%
Upgrade percentage	95%

- **Revenue per 1m^3 methane**

CNG price	Revenue per 1 m^3 methane
30	16.08
40	21.44
50	26.80
60	32.16

70	37.52

- **Feedstock**

Availability of feedstock	Organic fraction MSW	
Quantity (TPD)	10	20
Conversion rate	100	200
Biogas production in m^3	1,000	2,000
Methane production in m^3	600	1,200
Note: organic fraction is 57% of total waste coming in		

- **Revenue from PNG**

The feedstock for Sundernagar biogas plant is estimated for 10 TPD with 60% methane capacity for PNG generation.

Revenue from PNG	Value	Units
Daily production	600	m^3/day
Daily production	402	Kg/day
Daily revenue	24,120	INR
Annual revenue (lakhs)	88.03	INR

For the daily production capacity of 600 m^3 of PNG, the daily revenue for a given price of INR 60 is INR 24,120 which totals to revenue of INR 88.03 Lakhs for a year.

- **Revenue from other sources**

Feedstock	Organic fraction MSW (10 TPD)
Gate fee (per tonne)	300
Value – Daily revenue (10 TPD)	**3000**
Compost (per tonne)	2000
Value – Daily Revenue (20% or 2TPD)	**4000**

Revenue from other sources	Value (INR)
Gate fee (300 for 10 Tonnes)	3,000
Compost (2 Tonnes)	4,000
Total	**7,000**
Annual revenue (INR - lakhs)	**25.55**

For a given gate fee of INR 300, the daily revenue from gate fee for the 10 TPD organics that come into the plant is INR 3000. 10 TPD of Organics produces 2 tonnes of compost, therefore at a price of INR 2000 for compost; we get INR 4000, daily revenue from compost. Therefore the total revenue of from other sources annual is INR 25.55 Lakhs.

- **Total annual revenue potential from PNG**

Total Revenue	Value (INR)
PNG	24,120
Compost	4,000
Gate fee	3000
Total Daily Revenue	31,120
Annual revenue (Lakhs)	113.59

Therefore, the total annual revenue potential from PNG generation is *INR 113.59 Lakhs.*

- **Model variations**

Model variations	Option 1	Option 2	Option 3	Option 4
Feedstock	10	10	20	20
Price for PNG (as per CNG equivalent)	40	60	60	60
Compost price	2000	2000	2000	2000
Tipping fee	150	300	300	0
Total annual revenue	74	110	221	177

At various price levels the revenue potential from the generation of PNG differs. At a price level of INR 40 for 10 TPD fetches INR 74 Lakhs revenue which increases to INR 110 lakhs with INR 60 price level. With a higher amount of feedstock, the revenue earning potential also substantially increases as reflected in the table above.

6.3.5 Conclusion

The biogas plant will generate 120 Kwh of electricity a day for 10 TPD of organics, which at a PPA of INR 8; will reap in revenue of INR 56.06 Lakhs. The plant would generate 600m^3 of biogas which at the rate of INR 60 will reap in revenue of INR 88.03 Lakhs. Between the two options of energy generation, given that the state of Himachal Pradesh is electricity surplus and a PPA of INR 8 is difficult to achieve, the generation of PNG seems a lucrative and technically feasible model to adopt.

6.4 Biogas Design - Output

The biogas plant is designed by BBE Biogas BV, Dutch leading provider of Biogas solution. The process steps involved in the production of biogas with BBE technology is as follows

6.4.1 Pre- treatment

Products arriving at the site are weighed using the truck scale. The automated system registers all the trucks arriving and leaving the site in a central database. Solid biomass and manure are stored in the trench silo's, liquid biomass products (i.e. organic fats, food waste) and liquid manure are stored in the storage tanks. The solid materials are fed into the hydrolysis tank using an automated system that controls the amount of products. At the same time, the liquid manure and liquid biomass are inserted according to a special feedstock menu based upon optimal biogas yields.

6.4.2 Main Digestion Process

Pumps are installed between the digesters and in the central hall. The design of this plant is very flexible - all the digesters are connected and it is possible to pump the substrate from one tank to another. The roofs are constructed with a double membrane. This form of gas storage gives additional flexibility to the plant in cases of maintenance. The substrate is constantly mixed and heated to around 38 - 40 degrees Celsius. The substrate can be analysed for the most important values. If necessary, BBE Biogas can adjust the feedstock menu to ensure optimal biological circumstances and biogas yield at all times.

6.4.3 Post Treatment

After the main digestion process, the digestate (the former substrate) can be treated in different ways. The decanter separates the digestate into a liquid and a solid fraction. Both of these products can be fed back into the process if desired, but also they can be sold on the market. The solid part of the digestate can be further dried in the belt dryer, whereby dry matter contents of 95% can be reached. The dryer is heated by the heat from the CHP's.

6.4.4 Biogas

The biogas that is produced by the anaerobic digestion is transported towards the CHP's (Combined Heat Power). Before entering the CHP's the biogas is dried and can also be desulpherised if necessary. The BBE Biogas AD plants produce very clean biogas with methane contents of around 65% and low H2S contents.

Figure 22 is the design for the 10 TPD, biogas digestor to be set up in Sundernagar district, Himachal Pradesh, Design by BBE Biogas BV

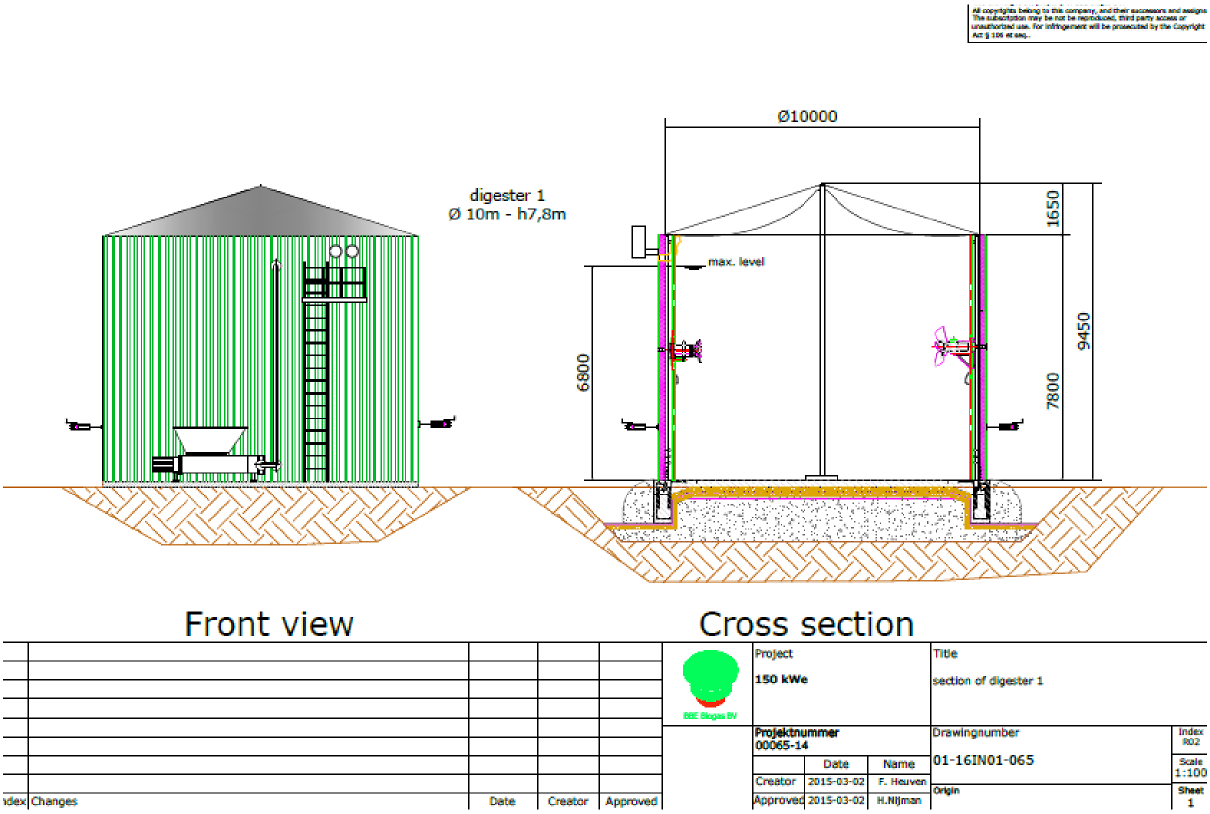


Figure 22: Section Digestor (BBE Biogas BV)

The system of BBE Biogas features a solid material feed-in system where the organic material can be inserted.

