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1. Introduction

1.1 Background

Biomedical Waste (Management & Handling) Rules were introduced under the Environment (Protection) Act, 1986. In Maharashtra, Maharashtra Pollution Control Board (MPCB) is the enforcement agency. In order to facilitate implementation of these Rules, MPCB authorizes operators to install and operate Common Biomedical Waste Treatment and Disposal Facilities (CBMWTDF). To recover the costs of capital and operations, the CBMWTDF operators/ transporters levy charges to the Health Care Establishments (HCEs). Current practice of selecting the CBMWTDF operator involves competitive bidding called by Urban Local Bodies (ULBs). ULBs tender out the process, and a CBMWTDF operator is selected on the least per bed (or kg, as the case may be) charge quoted. In this process, operators quote charges that may not be viable. This has given a concern to MPCB.

In order to evolve a rational scheme of charging MPCB engaged Environmental Management Centre (EMC). The charging scheme should be such that the CBMWTDF are viable and are operated on sustained basis and at the same time the charges to HCEs are reasonable, rational, and transparent.

1.2 Scope and Methodology

The scope of the study was limited to CBMWTDF operator & transporters in Maharashtra. The methodology adopted to arrive at a rational charging policy is depicted in **Figure 1.** Each the steps of the methodology are briefly described in this section.

1.2.1 Data Collection

Formats were developed, in consultation with MPCB, to obtain techno-commercial data from existing CBMWTDF operators and transporters. The formats had four heads such as: (a) General Information; (b) Technical Information on Treatment; (c) Transporter Details and (d) Financial Details. These formats are provided at **Annex-1a** and **Annex-1b.** MPCB facilitated and helped EMC to obtain such data from CBMWTDF operators and transporters.

In addition to collection of data, one to one meetings were held with some of the key operators/ transporters. In some cases, where one- to-one meetings were not possible, telephonic interviews were conducted. These interviews helped to fill the gap as well as improve insight on the operation of CBMWTDF.

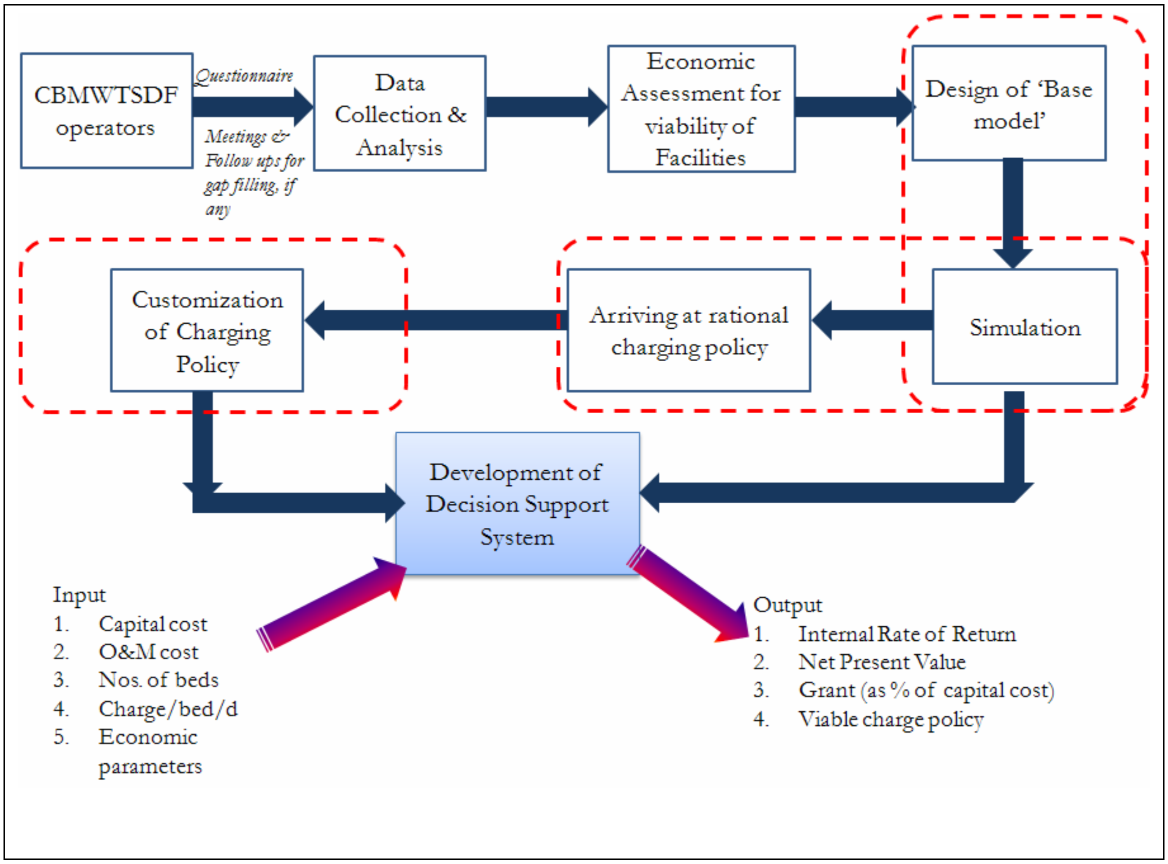


Figure 1-1 Methodology adopted for arriving at Rational Charging Policy

1.2.2 Review and Analysis of Collected Data

Data analysis was undertaken to understand the existing profile of CBMWTDF operations in terms of capacity, capital, investment, treatment technology, hours of operations, costs of operation and cost of transportation, etc.

This data was then analyzed to understand key parameters that influence viability of CBMWTDFs. Analysis was also done to establish relationships between the key parameters through regression models.

Each CBMWTDF was evaluated for its economic feasibility by computing its Net Present Value (NPV) and Internal Rate of Return (IRR).

1.2.3 Economic Assessment for Viability of facility

Based on the data received, economic viability of all the facilities was carried out in terms of NPV (Net Present Value) and IRR (Internal Rate of Return).