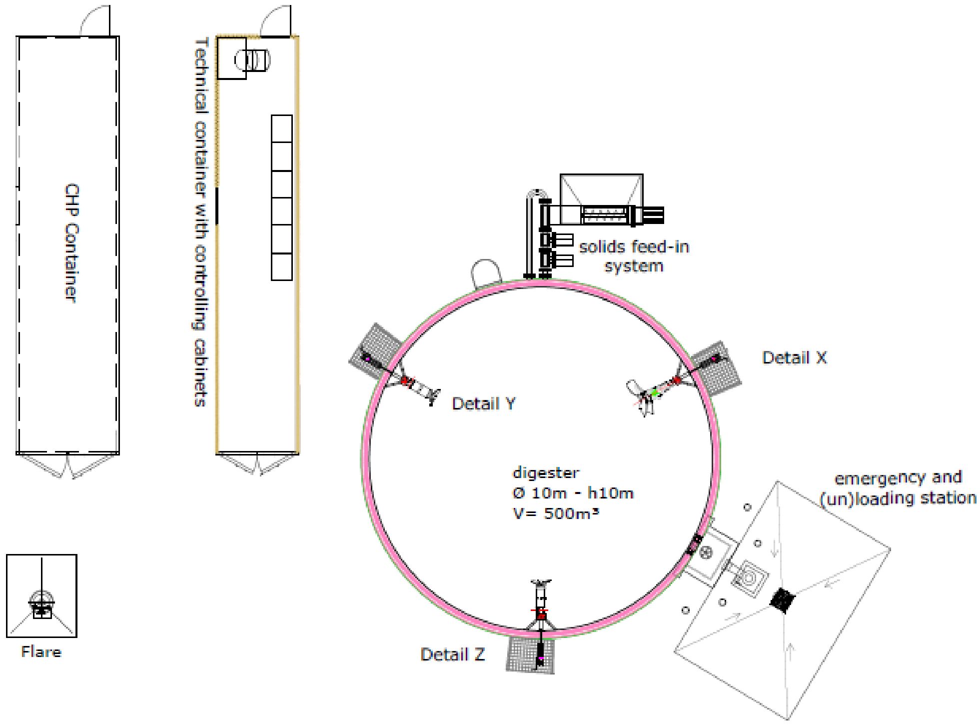


Figure 23: Site Map (BBE Biogas BV)

6.5 Financials

6.5.1 Investments

Investments and ops	Capacity	Total (INR - lakh)	Operations	Ops (INR - lakhs)/year
	10.00	320	5%	16
Biogas plant	20.00	620	5%	32

The above includes a capex support for 20% from the MoUD.

6.5.2 Financial Parameters

Parameters	
Equity	30%
Interest	5.0%
Profit allocation to payback	25.0%
Tax rate	33.0%
Tax holiday (years)	5.00
WACC	12%
Life time project	10.00

The biogas plant investment overview assumes that an upgrading, compressing and bottling plant is roughly as expensive as a generator. The WACC is set at 12. The tax holiday for 5 years (80JJA) has been taken into consideration.

6.5.3 Discounted cash flow – Electricity

a. Discounted cash flow for option 1, Electricity revenue potential for a PPA of INR 4 per kwh

Revenue		53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6
Gas		28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
Other		25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6
Operations		-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0
Operational margin		37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6
Loan		224.0	221.3	218.6	215.7	212.8	209.8	207.7	205.6	203.4	201.2
Interest		-26.9	-26.6	-26.2	-25.9	-25.5	-25.2	-24.9	-24.7	-24.4	-24.1
Financial margin		10.7	11.0	11.4	11.7	12.0	12.4	12.7	12.9	13.2	13.4
Net margin		10.7	11.0	11.4	11.7	12.0	8.3	8.5	8.6	8.8	9.0
Investment	**320.0**										
Cash flow	**-320.0**	10.7	11.0	11.4	11.7	12.0	8.3	8.5	8.6	8.8	9.0
Rate	**1.0**	1.1	1.3	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.1

With a given amount of 10 TPD of waste, and PPA of INR 4, the biogas plant has a potential of reaping in INR 53.6 Lakhs in revenue. The discounted cash flow statement takes into account the revenue from biogas and other sources to estimate INR 92.6 Lakhs in revenue. The operations costs incurred by the plant and the interest paid on borrowed capital are taken to estimate the cash flow.

The NPV for option 1 is INR -261.69 lakhs with an IRR of -26%

b. Discounted cash flow for option 2, Electricity revenue potential for a PPA of INR 8 per kwh

Cash (lakhs)											
Revenue		92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6
Gas		56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1
Other		36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5
Operations		-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0
Operational margin		76.6	76.6	76.6	76.6	76.6	76.6	76.6	76.6	76.6	76.6
Finance											
Loan		224.0	207.7	191.1	174.4	157.4	140.2	128.6	116.8	105.0	93.0
Interest		-11.2	-10.4	-9.6	-8.7	-7.9	-7.0	-6.4	-5.8	-5.2	-4.7
Financial margin		65.4	66.2	67.0	67.8	68.7	69.6	70.1	70.7	71.3	71.9
Taxes		0.0	0.0	0.0	0.0	0.0	23.0	23.1	23.3	23.5	23.7
Net margin		65.4	66.2	67.0	67.8	68.7	46.6	47.0	47.4	47.8	48.2

Investment	320.0										
Cash flow	-320.0	65.4	66.2	67.0	67.8	68.7	46.6	47.0	47.4	47.8	48.2
Rate	1.0	1.1	1.3	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.1

With a given amount of 10 TPD of waste, and PPA of INR 8, the biogas plant has a potential of reaping in INR 92.6 Lakhs in revenue. The discounted cash flow statement takes into account the revenue from biogas and other sources to estimate the revenue. The operations costs incurred by the plant and the interest paid on borrowed capital are taken to estimate the cash flow.

The NPV for option 1 is INR 17.66 lakhs with an IRR of 1%.

6.5.4 Net present value and IRR for various scenario's

NPV		**Option 4, electricity**		**Option 3, PNG**
NPV (lakhs)	261.69-	337.23-	141.03-	97.62
NPV (euro)	319,132.19-	411,254.42-	171,990.21-	119,048.21
IRR	**-26%**	**-14%**	**-5%**	**3%**

Conclusion

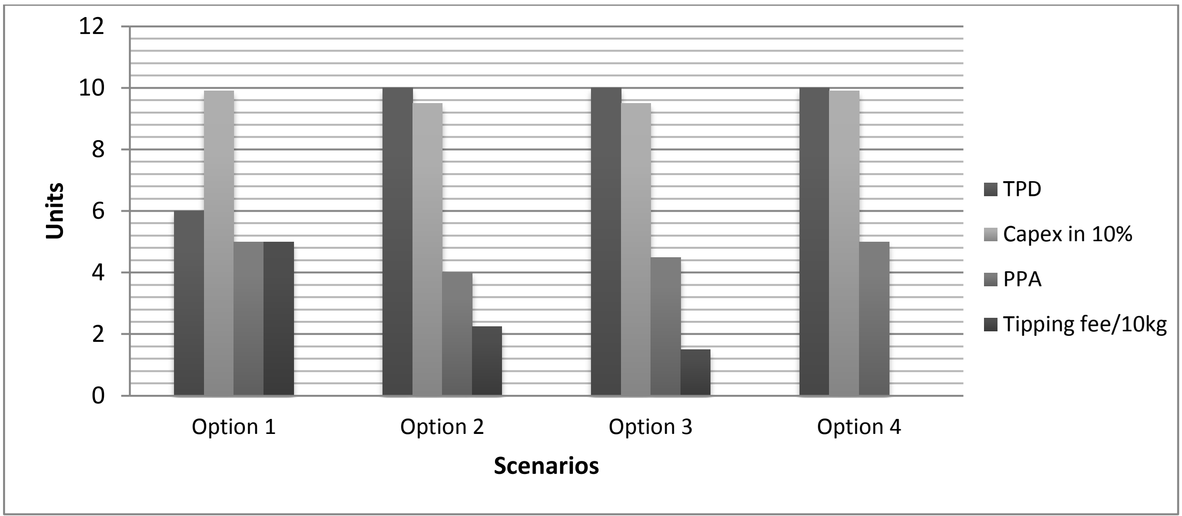
For small scale biogas plants the IRR will be negative even with high tipping fees, good PPA's, and capex support (20% from MoUD). As such it would not be suggested to approach a small scale biogas in HP as an opportunity for BOT but purely as a waste management facility in which the municipality should invest (EPC). Revenue generated from the plant could be used to pay for operations.

6.5.5 Scenario Analysis - Electricity

Reflected below are various scenario options and alternative possible outcomes for generating electricity at different rates of PPA and Tipping fee for different options of waste and capital expenditure support.

Scenario	Variables
Option 1	• 6 TPD • PPA at INR 5 • Tipping fee at INR 500/ton • VGF at 99%
Option 2	• 10 TPD • PPA at INR 4 • Tipping fee at INR 225/ton • VGF at 95%
Option 3	• 10 TPD • PPA at 4.5 • Tipping fee at INR 150/ton • VGF at 95%
Option 4	• 10 TPD • PPA at INR 5 • No Tipping fee • VGF at 99%

Note: For all the waste inputs, it is encouraged to also collect the waste from bulk generators like agricultural waste sources which are rich in organic content to feed into the biogas plant.



Note: The higher the PPA that can be garnered, the lower the tipping fee

- **Feedstock**

Waste TPD	**10**
Conversion rate	100
Methane	50%
Electric conversion	3.2
Operational hours	8
Compost/TPD	10%

- **Model variations**

	Option 1	**Option 2**	**Option 3**	**Option 4**
Waste TPD	6	10	10	10
Methane production	300	500	500	500
Units/day	960	1600	1600	1600
KwH	120	200	200	200
Electricity rate	5	4	4.5	5
Revenue/day (INR)	**4800**	**6400**	**7200**	**8000**
Compost production	1	1	1	1
Price for compost	1500	1500	1500	1500
Revenue/day (INR)	**1500**	**1500**	**1500**	**1500**
Tipping fee	500	225	150	0
Revenue/day	**3000**	**2250**	**1500**	**0**

Total revenue/day (INR)	9300	10150	10200	9500
Revenue/year (lakh)	**33.95**	**37.05**	**37.23**	**34.68**

6.5.6 Discounted Cash Flow – Various scenarios

a. Discounted cash flow for various tipping fee, PPA and Capex support scenario

Capex in crore (INR)	4
Opex	10%
WACC	12%
Growth (R & C)	2%

Year →	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
INR (lakhs)											
Option 1											
Revenue		33.95	36.42	39.14	42.12	45.39	48.99	52.95	57.33	62.17	67.52
Costs		40	40.8	41.62	42.45	43.3	44.16	45.05	45.95	46.87	47.8
Investment	**4**										
Cash flow	**-4**	**6.06**	**4.38**	**2.48**	**0.33**	**2.09**	**4.83**	**7.91**	**11.38**	**15.3**	**19.71**
Option 2											
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Revenue		37.05	39.82	42.87	46.21	49.9	53.96	58.44	63.39	68.87	74.96
Costs		40	40.8	41.62	42.45	43.3	44.16	45.05	45.95	46.87	47.8
Investment	**20**										
Cash flow	**-20**	**-2.95**	**-0.98**	**1.25**	**3.77**	**6.6**	**9.79**	**13.39**	**17.44**	**22.01**	**27.15**
Option 3											
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Revenue		37.23	40.02	43.09	46.46	50.16	54.25	58.76	63.75	69.27	75.4
Costs		40	40.8	41.62	42.45	43.3	44.16	45.05	45.95	46.87	47.8
Investment	**20**										
Cash flow	**-20**	**-2.77**	**-0.78**	**1.47**	**4.01**	**6.87**	**10.09**	**13.71**	**17.8**	**22.4**	**27.59**
Option 4											
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Revenue		34.68	37.22	40.02	43.08	46.45	50.15	54.24	58.75	63.73	69.26
Costs		40	40.8	41.62	42.45	43.3	44.16	45.05	45.95	46.87	47.8
Investment	**4**										
Cash flow	**-4**	**-5.33**	**-3.58**	**-1.6**	**0.63**	**3.15**	**5.99**	**9.19**	**12.8**	**16.87**	**21.45**

In the above mentioned options of waste, PPA and tipping fee, the biogas plant has a potential of reaping in positive cash flow from year 4 onwards.

6.5.7 Net present value and IRR for various scenario's

Capex support	99%	95%	95%	99%
NPV	7.86	16.39	17.74	13.21
IRR	**20%**	**21%**	**22%**	**25%**

Conclusion

For small scale biogas plants the IRR will be positive with a good NPV if a good PPA and tipping fee has been obtained along with good capex support.

7 Sanitary Landfill

7.1 Introduction of Sanitary Landfill

Sanitary landfilling, which is the controlled disposal of waste on the land, is well suited to developing countries as a means of managing the disposal of waste because of the flexibility and relative simplicity of the technology. Sanitary landfilling controls the exposure of the environment and humans to the detrimental effects of solid waste placed on the land. Through sanitary landfilling, disposal is accomplished in a way such that contact between waste and the environment is significantly reduced, and waste are concentrated in a well-defined area. The result is good control of landfill gas and leachate, and limited access of vectors (e.g., rodents, flies, etc.) to the waste. The practice of sanitary landfilling, however, should be adopted in accordance with other modern waste management strategies that emphasize waste reduction, recycling, and sustainable development.

The main construction features of a sanitary landfill are:

a. Impermeable bottom-liner (to prevent leachate leaking into soil and groundwater)
b. Waste core with a high quality gas extraction system and water infiltration system installed
c. Gas and rainwater impermeable capping (constructed partially on waste compartment who reached the final construction height)
d. Leachate collection system

The main features of sustainable landfills are:

a. Increasing inertness of waste core by converting as much as possible organic degradable content
b. Decreasing the contamination rate and quantity of leachate.

7.2 MSW 2000 Rules and Regulation on Lining

7.2.1 Sanitary Landfills

Landfilling is the ultimate disposal process for Municipal Solid Waste (MSW) management. The landfill is an unavoidable component in MSW Management and its planning and design, construction, operation & maintenance involves technical skills and safety measures in terms of health and environmental protection. The Municipal Solid waste (Management & Handling) Rules, 2000 specify relevant points with regard to site selection for proposed landfill site, facilities requires at landfill site, specification for landfilling, pollution prevention, water quality monitoring, ambient air quality monitoring, plantation at landfill site, closure of landfill site/ post closure, etc. These specific provisions are to be implemented as per rules and need to be ensured during the planning and design stage. The adequacy and performance of these provisions are to be monitored by the regulating authorities (SPCBs/PCCs) during issue of consent/authorization.

7.2.2 Regulatory aspects/provisions of sanitary landfills

As per MSW Rules, 2000 State Pollution Control Board (SPCBs) or Pollution Control Committee (PCCs), shall issue authorization in Form-III to the municipal authority or an operator of a facility within forty-five days stipulating compliance criteria and standards as specified in Schedule II, III and IV including such other conditions, as may be necessary. SPCBs/PCCs, after the receipt of application from the municipal authority or the operator of a facility including landfills, shall examine the proposal taking into consideration the views of other agencies like the State Urban Development department, the Town and Country Planning department, Airport or Air Base authority, the ground Water Board or any such other Agency prior to issuing the authorization.

Specifications for landfill Sites:

a. Site selection:

Landfill identification shall be done by 'Development Authorities' for the area falling under 'Development Authority', otherwise it shall be done by the concerned Municipal authority. The site selection shall be done based on examination of environmental issues. The landfill site shall be planned and designed with proper documentation of a phased construction plan as well as a closure plan. The landfill facility shall be nearby waste processing plant or an integral part of it. The landfill site shall be designed for 20-25 years. The proposed landfill site should be away from habitation clusters, forest areas, water bodies, monuments, national Parks, Wetlands and places of important cultural, historical or religious interest. Also, approval shall be taken from the concerned authorities in case the landfill site is located within 20 km from the airport/airbase.

b. Facilities at Site:

The landfill shall be fenced with proper gate at entrance for monitoring incoming waste/vehicles, to prevent entry of cattle, to keep record movement of vehicles and waste, etc. Also, provision of weigh-bridge may be made for assessing quantum of waste. Drinking water and other sanitary facilities and other safety measures including health check-up shall be provided to workers.

c. Specification for land filling:

Waste subjected to landfilling shall be compacted in thin layers to achieve maximum capacity of landfill. The disposed waste shall be covered immediately/at the end of working day with 10 cm of soil. Prior to commencing monsoon period, an immediate soil cover of 40-65 cm thickness shall be placed on the landfill with compaction to prevent rainwater infiltration. There is a necessity to provide proper drainage to divert run-off water from the active landfill cell.

After completion of landfill, a final capping shall be provided with (i) a barrier of soil cover of 60 cm of clay or amended soil with permeability of 1X10-7 cm/sec, (ii) on top of the barrier soil layer, there shall be a drainage layer of 15 cm and (iii) on top of the drainage layer, there shall be vegetation layer of 45 cm to support natural plant growth to minimize soil erosion.

d. Pollution Prevention:

In order to prevent pollution problems from landfill operation the necessary steps should be taken viz. (i) Diversion of storm water to minimize leachate generation and to avoid flooding/water logging, (ii) Construction of non-permeable linings system at the base and walls of waste disposal area against contamination from domestic hazardous waste. The liner shall be a composite barrier having 1.5 mm HDPE or equivalent having permeability least than 1X10-7 cm/sec. The water table should be at least 2 m below the base clay or amended soil barrier layer. (iii) Provision of leachate collection and treatment shall be made as per standards specified in MSW 2000 rules.

e. Water quality monitoring:

The ground water quality needs to be monitored within 50m periphery of landfill site. Also, ground water quality data to be generated before construction of landfill site for future reference.

f. Ambient air quality monitoring:

Installation of landfill gas control system including gas collection system shall be made at landfill site to minimize odour generation, prevent off-site migration of gases and to protect vegetation planted on rehabilitated landfill surface. The concentration of methane gas at the landfill site shall not exceed 25 LEL. The landfill gas collected from the facility shall be utilized either direct thermal application or power generation, otherwise, landfill gas shall be flared to prevent direct escape. Passive venting will be allowed if flaring is not possible.

g. Plantation at Landfill site:

A vegetative cover shall be provided over completed site as follows; (i) Selected species of locally adopted non-edible perennial plants that resistance to drought and extreme temperature shall be allowed to grow, (ii) The roots of the plants grown should not penetrate more than 30 cm, (iii) The plant species shall have ability to thrive on low nutrient soil and (iv) the density of plantation shall be sufficient to minimize soil erosion.

h. Closure of landfill site and post- care:

The post-closure care of landfill site shall be conducted after fifteen years and long term monitoring to assess; (i) maintaining integrity and effectiveness of final cover and repair required, (ii) efficiency of leachate collection system, (iii) ground water quality and action required to improve, (iv) maintenance and operation of gas collection system to meet the standards. The closed landfill may be used for human settlement after 15 years of post-closure care by ensuring gaseous emission and leachate compliance.

i. Special provisions for hilly areas:

Cities/ towns located in hilly areas shall adopt location specific methods of disposal with permission of concerned SPCB/PCCs.

7.3 Water (MSW 2000 Discharge requirements)

The MSW Rules 2000 stipulates basic rules in order to prevent underground water contamination and pollution caused by leachate from landfill flowing into the water table.

7.3.1 MSW Leachate Management Handling, 2000

In order to prevent pollution problems from landfill operations, the following provisions shall be made, namely:-

a. Diversion of storm water drains to minimize leachate generation and prevent pollution of surface water and also for avoiding flooding and creation of marshy conditions;
b. Construction of a non-permeable lining system at the base and walls of waste disposal area. For landfill receiving residues of waste processing facilities or mixed waste or waste having

contamination of hazardous materials (such as aerosols, bleaches, polishes, batteries, waste oils, paint products and pesticides) minimum liner specifications shall be a composite barrier having 1.5 mm high density polyethylene (HDPE) geo-membrane or equivalent, overlying 90 cm of soil (clay or amended soil) having permeability coefficient not greater than 1×10^{-7} cm/sec. The highest level of water table shall be at least two meter below the base of clay or amended soil barrier layer;

c. Provisions for management of leachates collection and treatment shall be made. The treated leachates shall meet the standards specified in Schedule- IV;

d. Prevention of run-off from landfill area entering any stream, river, lake or pond.