1.2.4 Design of base-model

In order to allow the charging policy to be applicable to a wide range of situations such as, 500 to 15,000 beds, simulations were required to be performed around a 'Base model'. Base models were developed for both CBMWTDF facilities with incinerators and with deep burials in Microsoft® Excel™. The data needed to establish the base model derived from the data provided by the CBMWTDF operators/transporter.

1.2.5 Simulation

Simulation were carried out around the base model by varying Numbers of beds (500 to 10,000 beds with interval of 250 beds) and charges in Rs./bed/day (Rs. 2 to Rs. 15/bed/d with interval of 0.5 Rs.). For each combination of bed and charge/bed/day; NPV and IRR was calculated to assess the economic viability. As the number of beds was varied, it was necessary to estimate corresponding capital and operating costs of the CBMWTDF. To obtain such estimates, capital cost data for various incinerator capacities was used. Based on the data provided by the operators, a model was established between the number of beds and distance travelled. This model has provided a basis to estimate operating costs.

1.2.6 Arriving at Rational Charging Policy

Simulation was carried out 1593 times. In all 1593 simulations, economically viable combinations of number of beds and charges were worked out that fell between 10% -20% IRR. This provided a basis for rational charging policy on bed or bed equivalent basis.

1.2.7 Customization of Charging Policy

The bed based charging policy does not differentiate between the charges to HCE in proximity or at far distances from CBMWTDF. If such a distinction is to be provided, then the BMW charge would need to be prescribed on both bed as well as on distance basis. A solved example is provided how such a customization could be carried out at the end of the Operator.

It is possible that in some CBMWTDF, the charges required to ensure economic viability could be steep and much more than so called "willingness to pay". However, the setting up of the CBMWTDF may be warranted due to adverse health and environmental impacts. In such instances, a grant may need to be provided. An example is worked out to illustrate how such cases could be analyzed and how the grant portion could be computed to maintain reasonable level of BMW charges.

1.2.8 Development of Decision Support System

A Microsoft Excel Model is developed as a Decision Support System (DSS) to assist MPCB. . For the cost data provided on the facility, the model gives the NPV and IRR of the CBMWTDF as an output. The DSS thus allows checking on the economic viability of the facility based on the charges proposed by the Operator. The DSS also allows customization of the charges to account for transportation distance if so desired. Further, the DSS also helps in recommending the grant component if found relevant

2. Existing Scenario of CBMWTDF Establishment and Operation

2.1. Profile of present charges

The present practice of establishing the CBPWTDF operators involves competitive bidding called by Urban Local Bodies (ULBs). ULBs tender out the process and a CBMWTDF operator is selected on the least per bed or kg charge quoted. The selected operator of CBMWTDF then obtains Consent to Establish and Consent to Operate from MPCB.

The present practice of establishing the CBPWTDF operators by ULBs and granting Consent by MPCB does not assess and ensure the economic viability.

Several CBMWTDFs have come up in various States of India. The charges towards transportation, treatment and disposal are paid by the HCEs to operators & transporters. The charges vary from State to State and location to location within the States. The data available regarding charges have been collected and compiled and provided in **Figure 2.1**.

Based on **Figure 2.1**, following observations can be made:

i. Charges on bedded HCEs are per bed per day basis in most States (where data available), except in one case in Maharashtra and one in Madhya Pradesh, where it is in kg of waste basis.

ii. There is a wide variation in charging scheme from one State to another, say Rs. 1.5/bed/d to Rs. 7.7/bed/d. Also there is variation from one city to another, even within the State (in Madhya Pradesh, Rs. 3/bed/d to Rs. 6/bed/d).

iii. For non-bedded HCEs, charging is per month basis. These charges vary from Rs. 300.0/month to Rs. 500.0/month.

iv. In States, like West Bengal and Kerala higher charges are levied on private run HCEs compared to Government run HCEs.

v. Only in the State of Punjab, charges to HCEs are divided into transport and treatment & disposal operations. The transport charge varies from Rs.0.5/bed/d to Rs.1.0/bed/d based on the distance (in km).