7.3.2 Water Quality Monitoring

Before establishing any landfill site, baseline data of ground water quality in the area shall be collected and kept in record for future reference. The ground water quality within 50 metres of the periphery of landfill site shall be periodically monitored to ensure that the ground water is not contaminated beyond acceptable limit as decided by the Ground Water Board or the State Board or the Committee. Such monitoring shall be carried out to cover different seasons in a year that is, summer, monsoon and post-monsoon period.

Usage of groundwater in and around landfill sites for any purpose (including drinking and irrigation) is to be considered after ensuring its quality.

Table 34: The following specifications for drinking water quality shall apply for monitoring purpose

		IS 10500: 1991 Desirable limit (mg/l except for pH)
1	Arsenic	0.05
2	Cadmium	0.01
3	Chromium	0.05
4	Copper	0.05
5	Cyanide	0.05
6	Lead	0.05
7	Mercury	0.001
8	Nickel	-
9	Nitrate as NO_3	45
10	PH	6.5-8.5
11	Iron	0.3
12	Total hardness (as $CaCO_3$)	300
13	Chlorides	250
14	Dissolved solids	500
15	Phenolic compounds (as C_6H_5OH)	0.001
16	Zinc	5
17	Sulphate (as SO_4)	200

7.4 Criteria for Sanitary Landfill

A sanitary landfill is the most effective medium of permanent disposal of the ultimate rejects from MSW. The isolation of waste from the environment by the construction of a sanitary landfill requires certain pre-determined criteria to ensure that the waste is disposed of suitably without having detrimental effects on the environment.

Listed below are the key criteria to be considered while selected the area for a sanitary landfill:

I. Access to a main road for logistical reasons
II. The sanitary landfill area and the close surrounding should not have habitation by citizens
III. The area should be zoned in urban developments in the near future
IV. There must be provision for access to a drainage system (to discard leachate water after cleaning)
V. The selected area should not be located in/near agricultural areas or specially protected areas of to prevent the negative effects of environmental contamination
VI. Distance to the target area from where the waste will be collected should not be too vast
VII. There must be easy availability of cover materials to be put between layers of household waste
VIII. Approximately, 1 hectare of landfill (10.000 square meters) equals 100.000 tons (weight) of household waste

If a waste separation facility would also be installed, the below would have to be additionally considered:

IX. Connection to a high power electricity grid of industrial capacity
X. Easy access and connection to a main road for transportation of end materials to clients post separation

7.5 Trisoplast®: the innovative mineral barrier for environmental protection and waterproofing

7.5.1 Introduction

In addition to being used for normal water insulating purposes, the flexible Trisoplast mineral barrier is used for a wide range of applications to prevent contaminated water from entering the environment. Worldwide, the understanding and need for environmental protection is becoming increasingly important. Effective sealing systems with high lifetime expectations are required to protect our groundwater, air and soil.

Trisoplast offers a number of advantages compared to other sealing systems, resulting in a cost-effective, high level of environmental protection.

7.5.2 Trisoplast®

Trisoplast is a patented mineral barrier, which was developed in the Netherlands by Trisoplast Mineral Liners. Its outstanding performance is achieved on-site by simply mixing the special bentonite-polymer component with mineral filler, e.g. sand. The mixture is installed as a robust layer and can be covered immediately by a layer which provides the necessary confining pressure. After finishing the construction the Trisoplast layer absorbs the first water from the environment that reaches the layer. This causes the bentonite clay to swell and form a network of chemical bonds with the dissolved polymer to create a strong, dense hydrogel structure. Whereas Trisoplast predominantly gets its mechanical strength from sand, the bentonite-polymer gel provides the necessary flexibility and hydraulic performance which is 100 to 1000 times better than with traditional mineral barriers.

- *Covering layer*
- *Drainage layer*
- *Subgrade*

7.5.3 The use of Trisoplast

Trisoplast has become the preferred mineral barrier for landfill applications in the Netherlands. In addition, it has also already been approved as suitable mineral barrier for landfill and contaminated land applications in a number of other European and non-European countries.

Trisoplast applications also include industrial sites, tank farms, environmental facilities, dredging spoil depots, reservoir basins, contaminated land, waterways and ponds, irrigation, dams, etc.

7.5.4 The main advantages

A number of renowned independent institutes in several European countries have carried out extensive research into Trisoplast under the supervision of the relevant federal and local authorities. The results showed that Trisoplast has significantly better barrier properties in comparison with traditional mineral barriers:

- Extremely low permeability
- Self-healing ability
- Robustness
- Ability to cope with differential settlement due to high flexibility
- Gel formation prevents erosion of bentonite
- High chemical and physical stability
- High moisture retention capability (high resistance to drying out)
- Simple sealing to structures and penetrations
- Easy & fast installation
- Long term slope stability
- Gain of void space due to reduced layer thickness
- Low gas permeability
- High life expectancy

7.5.5 Innovation

All sealing systems, mineral barriers as well as geo-membranes, have certain limitations. Therefore, the development of new techniques or further improvements to existing systems is required in order for them to better deal with the various environments they are used in. Traditional mineral barriers are often the preferred option due to their robustness and their high, natural durability. However, these might develop harmful cracks as a result of differential settlement or desiccation. With Trisoplast, these negative effects are effectively prevented due to its high plasticity and chewing-gum like behaviour.

The mechanical properties, especially the high friction angles in combination with significant cohesion values, make it possible to design steeper slopes without additional reinforcement. Moreover, this possibility, together with significantly reduced thickness, results in additional, valuable void space. The polymer enhancement in Trisoplast also leads to a higher chemical stability and an improved sealing performance.

7.5.6 Easy to use

The fairly dry Trisoplast mixture, which is normally produced in a mobile mixing plant, is best installed using a hydraulic excavator. Sufficient compaction is easily achieved by using a small compactor, a roller or vibrating plate. Mineral barriers are often used to isolate industrial sites in order to prevent pollution by spill or calamities. In case of isolation of liquids that do not cause clay barriers to swell (e.g. oils, strong salt solutions), after installation the design must ensure sufficient water saturation of the layer, either by rainwater or by artificial means.

The key environmental hazards caused by unscientific treatment of waste are

- Hazardous Gas Emissions: India is one of the world's largest emitters of methane from landfills. Methane makes up around 29% of the total Indian Green House Gas emissions, while the global average is 15%
- Water Quality Contamination: The dumping of untreated waste in rivers, lakes have led to bio-accumulation of toxic substances in the food chain through plants and animals that feed on it. Unscientific dumping also causes the leachate from the waste to seep into the water table, causing water contamination
- Natural Habitat Degradation: Direct dumping of MSW in open ground has resulted in unnatural degradation of human habitat that cannot be used for settlement or any other activities.
- Health Hazards: Uncollected MSW can also forming of stagnant water bodies resulting the breeding ground of water borne diseases that include malaria, dengue, filariasis, typhoid, dysentery etc.

The above stated points reiterates the need of the hour in India, which is treatment of waste by adopting scientific technology with the rational and sustainable utilization of natural resources and its protection from toxic releases is vital for sustainable socio-economic development.

7.6 Waste stream composition analysis – Inert

7.6.1 Waste – Inert

The daily waste generated in the cluster of Sundernagar, Mandi and Ner Chowk is 30.5 tonnes which comprises of roughly 18% inert after sorting for recyclables, organics and plastics. The average daily inert generation is 5.67 tonnes. Based on estimations the total production of inert in the cluster for a week is 39.69 tonnes and for a year is 2069.55 tonnes.

Table 35: Inert Waste Generation

Cluster	Total Waste generation (tonnes/day)	Percentage Inert	Daily Inert Waste generation (tonnes/day)	Weekly Inert Waste Generation (tonnes/week)	Yearly Inert Waste Generation (tonnes/year)
Sundernagar	11	18%	1.98	13.86	722.7
Mandi	18	19%	3.42	23.94	1248.3
Ner Chowk	1.5	18%	0.27	1.89	98.55
Total	30.5	18%	5.67	39.69	**2069.55**

Considering the population growth rate 1.2% (national average) and the per capita daily waste generation of 450 grams the generation of inert waste will also grow at 1.2% annually. The daily generation of inert waste will grow from 5.67 tonnes/day in 2015 to 8 tonnes/day in 2045 as reflected in Figure 24 below.