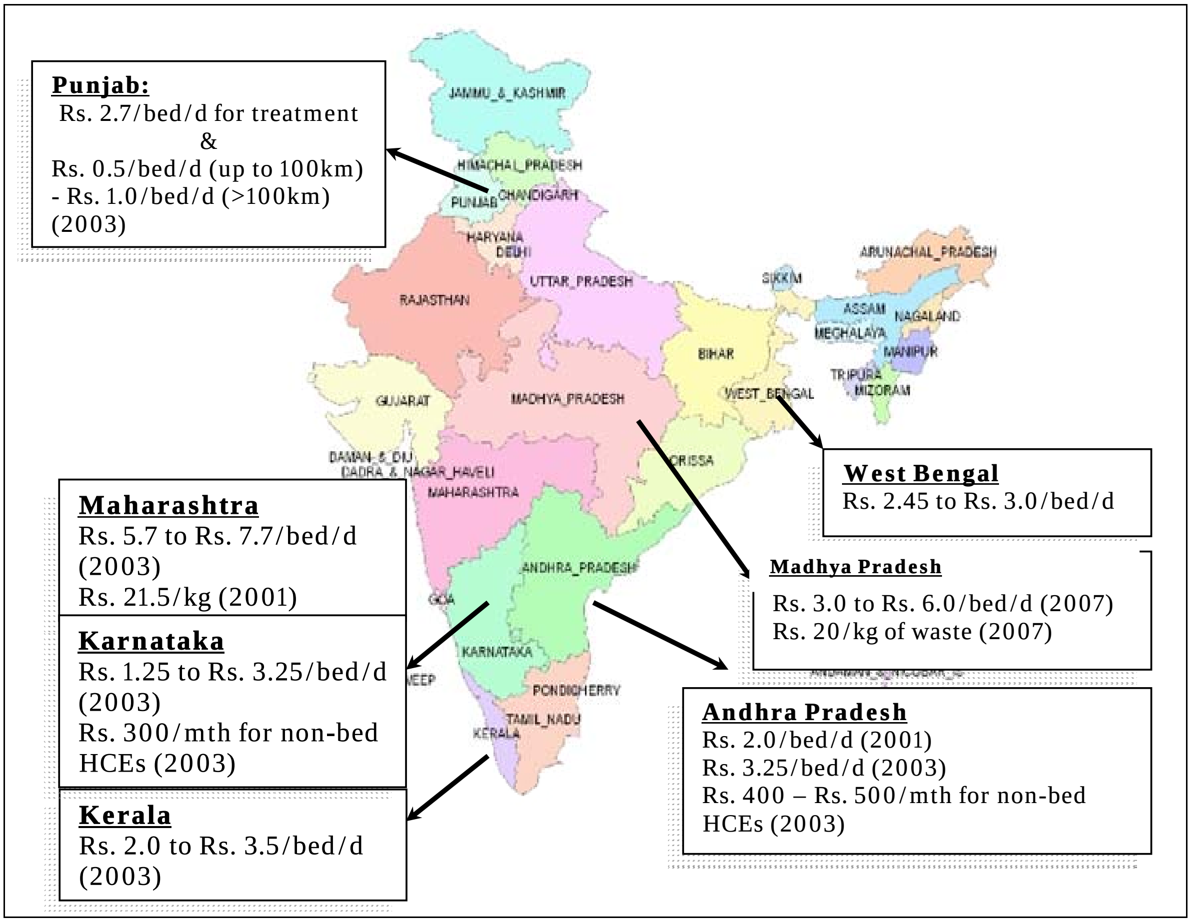


Figure 2-1 Charging Basis Followed in Various States of India

2.2. Types of CBMWTFs

The management of BMW is undertaken in two separate routes viz. CBMWTDFs having incinerators and CBMWTDFs having deep burial systems. A brief technical description of each of these routes is presented below:

2.2.1 CBMWTDFs with Incinerators

CBMWTDFS with incinerators use a combination of incinerator, autoclave and shredders. Incinerable BMW is incinerated. The non-incinerable BMW is autoclaved and shredded.

The incinerable fraction of BMW (categories 1, 2, 3, 5 and 6 as per BMW Rules) are segregated at source and sent to incinerators. As per current estimate, in Maharashtra incinerable fraction is approx. 69% of the total

BMW stream. Incinerators from 5 to 300 kg/hr capacity are in use in CBMWTDFs in Maharashtra. However, as per specifications provided by CPCB, the incinerators are to be designed for capacity more than 50 kg/hr. For 50 kg/hr capacity, CPCB specifies that, the minimum hearth area shall be 0.75 m^2 and the minimum flow of the flue gas in the secondary chamber shall be 0.6m^3/sec at 1050°C. The incinerator comprises of two separate chambers called the primary and the secondary chamber. The operational temperatures in primary chamber should be approx. 850°C $\pm$ 50°C, and that in the secondary chamber should be approx. 1050°C $\pm$ 50°C. Air supply in the primary and secondary chamber shall be regulated between 30%-80% and 170%-120% of stoichiometric amount respectively. Primary air shall be admitted near / at the hearth for better contact. In the incinerator the firing is assisted by use of diesel oil. The proportion of diesel oil use is approx. 0.1 - 0.26 L/kg of incinerable BMW. The incineration residue (or ash) is potentially hazardous in nature and are disposed off with authorized Common Hazardous Waste Treatment, Storage and Disposal Facilities (CHWTSDF). The gaseous fume generated in the process is to be treated using high pressure venturi scrubber system. The scrubbing medium (alkaline with pH > 6.5) is prescribed to be circulated @ 2-2.5 liters/m^3 of saturated flue gas at venturi outlet. As per CPCB specifications the flue gas should have combustion efficiency of 99%.

Autoclaves and shredders are used for BMW categories 4, 6 and 7. Autoclaving is a low-heat thermal process where steam is brought into direct contact with waste in a controlled manner and for sufficient duration to disinfect the wastes. Autoclaves could be gravity flow or vacuum type. In both types, BMW is subjected to a temperature of not less than 121°C and pressure of 15 per square inch (psi) for an autoclave residence time of not less than 60 minutes. For optimum results, pre vacuum based system be preferred against the gravity type system. For ease and safety in operation, the system should be horizontal type. The autoclave used high pressure and temperature to neutralize the probable contaminants present. As per the CPCB requirements the pressure and temperature of the autoclave should be regularly recorded. Microwaving and Hydroclaving are two other options that may be used instead of the autoclaving. However, out of 24 CBMWTDFs records received, all are using autoclaves.

After the treatment by autoclave, shredder is used to pulverize and homogenize the disinfected waste stream. These are electro-mechanical equipment with hydraulic moving parts. The disinfected BMW is fed (mostly mechanically) into the top hopper, which has lids attached that could be closed after feeding. A motor is attached to a gear box ridden cutting mechanism. CPCB specifies that shredder should have low rotational speed (maximum 50 rpm). This will ensure better gripping and cutting of the bio-medical waste. The minimum capacity of the motor attached with the shredder shall be 3 kW for 50 kg/hr, 5 kW for 100 kg/hr and 7.5 kW for 200 kg/hr and shall be three phase induction motor. This will ensure efficient cutting of the bio-medical wastes as prescribed in the Bio-medical Waste (Management & Handling) Rules.

2.2.2 CBMWTDF with Deep Burial Facility

Category 1 and 2 bio-medical wastes comprising of human and animal anatomical waste as per BMW Rules could be alternatively dug deep into earth. Deep burial facilities are only allowed in a small rural areas having population less than five lakh. A pit or trench for burial should be approx. 2 meters deep. It should be half filled with waste, and then covered with lime within 50 cm of the surface, before filling the rest of the pit with soil. When wastes are added to the pit, a layer of 10 cm of soil shall be added to cover the wastes. The BMW rules prescribe the deep burials to come up in areas with relative hard and impermeable soil type. Also, the rules prescribe that there should not be any open well in the vicinity of the deep burial site.

It was noted that out of the 29 questionnaire received, only 5 were from CBMWTDFs with deep burials (less than 17%). During interviews with them, it became evident that most are planning to install incinerators. Some CBMWTDFs with deep burials have already installed incinerators.