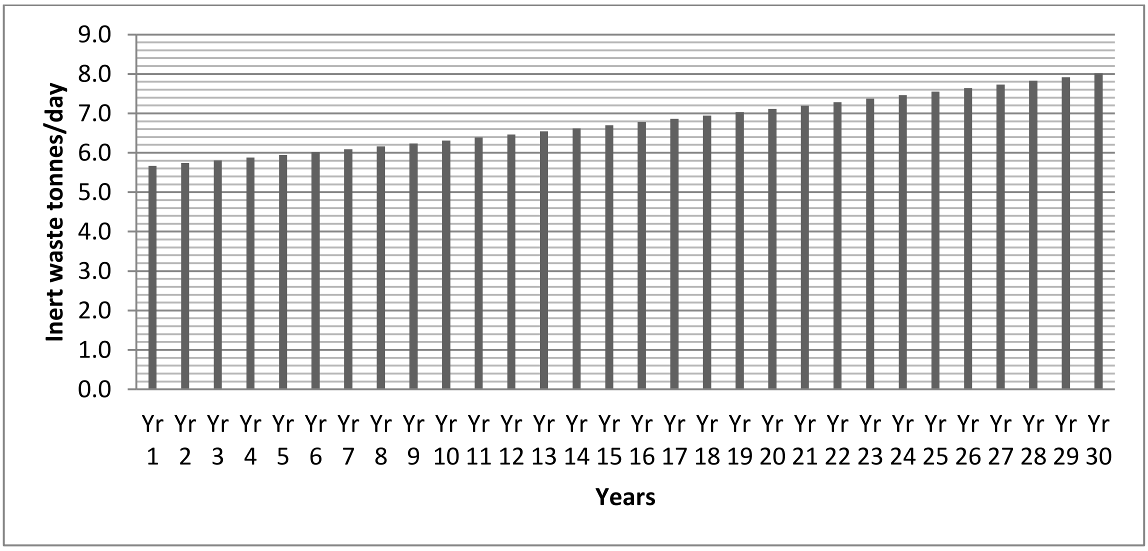


Figure 24: Growth of inert waste generation in the cluster

7.7 Land Location

Figure 25: Map of Mandi SWM Site

The Mandi landfill site is located at latitude 31°42'25.554"N and longitude 76°58'58.94"E

Figure 26: Mandi Site

7.8 Landfill Design

In this segment the preliminary reference design for a sanitary landfill site is described. The landfill lay-out should enable a practicable, sustainable and profitable operation of the facility. Once the final preferable site is chosen, this preliminary design can be adjusted for the local conditions of the site.

7.8.1 General aspects

Good design of a landfill site will prevent or reduce, as far as possible, negative effects on the environment, as well as risks to human health arising from the landfilling of waste. Landfill design is an interactive process incorporating conceptual design proposals, the findings of the environmental assessment and environmental monitoring results, risk assessments and the conclusions reached in investigations.

The designer should consider all environmental media that may be significantly impacted through the landfill. The chosen design will have a major influence on the operation, restoration and aftercare of the facility.

Aspects that must be considered are listed below:

- National and local legislation concerning Solid waste management facilities
- Access to the site is restricted (a fencing and a access gate are needed)
- Maximum height and slope dictate the total volume of the landfill
- Time of operation of the landfill dictates (with waste quantities and the effort in compacting the waste) the volume needed for the landfill
- Nature and quantities of waste
  - The waste types accepted at the landfill will dictate the control measures required.
  - Waste quantities dictate the size of the landfill and the scale of the control measures.
- Water control
  - To reduce leachate production, control measures minimising the quantity of precipitation, surface water and groundwater entering the landfilled waste need to be taken;
  - Water from the roads, from cleaning the wheels, from the offices (grey water) will need to be collected, treated (optional) and discharged
  - Contaminated water from the landfill (= leachate or black water) will need to be collected, treated (optional) and discharged.
- Protection of soil and water
  - A liner under the waste must be provided for the protection of soil, groundwater and surface water.
- Leachate management
  - An efficient leachate collection system has to be provided to ensure that leachate accumulation at the base of the landfill is kept to a minimum.
- Landfill gas control
  - The accumulation and migration of landfill gas must be controlled. Landfill gas needs to be collected and treated, used or disposed in a safe manner.
- Environmental nuisances
  - Provisions should be incorporated in the design to minimise and control nuisances arising from the construction, operation, closure and aftercare phases of the landfill. A nuisance that may arise from landfilling includes: traffic, noise, odour, dust, litter, birds, vermin and fires.
- Physical stability
  - Considerations must be given to the stability of the subgrade, the basal liner system, the waste mass and the capping system.
- Visual appearance and landscape
  - Consideration should be given to the visual appearance of the land-form during operation and at termination and closure of landfilling.
- Operation and restoration requirements
  - The designer must consider the manner of site development and the necessary site infrastructural requirements during landfill operation and restoration.
  - Landfill sites should be developed on a phased basis.
- Monitoring requirements
  - The designer should consider monitoring requirements at the design stage
- Estimated costs
  - The designer should estimate the cost of the total project (construction, operation, closure and aftercare) and should seek the most cost-effective lay-out of the landfill

  - Consideration should be given to the financing of the facility at the design stage in order to ensure that sufficient funds can be generated
- After use;
  - The after use of the facility should be compatible with the design of the capping system and the surrounding landscape
- Risk assessment;
  - The design and engineering of a landfill should be supported by a comprehensive assessment of the risk of adverse environmental impacts or harm to human health resulting from the proposed development.

7.8.2 Site description and characteristics

The landfill site needs to accommodate the following activities and constructions

Table 36: Activities and constructions of a general design of a sanitary landfill site

Activity	Construction	Remark
Administration	Offices, fence and gate	
	Parking lot for employees	
Weighing of waste	Weigh bridge and office window	
Separation of waste	Separation hall	Optional
Landfilling of waste	Bottom liner	
	Phased sanitary landfill	
	Wheel cleaning unit	
	Daily cover soil depot	
Compacting of waste	Bulldozers, trucks, compactor	
	Maintenance and indoor parking area	
Composting of waste	Composting plant	Optional
Gas extraction	Gas extractor and/ or utiliser	Optional
Water management	Leachate collecting system	
	'Grey water' collecting system	
	Groundwater monitoring system	
Water treatment	Water treatment facility	Optional
	Leachate storage	Optional
	Connection to public sewer system	

7.8.3 Landfill Design and Layout

A landfill is divided into two parts:

- The actual landfill area
- The service area

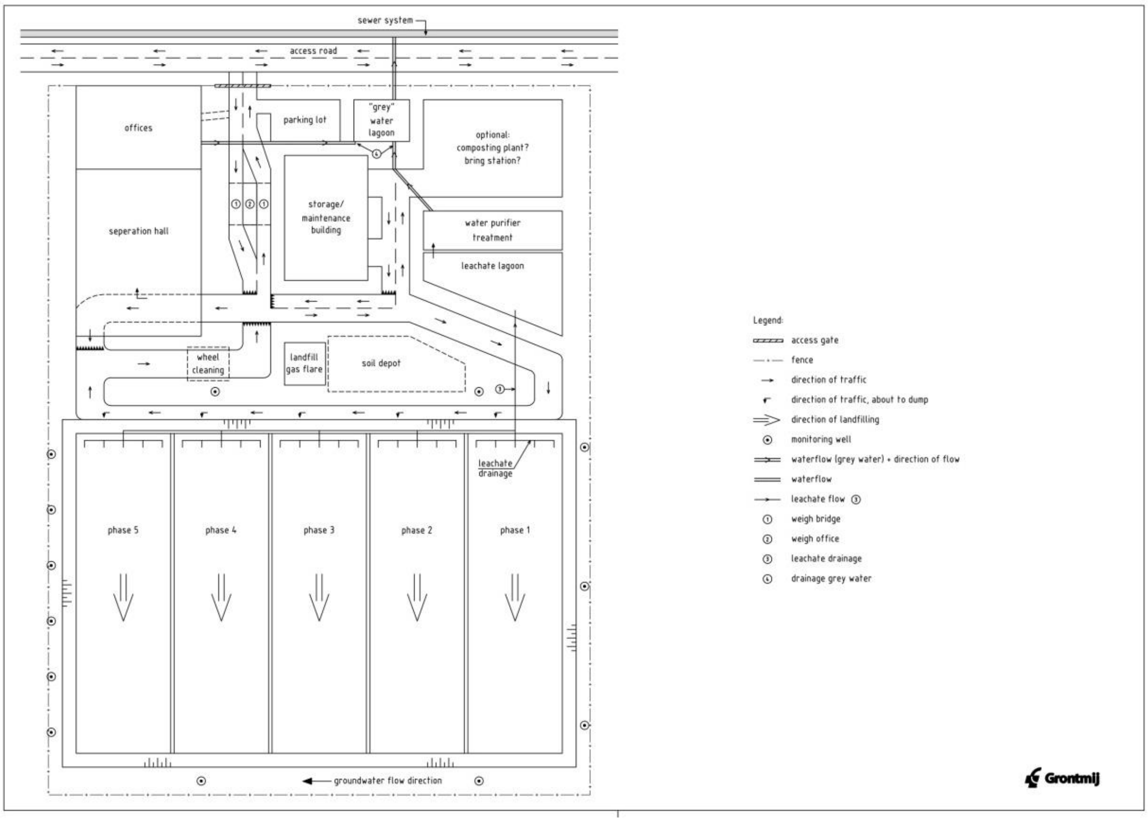


Figure 27: Example of landfill layout

7.8.4 Landfilling area

The dumping area is situated at the back of the location. In this way the (visual) nuisance is minimised and the possibility of future expansion of the site is kept open. The dumping area is divided into phases in order to keep the area in exploitation (active landfilling) as small as possible. This is preferable for a number of reasons:

- Minimising the amount of leachate;
- Spreading of investment costs;
- Parts of the location are not in use (yet) and can be used otherwise (agriculture, forest, etc.)

At first, phase one is excavated to the maximum depth (determined by the groundwater table and geotechnical requirements) and a bottom liner is constructed. The type of bottom liner depends on the type of waste.

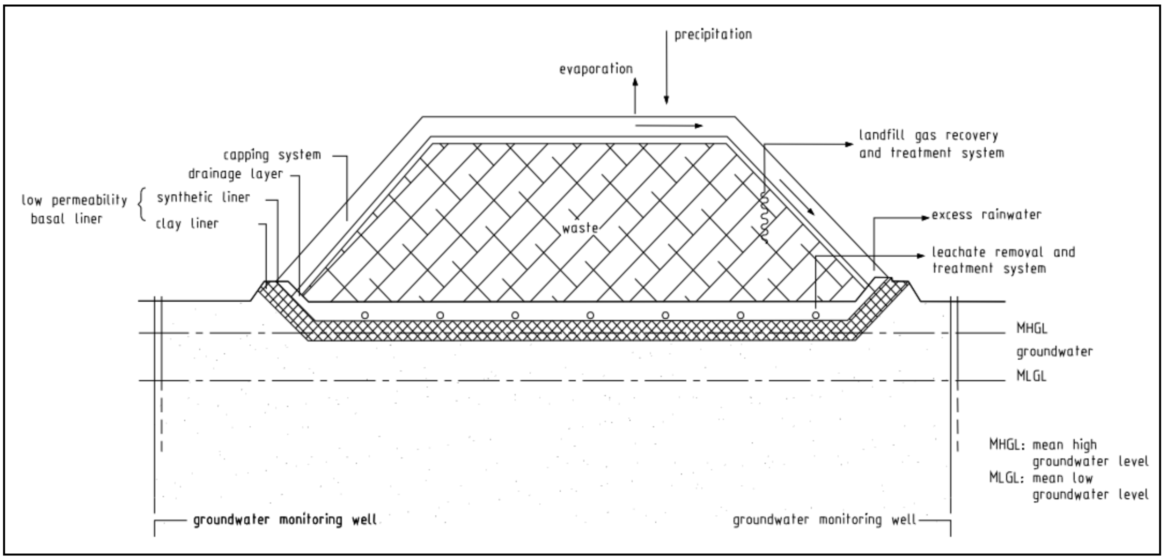


Figure 28: Waste disposal site with integrated pollution control (after care phase)

7.8.5 Service area

The service area provides the necessary supportive services needed for the proper management of the landfill. Depending on the type and amount of waste, the service area needs specific services, requiring the proper level of technical development.

a. Fence

Main goal of the fence is to prevent trespassing. No unauthorised individuals should be able to enter the sanitary landfill. The fence should be durable and reliable and approximately 2.5 m high. The main gate should be locked outside opening hours.

b. Weigh bridge

Main goal of the weighbridge is to determine the amount of waste deposited on the landfill site. Trucks containing waste will be weighed driving on and off the landfill site. The difference is the amount of waste dumped. The weighbridge should therefore be large enough to weigh a truck. The weighbridge should be tested regularly, according to local/Indian legislation. Depending on the amount of waste, the decision can be made to construct two weighbridges. This is an extra investment. Therefore the financial pros and cons should be considered thoroughly.

c. Offices

Main goal of the offices is to accommodate e.g. the working staff, administration, laboratory, eating and drinking facility, restrooms and directors offices.

d. Road plan

The road plan is designed in such a way that the trucks do not carry dirt from the landfill to the public road. Also the plan is kept as simple as possible, to avoid possible hazardous situations.

The roads must be equipped with a closed drainage system, carrying the water to the 'grey' water storage. The water from the road can be contaminated (so-called grey water) and should therefore be dealt with in a controllable way.

e. Wheel cleaning unit

The main goal of the wheel clean unit is to clean the wheels of trucks that have been dumping at the landfill site. Before the trucks enter the public roads, it should be made sure, that no dirt or waste is carried to the public road.

f. Leachate storage and treatment

Main goal is to purify the existing leachate to the level that it can be transported to the public sewer system or surface water.

g. “Grey” water storage

Main goal is to prevent that grey water infiltrating into the soil. Rain water from paved areas, purified leachate and cleaning water is collected in the grey water storage and dumped on a sewer system. The water should be analysed regularly to check whether the dumped water contains parameters that should not be dumped on a sewer system.

h. Storage/ maintenance building

Main goal is to facilitate the storage and maintenance of trucks, bulldozers and equipment in a secured building.

i. Landfill gas facility

Main goal during exploitation is to decrease odour nuisance and increase stability. After the construction of a top cover the gas facility vents or flares the gas produced by the waste. The facility consists of a flare or a vent that actively extracts the gas from the landfill. It can be considered to use the gas for instance for heating. However, the amount of landfill gas must be continuously sufficient to ensure ongoing heating services. Because of safety, it is important to keep a distance of approximately 10 meters from the flare. This includes buildings and roads.

j. Separation hall (optional)

Main goal of this optional service is to separate useable waste, whenever it is not collected separately already and therewith increase recycling of waste and diminish the total amount of waste dumped on the landfill.

k. Composting plant (optional)

Main goal of a composting plant is to recycle organic waste and diminishing the amount of waste dumped at the landfill. It should only be constructed when it is a profitable investment. The possibilities to sell the compost must be present and the waste must contain enough organic matter.

7.8.6 Adaptation to deviations of the preliminary design

Most sites are not like the ideal square, flat and horizontal site, or do not have an access road and a public sewer system. The Mandi district is a hilly area. The adaptations that can be made in order to construct a sustainable sanitary landfill in a different shaped site are relatively easy, taken the following basic rules:

- Keep the service area and the landfill area separated areas
- Construct the necessary services
- Construct a phased landfill
- Construct a route for the trucks who dump waste so that they reach the following chronological route, preferably not returning on their tracks
  - Weigh bridge
  - Dump site
  - Wheel cleaning
  - Weigh bridge
- Secure slope stability whenever the site is not horizontal, technical adaptations can be used to improve slope stability
- Construct a top cover with a maximal slope of 1 (vertical): 3.5 (horizontal).

7.8.7 Considerations

A landfill must be a sustainable and profitable operation. Therefore it must be designed, so that it can function in the most efficient way. A few considerations can be made in order to make the landfill efficient:

- Dump retrievable. At the start of the exploitation period, the waste is possibly not separated in the most efficient way. This means that useable materials are dumped in the landfill. If this waste is dumped retrievable, useable materials can be separated in a later stage of the exploitation.
- Dump large quantities of waste of similar composition separate from the other waste streams, so that they can be retrievable.
- Investigate whether a gas utilised can be cost-effective in a later stage of the exploitation;
- Investigate whether a mechanical waste separator can be cost-effective in a later stage of the exploitation. This investigation should include the possible retrieval of dumped waste in the first stages of the landfill;
- Use soil from the location itself, when suitable for daily or final capping;
- Keep the distances over which waste must be transported within the facility as short as possible, including the distances between the different facilities;
- Use as much area for landfilling and keep the service area as compact as possible.

7.9 Financials

7.9.1 Capital expenditure

Table No.37 reflects the total costs of lining of the sanitary landfill in Mandi. To comply with MSW 2000 rules, the Trisoplast Mineral Liners application would be combined with HDPE (1.5mm) and Geotextile (200 GSM).

The total cost of application HDPE and Geotextile lining to abide by the MSW 200 rules is INR 1,256 per m^2, the application of Trisoplast Mineral Lining would be INR 1,000 per m^2, cost for setting up the leachate drainage system would be INR 1,316 per m^2, and the cost of the leachate collection system is INR 312 per m^2. Therefore, the total cost of lining the sanitary landfill would amount to INR 3,884 per m^2, which adds up to INR 1.70 crores for 4,400m^2 of the sanitary landfill at Mandi.

Table 37: Estimated cost for Sanitary landfill

Bottom-liner	**EUR**	**€/m^2**	**INR**	**INR/m^2**
Installation of support layer liner				
Soil (delivered on work) 2 m thick	10	€/m^2	700	INR/m^2
Installation of soil (excavator, bulldozer, compacting)	1.5	€/m^2	105	INR/m^2
HDPE (1.5 mm) with application	4	€/m^2	263	INR/m^2
Geotextile (200 GSM) with application	3	€/m^2	188	INR/m^2
Subtotal	11.5	€/m^2	1256	INR/m^2
Trisoplast bottom-liner (10 cm thick including installation)	14	€/m^2	1,000	INR/m^2
Installation of leachate drainage system bottom liner				
Sand/gravel permeability k=> 10m/day (delivered on work) 0,5 m thick	10	€/m^2	700	INR/m^2
Installation of sand/gravel (excavator, bulldozer)	0.75	€/m^2	53	INR/m^2
Leachate collection pipes (every 10 m, including internal collection pipes) PE perforated pipe Ø 200 mm	3	€/m^2	210	INR/m
Gravel around pipes (delivered on work) 1,5m^3/m1 average 1000m1/hA	1.5	€/m^2	105	INR/m^2
Installation of gravel, pipes (excavator, bulldozer)	0.25	€/m^2	18	INR/m^2
leachate collection puts (average 1/per hA), inside and outside compartment	0.8	€/m^2	56	INR/m^2
Installation of gravel, pipes, puts (excavator, bulldozer), including connections	2.5	€/m^2	175	INR/m^2
Subtotal	18.8	€/m^2	1,316	INR/m^2
Leachate collection outer skirts bottom-liner (average/hA)				
Dikes (soil delivered on work) 1,5m^3/m1 average 250m1/hA	0.2	€/m^2	14	INR/m^2
Gravel (delivered on work) 1,5m^3/m1 average 250m1/hA	0.45	€/m^2	32	INR/m^2
PE perforated pipe Ø 160 mm	3.75	€/m^2	263	INR/m
Installation of soil, gravel, pipes (excavator, bulldozer)	0.06	€/m^2	4	INR/m^2
Subtotal	4.46	€/m^2	312	INR/m^2
Total Bottom Lining	**55**	**€/m^2**	**3,884**	**INR/m^2**

Note: The calculations are based on indicative prices which could vary marginally from the final prices

Total Investment	Value
Area (m^2)	4400
Total investment in crore (INR)	**1.70**

Conclusion: The total cost of construction of the sanitary landfill in Mandi district of Himachal Pradesh would be INR 1.70 Crores.