2.3. Type, Location and Capacities of CBMWTDFs

Data was received from 29 Numbers of CBMWTDF operators and transporters through formats; that were developed with inputs from MPCB. The data received from the CBMWTDF operators and transporters included: (a) technical information pertaining to waste collected and incinerated, (b) economic information like capital expenses, operation & maintenance cost as well as revenue generated.

In addition to collection of data, one to one meetings were held with some of the key operators/ transporters. In some cases, where one- to-one meetings were not possible, telephonic interviews were conducted. These interviews helped to fill the gap as well as improve insight on the operation of CBMWTDF. The minutes of the meeting are enclosed at **Annex 2-1.**

Based on the data/ information received a profile in the form of fact sheet has been prepared for each CBMWTDF operators and are provided at **Annex 2-2**. The analysis results and the key findings are given below.

Also, literature review has been carried out to obtain experience of bio-medical waste management in developed countries. The same is enclosed at **Annex 2-3**.

The data related to waste received, members and beds served, distance travelled for waste collection, and others are given in **Table 2-1**.

Table 2.2-1 Information obtained on the CBMWTDFs

Facility no.	Location	No. of beds served	Numbers of members	Kg/d (total)	Incinerator capacity (kg/hr.)	Incinerator Operation (hrs/d)	Incinerable (kg/d)	Non-incinerable (kg/d)	Non-incinerable to Incinerable ratio	Distance travelled (km/d)
F1	Palghar	1035	33	70	N/A	N/A	30	40	01:00.7	682
F2	Kalyan	6430	947	826	90	7	716	110	01:06.5	295
F3	Thane	6612	2105	920	50	14	535	385	01:01.4	700
F4	Ahmednagar	5910	827	600	100	8	450	150	1:03	1250
F5	Jalgaon	4063	698	331.1	70	5	300	31.1	01:09.7	360
F6	Nasik	8109	1608	2050	300	8	1800	250	01:07.2	965
F7	Nanded	1520	282	212	100	3	132	80	01:01.7	200
F8	Chandrapur	130	24	5	10	1	5	0	0	10
F9	Panvel	8176	1348	2000	150	13	1920	80	1:24	550
F10	Miraj	3250	433	650	50	10.5	550	100	01:05.5	550
F11	Solapur	4783	414	518.34	75	10	516.67	1.67	06:09.4	550
F12	Ratnagiri	2161	726	215	50	6	94.88	92.27	01:01.0	1142
F13	Amravati	6566	981	1250	100	12.5	1150	70	01:16.4	1875
F14	Nagpur	8159	1571	2000	200	8	1819.87	43.07	01:42.3	980
F15	Ichalkaranji	1642	415	200	50	4.5	137.5	62.5	01:02.2	125
F16	Kolhapur	4489	723	295	50	5	165	130	01:01.3	45
F17	Kudal	906	323	45	N/A	N/A	8	37	01:00.2	400
F18	Satara	1714	641	262.5	100	3.5	250	12.5	1:20	421
F19	Gondia	837	115	126	50	3	75	51	01:01.5	305
F20	Talegaon	1645	380	310	50	4	200	110	01:01.8	160
F21	Akluj	876	428	337	75	8	130	207	01:00.6	161
F22	Karad	1183	184	48	30	1	22	26	01:00.8	43
F23	Uran	275	22	45	N/A	N/A	9	36	01:00.3	17.5
F24	Pimpri Chinchwad	6778	466	630	50	14	500	130	01:03.9	250
F25	Baramati	1731	311	630	N/A	N/A	500	130	01:03.9	450
F26	Udgir	1680	210	22	N/A	N/A	0	22	0	290

F27	Latur	3769	910	202	100	3	200	2	0.11111	875
F28	Aurangabad	1004	325	1350	300	8	1200	150	1:08	1550
F29	Buldana	1680	210	67.5	50	1.5	55	12.5	01:04.4	290

Note: N/A cases indicate CBMWTDF facilities with deep burial.