8 Financing for Project

8.1 Financing from commercial banks

Risk evaluation framework used by many banks allocates maximum risk to PPP infrastructure projects. Therefore, banks ask for other comfort factors (such as balance sheet support from sponsors, corporate and sometimes personal guarantees from promoters, creation of debt service reserves, etc.) which cannot be captured in the evaluation the relationship between the project risk and lending terms. Therefore, based on the comfort factors developers finally provide, the banks tweak the interest rates a bit.

Banks agree on financing the project if they feel they have a basic comfort with the promoter, the sector and the project concept. The pricing of the loan is done on the basis of discussion with promoters, comparison with pricing got for similar projects from other banks as well as the pricing on a similar project financed earlier. This comparison probably results in similarities in the interest rate of the loan. Several risks like Construction risk, O&M risk, Regulatory risk, Demand risk etc. are rated on the basis of judgement of the bank's deal team and in all the high risk areas specific mitigation measures are demanded. In addition banks also earn from projects beyond the debt that they give out. Other income which can earn fee based income for banks comes from providing financial advisory to the project, providing guarantees and carrying out the loan syndication for the project. Therefore, the interest rate charged by the banks is directly proportional to the risk associated with the project.

8.1.1 Infrastructure financing by commercial banks follows the below process

a. The project needs to establish technical feasibility and economic viability. In addition, sensitivity analysis shall also be examined to ensure that the project establishes its viability with variations wherever needed
b. Considering the huge outlay of funds, finance is generally considered under consortium arrangement with term lending financial institutions and other banks.
c. Banks usually provide Syndication services to assist the promoters. Memorandum of Understanding (MOU) has been signed with India Infrastructure Finance Company Limited (IIFCL) for enabling flow of funds for the infrastructure projects syndicated by us.
d. *Rate of interest, security and repayment period* for infrastructure financing would depend on nature of project, quantum of loan, repayment duration, cash generation, repayment capacity etc.

8.2 Financing options in India

8.2.1 Financing options under Swachh Bharat – Urban

The Swachh Bharat mission was launched by Shri Shri Narendra Modi, and was implemented for over 5 years starting from 2nd October, 2014 in all 4041 statutory towns. In the space of solid waste management, it aims to strengthen of urban local bodies to design, execute and operate modern and scientific SWM systems and create an enabling environment for private sector participation in capital expenditure and operational expenditure.

It aims to implement a systematic process that comprises of waste segregation and storage at source, primary collection, secondary storage, transportation, secondary segregation, resource recovery, processing, treatment, and final disposal of solid waste through creation of committees at central, state and ULB level.

A National Advisory and Review Committee (NARC) headed by the Secretary, ministry of urban development (M/oUD) has been set up, which will be responsible for

- Approval and release of instalment of funds for states / UTs by Central Government under the mission.
- And, to monitor outcomes and performance of projects sanctioned under SBM (Urban)

A High Powered Committee (HPC) under the chairpersonship of the State's Chief Secretary, and with members drawn from concerned departments (including a MoUD representative) has been set up at the state level and shall be responsible for the management of SBM (Urban) at the State / UT level. Their further roles shall be:

- Sanction projects relating to Solid Waste Management recommended by the ULBs.
- Plan for additional resource mobilization.
- Plan for fund flow in the short, medium and long term
- Recommend proposals for release of instalments of funds for projects under the mission
- Monitor outcome and O&M arrangements of projects sanctioned and completed under the mission

The SBM (Swachh Bharat Mission) State Mission Directorate will be located within the Urban Development Department (UDD) in the State / UT and will create / notify a uniform structure across the state for the planning, designing, project preparation, appraisal, sanction and implementation of sanctioned projects under the mission at the ULB level.

Furthermore, at the ULB level, ULB's are to prepare DPR for solid waste management of their city in consultation with state governments. Smaller cities can form clusters to become viable entities to attract private investment. 100% Cost reimbursement for preparing the DPR shall be done by GoI as per unit cost and norms set up by NARC.

The State High Powered Committee (HPC) will authorize institutes of national repute for appraisal of DPRs for the technical and economic appraisal of DPRs for projects recommended by ULBs. No appraisal will be done by MoUD. The cost of DPR appraisal by these institutes shall be an admissible component under administrative costs, subject to norms as approved by MoUD. Further responsibilities of the HPC include:

- Approval of the DPR as well as the financial model of solid waste management.
- To ensure that DPRs should be aligned with Govt. of India's goals outlined in the NUSP 2008, SWM rules, advisories, CPHEEO manuals (including cost-recovery mechanisms), O&M practices and Service-level Benchmark advisories released by M/o UD from time to time. Street Sweeping and litter control interventions will be part of DPR which is essential for a clean city.

8.2.2 Viability gap funding: Urban

Under Swachh Bharat Mission, projects under PPP mode are encouraged, to invite private capital in urban infrastructure as well as to bring in private sector efficiency in delivery of urban services and O & M. It is also understood that in the current scenario, there may be a requirement for viability gap funding. For solid waste management, revenue streams such as Compost from organic waste, recycled construction material from C & D waste, Power from waste to energy plants can be leveraged.

As stated in the guidelines, the VGF grants will be released to the state government upon acceptance of the proposal of the State Government for SWM. ULBs will initiate project preparation and bidding as per the Swachh Bharat for SWM. Central government incentive for the SWM projects will be in the form of a maximum of 20% Grant / VGF for each project and the state governments can also add or generate funds for ULB's as additional incentives over and above minimum 25% share required to make the projects viable. Once the funding reaches the states in instalments, the states will release the Central Government share of VGF adding their share in conformity with the contractual requirements of the project taken up on PPP mode.

Furthermore, in case state government feels that a project is not suitable to be taken under PPP methodology, it may then consider the GOI share (as per funding pattern) to be treated as Grant from GOI to the ULB. It will be up to the state government and ULB to arrange for the balance resources for the project, which must be ensured at the time of approving a project.

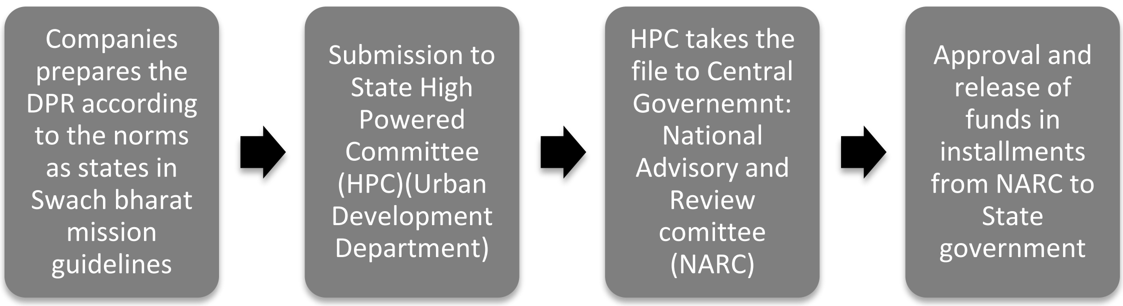


Figure 29: Process of funds release

Furthermore, the implementation of SWM projects will be as per directions of State Level High Power Committee and the SWM projects that are sanctioned by the State level HPC must include a representative of the MoUD. The States have also been granted the freedom to choose the technology for SWM project. However, The Ministry of Urban Development shall, from time to time, bring to the notice of the States, through advisories and manuals, and other consultative mechanisms, various options available in these fields

8.2.3 Financing options under Swachh Bharat – Rural

Swachh Bharat Gramin guidelines came into effect from 2nd October 2014 under the Swachh Bharat Mission. The mission in rural areas focuses on improving the levels of cleanliness in rural areas through Solid and Liquid Waste Management activities and making Gram Panchayats Open Defecation Free (ODF), clean and sanitized.

For Solid Waste Management, states are to decide the technologies suitable to their areas. Collection, segregation and safe disposal of household garbage, decentralized systems like household composting and biogas plants shall be permitted. Activities related to maximum reuse of organic solid waste, as manure shall be given highest preference under this scheme.

All gram panchayat's (GP's) have been targeted for coverage for a SLWM project. However, SLWM Projects for each GP should be part of the annual District Plan and State level Scheme Sanctioning Committee (SLSSC) should approve The Annual District Plan. Furthermore, every State should have at least one SLWM Consultant at the State level and one SLWM Consultant in each District DWSM/DWSC to guide the preparations of the SLWM projects.

The total assistance under SBM (G) for SLWM projects shall be worked out on the basis of total number of households in each GP, subject to a maximum of INR 7 lakh for a GP having up to 150 households, INR 12 lakh up to 300 households, INR 15 lakh up to 500 households and INR 20 lakh for GPs having more than 500 households. Funding for SLWM project under SBM(G) is provided by the Central and State Government in the ratio of 75:25. Any additional cost requirement is to be met with funds from the State/GP, and from other sources like Finance Commission funding, CSR, Swachh Bharat Khosh and through the PPP model.

8.3 Detailed breakup of financing available for the project – proposed by Urban Development, Himachal Pradesh

S.No	Name Of The ULB	Funds Available	Approx. Cost for installation of Bin Lifting system	Approx. Cost of new tipper truck for mounting of crane	Balance	Approx. No Bins which can be installed
		Lacs (INR)	Lacs (INR)	Lacs (INR)	Lacs (INR)	Nos.
1	Dharmasala	150.25	15	20	115.25	29
2	Jawalamukhi	90.88	15	20	55.88	14
3	Paonta Sahib	202.85	15	20	167.85	42
4	Sunde Nagar	72.58	15	20	37.58	9
5	Solan	133.03	15	20	98.03	25
6	Ghumarwin	97.92	15	20	62.92	16
	Total	**747.51**	**90**	**120**	**537.51**	**134**

Approx. No of Bins That Can be installed out available Budget (A)	134
20% Grant from HP Govt	149.50
No of Bins that can be installed from 20% grant	37
Total No of Bins that Can be installed	171

8.4 Dutch Good Growth Fund (DGGF)

The Netherlands has many SMEs that want to invest in or export to emerging markets. More often than not, their initiatives aim at having a positive impact on the target countries' economically. Furthermore, the positive impact extends to employment, production capacity and knowledge transfer in developing countries and emerging markets.

There are however the following hindrances in converting these opportunities:

- Developing countries and emerging markets by virtue carry high risks that make banks reluctant to finance
- Indigenous entrepreneurs themselves face the same problems as a foreign investor
- There is little or no access to regular or big financial services

In order to overcome these hindrances, the DGGF improves access to funds to exporters in Netherlands that aim at entering developing countries and emerging markets; thereby bridging the gaps in funding. A business potential that showcases revenue to the entrepreneurs in Netherlands and prove to boost the economic condition of the target country, are eligible to apply for the DGGF loans, guarantees and share capital (via intermediary funds). DGGF facilitates financial aid when banks fail to provide the same.

8.5 Payment terms of the Himachal Pradesh Government

The Open tender shall be invited by the HP government to meet with the Procurement and Installation of under Ground bins as per required Specifications and payment terms shall be governed by Govt. of Himachal Pradesh Finance (regulations) Department Notification No. Fin(C) A (3)5/2005 Shimla 171002 dated 12th August 2009.

The details of the regulations and payment terms are:

(1) Payment for services rendered or supplies made shall be released only after the services have been rendered or supplies made; provided that Advance or On Account payments may be made in the following cases, namely: -

a. To the contractors executing maintenance contracts for servicing of machinery and electronic equipment's;
b. To the contractors executing fabrication contracts, or turn-key contracts.

(2) Where it is essential to make advance payment under sub-rule the amount shall not exceed the following limits, namely: -

a. Thirty percent of the contract value to the private contractors; and
b. Forty percent of the contract value to a State or Central Government Organization or a Public Sector Undertaking;

(3) Pro-rata on account payment up to 80% of the supplies made or service rendered may be made pending completion of contract, after assessing the same.

(4) The Government may relax, the ceilings (including percentage laid down for advance payment) mentioned under sub-rules (2) and (3). While making any advance payment, adequate safeguards in the form of bank guarantee shall be obtained from the contractor.

(5) Part payment to contractors may be released after he dispatches the goods from his premises depending upon the terms and conditions of the contract.

8.6 Subsidy options

Table 38: Subsidy Options

	Benefit	Details
a)	**Income Tax - 100% Depreciation** (Investment in Scrubbing/Desulphurization units as well as other Air pollution Control Equipment enjoy a 100% tax depreciation)	As per Income Tax Act, 1961, Specified Air Pollution Control Equipment and Water Pollution Control Equipment are eligible for 100% depreciation on the cost of equipment in the 1st year itself. *-Scrubber counter current/venture/packed bed/cyclonic scrubbers*
b)	**Tax Holiday (Section 80 JJA of the Income Tax Act)** (All profits from the processing of municipal solid waste enjoy a tax holiday)	**80JJA.** Where the gross total income of an assesse includes any profits and gains derived from the business of collecting and processing or treating of bio-degradable waste for generating power (or producing bio fertilizers, bio-pesticides or other biological agents or for producing bio-gas or making pellets or briquettes for fuel or organic manure, there shall be allowed, in computing the total income of the assesse, (a deduction of an amount equal to the whole of such profits and gains for a period of five consecutive assessment years beginning with the assessment year relevant to the previous year in which such business commences)."
c)	**Basic Customs Duty**	Concessional basic customs duty of 5 percent on machinery and equipment required for setting up of compressed biogas plants (Bio-CNG).
d)	**Excise Duty**	Full exemption from excise duty on machinery, equipment, etc. required for the initial setting up of Compressed Biogas Plant

The production of electricity and Bio-CNG from landfill gas needs to adhere to some license and policy requirements stipulated by the government.

Table 39: License Required for Bio-CNG

	Activity - Licenses Required	Details
a)	Filling and storage of compressed biogas in CNG cylinders	License required from Petroleum & Explosives Safety Organization (PESO) and Licenses issued State Pollution Control Department (PCD) A person wishing to obtain or renew a licence under these rules shall submit an application, in writing, to the Chief Controller or Controller of PESO
b)	Waste Management Site	A No objection Certificate (NOC) is required for setting up a waste management plant and extraction of landfill gas

9 Strategic Risk Analysis

9.1 Risks associated with the biogas plant

Biogas production form can contribute to sustainable energy production, especially when nutrients conserved in the process are returned to agricultural production. Little energy is consumed in the process, and consequently the net energy from biogas production is high compared to other conversion technologies. The technology for methane production is scalable and has been applied globally to a broad range of organic waste feedstock.

The main risks associated with biogas productions are potentially explosiveness, asphyxia, toxicity and disease.

a. Gas Explosion

A bio gas plant may contain, or have activities that produce, explosive or potentially explosive atmospheres. Methane, which is makes up from 50% to 75% of biogas, forms explosive mixtures in air and may possess serious explosion dangerous. The lower explosive limit of methane is 4.4 vol. % and the upper limit 16.5 vol. %. Under and upper this limits methane cannot be ignited under normal ambient circumstances. Explosions can cause loss of life and serious injuries as well as significant damage. Preventing releases of dangerous substances through backup systems such as flaring systems and gas storage and preventing sources of ignition are the widely used ways of reducing the risk. Also, operating staff on biogas plants should ensure that no air is allowed to enter the digester or gasholder. All piping and equipment must be sealed properly to prevent gas from escaping to the outside. There must be no smoking and all electrical installations, including light switches, torches etc. must be of the explosion-proof type, as the smallest spark could ignite escaped gases.

b. Noise

Noise is defined to be disturbing sound. Any location where sound does not cause disturbance, even it is very loud, does not incur restrictions. The area in a biogas plant where noise is most intense is near the gas engine, hence some things to ensure are:

- The operation of engines, machines, and plant must correspond to the state of the art of noise protection.
- Impact sound - radiating plants must be decoupled from airborne sound - radiating buildings and components.
- In exhaust gas pipes and/or in openings for ventilating enclosed spaces, sound absorbers have to be installed.
- Doors, gates, and windows of the generator house must be closed when the engine is under load.
- The space close to the generator house must be noise - protected by sound - damping measures according to local regulations.

c. Disease

As Anaerobic Digestion relies on a mixed population of bacteria of largely unknown origin, but often including animal waste, to carry out the waste treatment process care should be taken to avoid contact with the digester contents and to wash thoroughly after working around the digester (and particularly before eating or drinking). This also helps to minimize the odours spread which may accompany the digestion process. The digestion process does reduce the number of pathogenic (disease causing) bacteria, particularly at higher operating temperatures, but the biological nature of the process need to be kept in mind.

d. Water Pollution

A big danger to the environment arises when water, e.g., from pressing plants or contaminated precipitation water, penetrate into the soil or, even worse, reach the groundwater. Main causes can be insufficiently tightened ground within the plant site, cracks in tanks and/or in the crankshaft housing corrosion of pipework. To eliminate these hazards the best available measures must be taken in biogas plants to protect water from contamination and even more from unfavourable changes of water at any place.

9.2 Risks associated with sanitary landfill

A sanitary landfill is a solid waste management facility that utilizes an engineered method of land disposal, primarily for municipal solid waste. Although this method of waste disposal is controlled and monitored very closely, sanitary landfills' basic conditions are compaction of the waste and control and prevention of negative impacts on the public health and on the environment. Although sanitary landfills are an improvement over previous methods, there are still many issues and concerns associated with this method of waste disposal.

Inherent to the landfill there are several risk factors that would have to be addressed:

a. MSW 2000 Rules

As per MSW 2000 rules organic waste is not allowed in the sanitary landfills. In India currently the waste that is generated is highly organic and mixed. Segregation at source is virtually absent, even if segregation is done manually or by way of machines (MRF, VM Press, Trommels etc.), the waste still cannot be considered 100% segregated. Owing to the characteristic of Indian waste which is highly organic, segregation is highly difficult therefore there is a high propensity and chances of organic waste ending up in sanitary landfills.

b. Segregation at Source

In India segregation at source is an almost absent phenomenon, without segregation at source pure sanitary landfilling seems unlikely. Sanitary landfilling ideally should get only the absolute inert from the landfills, however that is very unlikely in the Indian scenario. Therefore, unless segregation at source has been implemented in India in waste management, scientific landfilling always holds a risk of taking in waste other than inert.

c. Unfavourable Terrain

The terrain in questions for the sanitary landfill is not the most favourable terrain for landfilling. The terrain is very complex and undulating with steep slopes and valleys. The landfill design would therefore have to be made well suited for the typical characteristics of the mountainous terrain. Such a landfill design although can be made would be complex. Additionally the plot in questions at

Mandi, is a small site and the movement of construction machinery and equipment to the site of landfilling would be cumbersome, time consuming and expensive. The inherent characteristics of the site in Mandi would have to be considered an essential input in construction of the sanitary landfill.

d. Threat to water systems

If rainwater soaks into the landfill, it creates bad-smelling liquid waste that can carry poisons from trash into the groundwater. This is why it is important to line the landfill well and not to make it near a river, stream, or lake. Trisoplast mineral liners rules leakage out, however proper leachate collection systems would have to implement in order to make sure that the leachate does not seep into the water systems that is used to domestic consumption. Leachate water will be mixed with harmful toxins which can be detrimental to health; therefore adequate measures should be taken to ensure that there is no leakage.

With proper precautions and preventive measures in place the risks associated with Biogas plant and sanitary landfilling can be completely avoided, and the benefits of the waste management can be subsequently reaped.

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