2.4. Analysis of Data

2.4.1 BMW Treatment and Capacity of Facilities

The BMW treatment capacity of the facilities is shown in **Figure 2-2.**

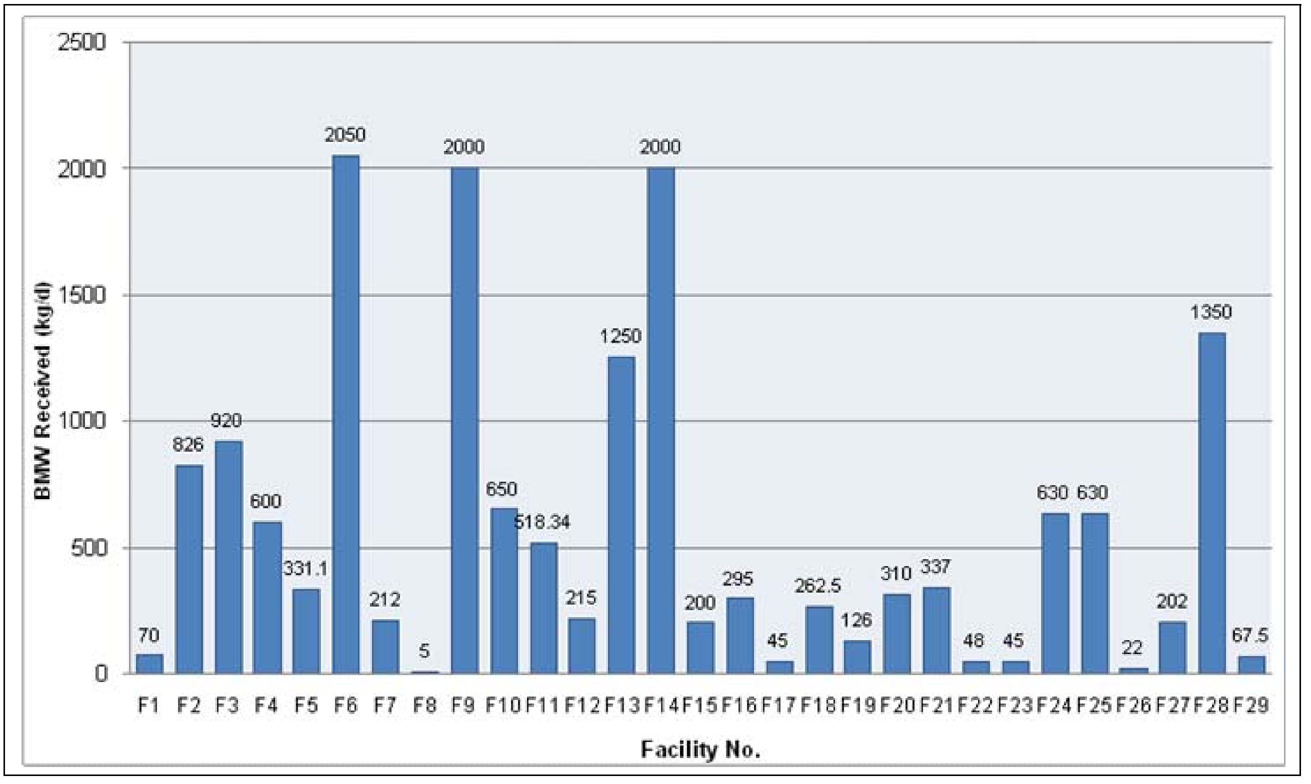


Figure 2-2 Bio-medical Waste Treatment and Disposal Capacity of facilities

Following observations are made from **Figure 2-2**:

i. The maximum capacity is 2050 kg/day. The minimum capacity is 5 kg/day only.

ii. Out of 29 facilities, there are five facilities whose capacity is less than 50 kg/day.

iii. There are 3 facilities which has 2000 kg/d or more capacity.

2.4.2 Incinerator Capacity Utilization

The installed incinerator capacity and its daily operation (in terms of hrs/d) by the CBMWTDF operators are shown in **Figure 2-3**.

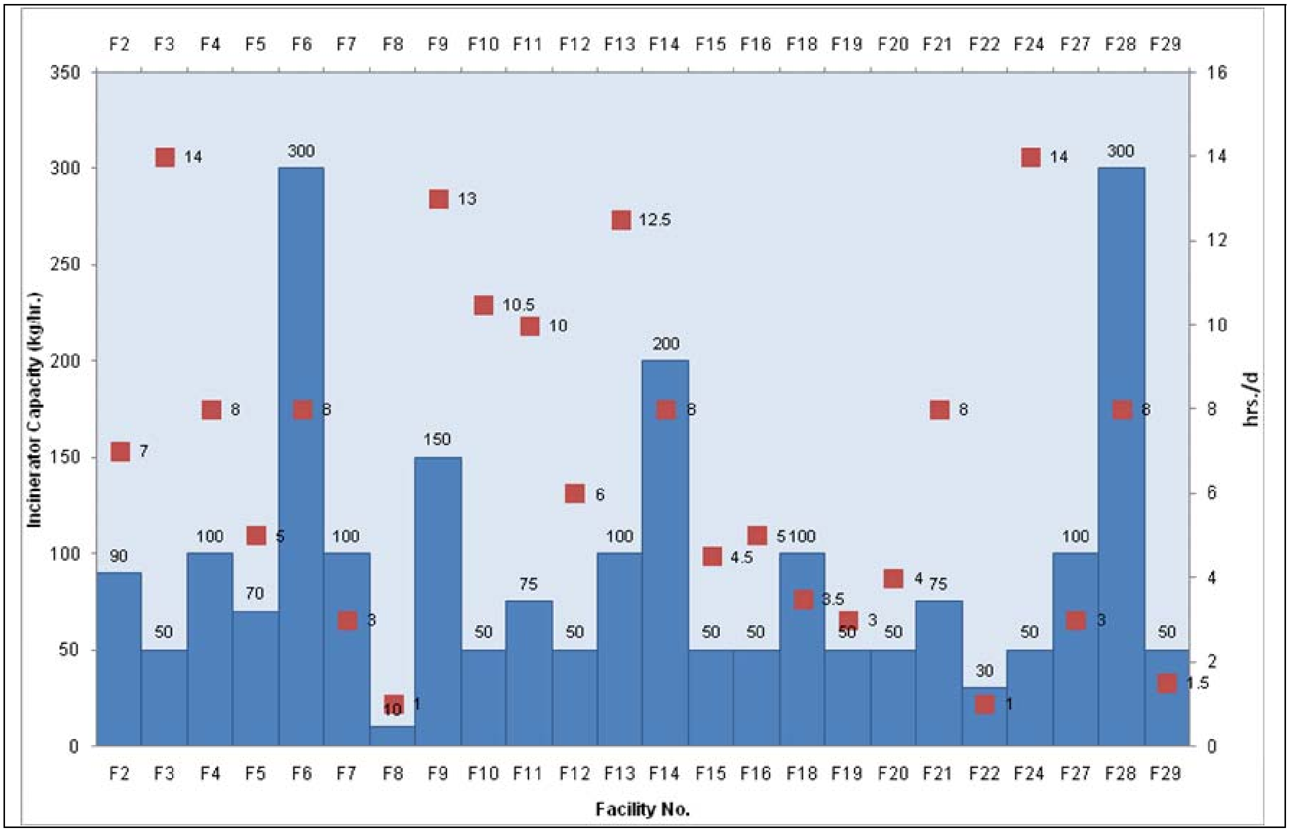


Figure 2-3 Incinerator Capacity and hrs. of operation/d of different CBMWTDFs

From **Figure 2-3**, following observations could be drawn:

- The incinerator capacity ranges from 10 to 300 kg/hr.
- Hours of incinerator operation ranges from 1 to 14 hrs./d.
- The capacity utilization ranges from 20% to 114%, with an average of 62.6%.
- A diesel(LDO) fired incinerator takes approx. 1/2 hr. to reach the desired primary chamber temperature of 850^{0}C and secondary chamber temperature of 1050^{0}C after charging of BMW. Also it requires flushing after completion of incineration after the last feed of waste. Thus, running an incinerator for short duration will lead to non optimum utilization of fuel.

2.4.3 Arriving at Bio-medical Waste Generation Factor

Based on the data received from the CBMWTDFs, the BMW generation factor in terms of kg/bed/day was established. The same is shown through **Figure 2-4** and **Figure 2-5.**

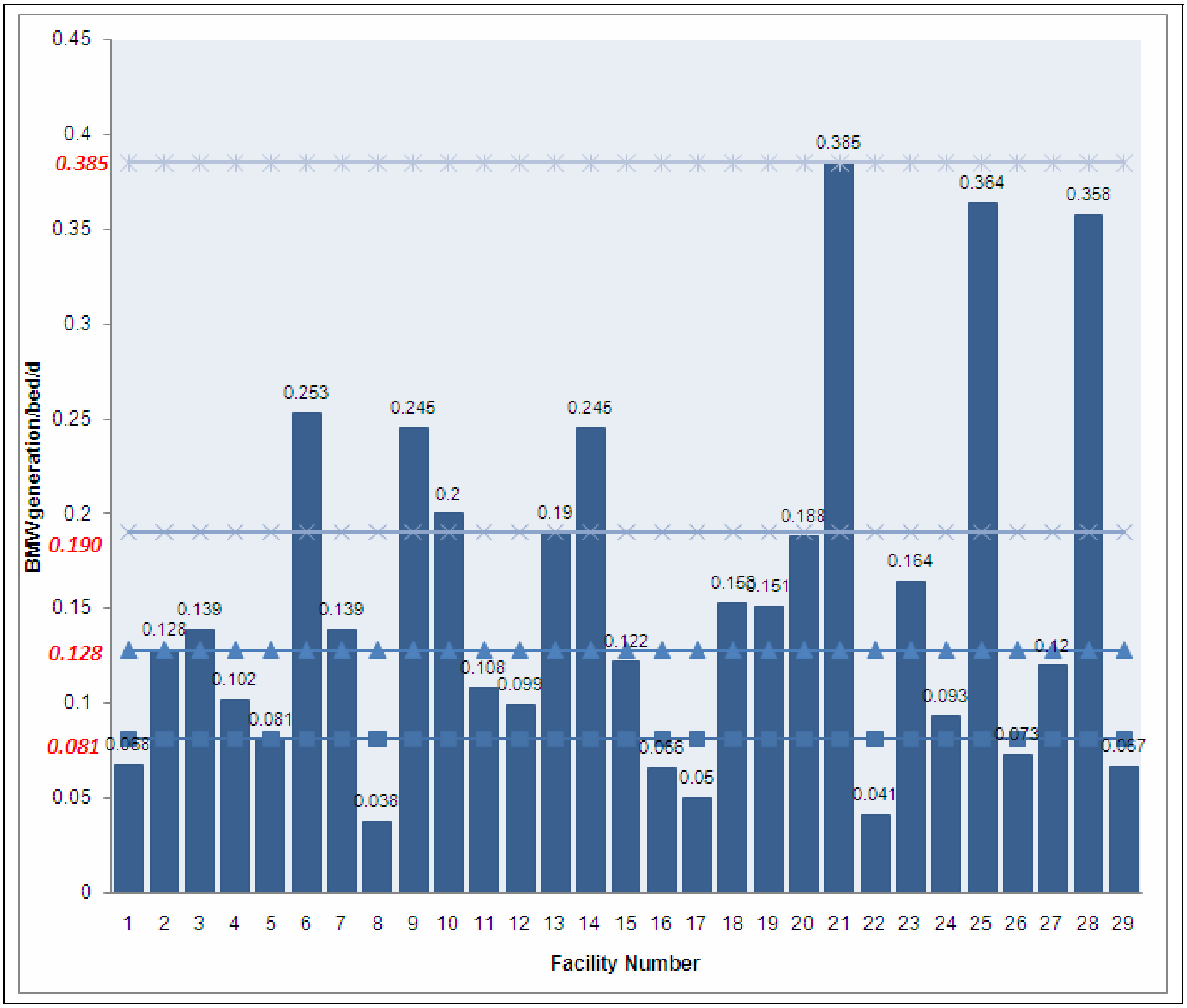


Figure 2-4 BMW generation per bed per day by each CBMWTDF

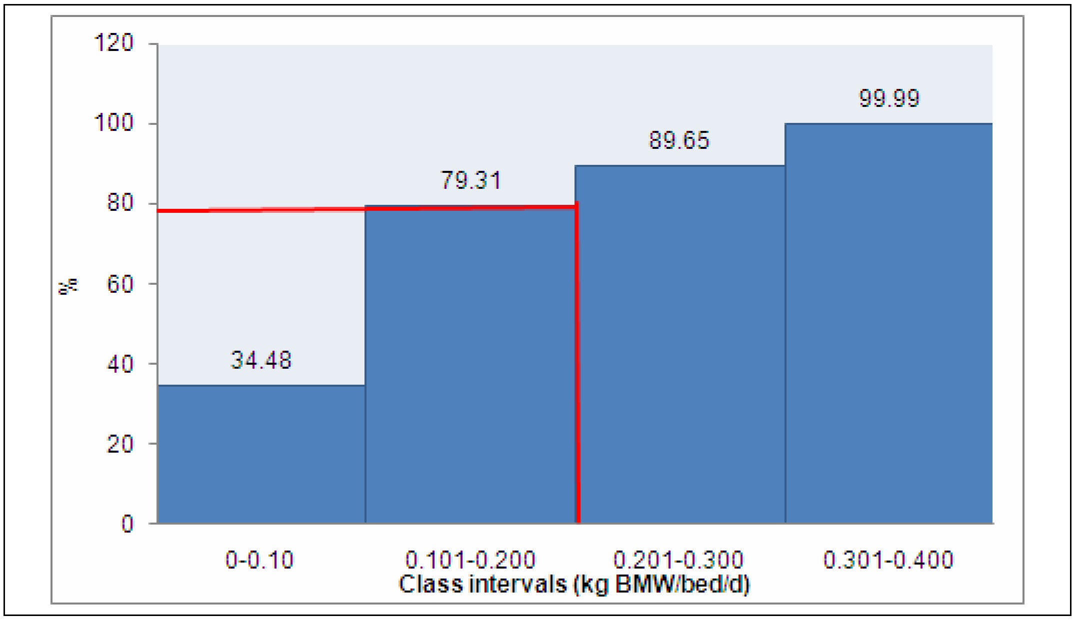


Figure 2-5 Cumulative Frequency Distribution of BMW generation/bed/day

The following could be derived from the Figure 5 and 6 above.

- The average BMW generated/bed/d comes to approx. 0.1556 kg BMW/bed/d. This mean value has approx. 64% data falling below it.

- A cumulative frequency distribution curve is given in Figure 6, which shows that approx. 79.3% (say, 80%) of the data are below the designated 0.20 kg BMW/bed/d value.

Based on this analysis, per bed BMW generation factor is estimated to be 0.20 kg/bed/day. This factor corresponds to nearly 80 percentile of the data collected and number of beds data collected from 29 facilities. This corresponds to the national estimate cited by Nasima Akter in her 2000 paper titled "Medical Waste Management: a Review". [1] For India, this estimate is also at par with several developing courtiers like Brazil.

[1] N. Akter. Medical Waste Management: a Review. School of Environment, Resources and Development. Asian Institute of Technology, Bangkok. January 2000.

2.4.4 Relationship between No. of Members Served and BMW Received (kg/d)

The relationship between the no. of members served and BMW received (kg/day) is shown in **Figure 2-6.** This relationship is of the form $y = 0.708x^{1.013}$, where x is Numbers of members and y is BMW received by the facility in kg/d[2].

Figure 2-6 Relationship between Numbers of Members vs. BMW Received (kg/d)

It may be observed that there is a high correlation (R^2 = 0.752) between the numbers of members served and the total BMW received by a CBMWTDF.

[2] All data used in this section is present (2009) data provided by CBMWTDFs

2.4.5 Relationship between Numbers of Beds Served and BMW Received (kg/d)

The relationship between the no. of beds served and BMW received (kg/day) is shown in **Figure 2-7.** This relationship is of the form $y = 0.026x^{1.206}$, where x is the numbers of beds served/d and y is BMW received by facility in kg/d.

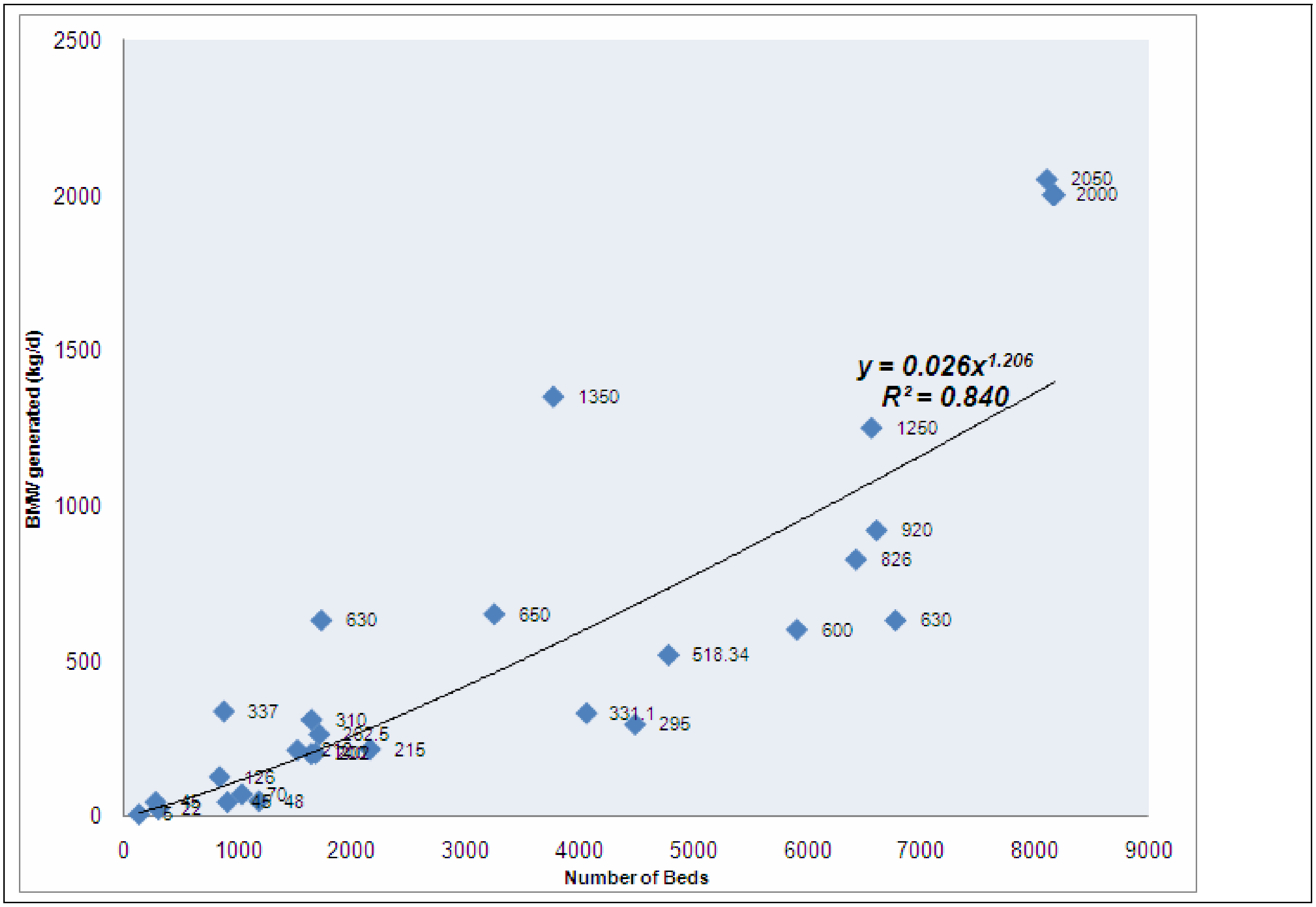


Figure 2-7 Plot of Numbers of Beds vs. BMW Received (kg/d)

Thus, it could be concluded from above, that:

I. Though there is high correlation (R^2=0.752) between the Numbers of members served and the total BMW received, it is observed from **Figure 2-7** that there is higher correlation (R^2 = 0.84) between the Numbers of the beds served by each CBMWTDF and BMW received.

II. Thus, it could be concurred, that the BMW generation is more closely related to beds than compared to each facility.

2.4.6 Relationship between Numbers of Members Served and Distance Travelled (km/d)

The relationship between the no. of members served and cumulative distance travelled in a day (km/day) is shown in **Figure 2-9.** The relationship is of the form $y = 3.159x^{0.754}$, where x is the Numbers of members served and y is km travelled/day.

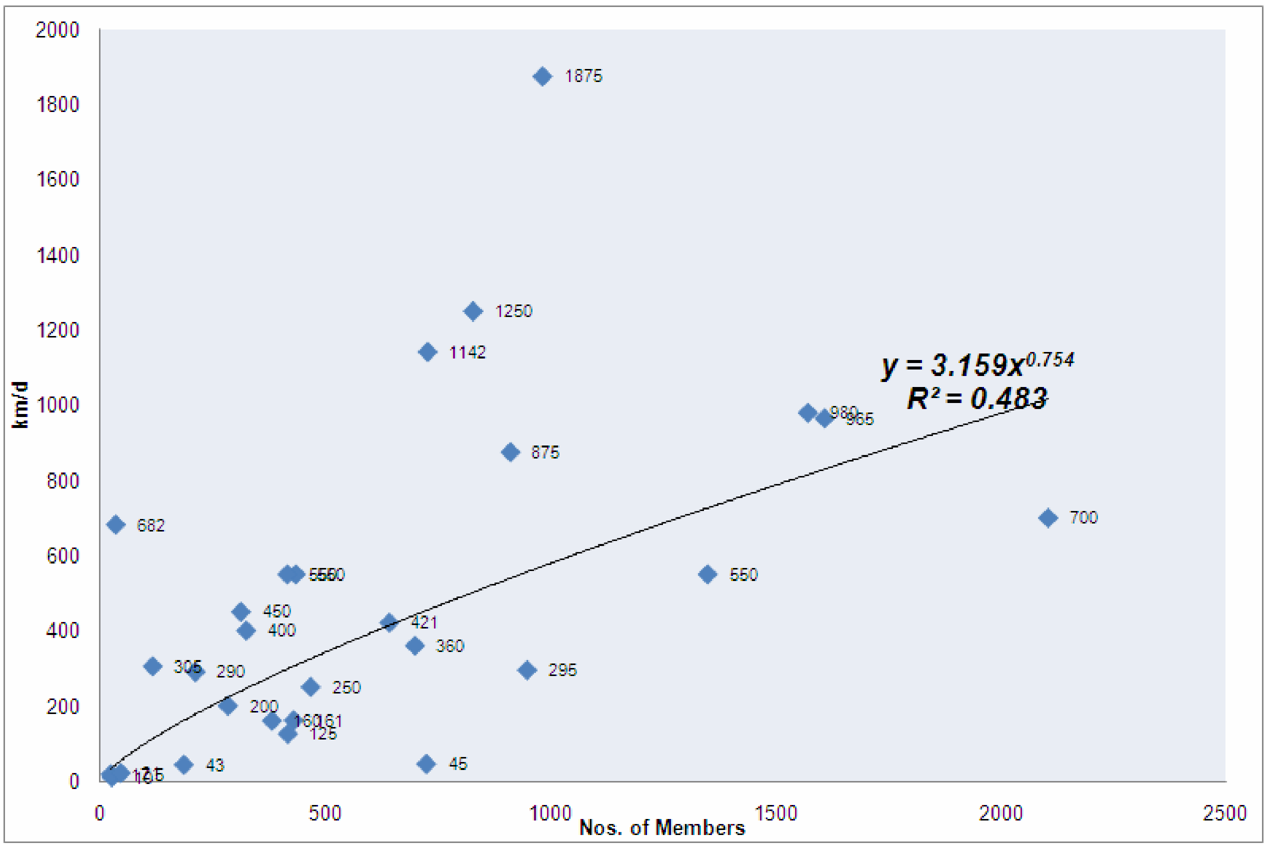


Figure 2-8 Relationship between Numbers of Members vs. km/d

2.4.7 Relationship between Numbers of beds Served and Distance travelled (Km/d)

The relationship between the no. of beds served and distance travelled (km/day) for CBMWTDFs with incinerators is shown in **Figure 2-9.** This relationship takes the form $y = 0.256x^{0.907}$, where x is number of beds and y is km travel/d.

Figure 2-9 Relationship between Number of Beds vs. km /d Travel

It may be observed from **Figure 2-8** and **Figure 2-9** that model based on the number of beds has better statistical significance (R^2 =0.515) than model based on the number of members served (R2 = 0.483). Hence equation $y = 0.256x^{0.907}$ could be used to estimate the distance travelled based on the number of beds served.

2.5. Economic Assessment

Based on the data received an economic assessment was carried out. For this purpose, economic data was collected from CBMWTDFs.

2.5.1 Capital Investment

The CBMWTDF wise capital investment and year of investment for each CBMWTDFs is given in **Table 2-2.**

Table 2-2 CBMWTDF wise Capital Investment and Year

#	Facility no.	Location	Year estd.	Capital investment
1	F1	Palghar	2004	4,026,275.00
2	F2	Kalyan	2003	17,715,610.00
3	F3	Thane	2003	5,314,683.00
4	F4	Ahmednagar	2004	11,273,570.00
5	F5	Jalgaon	2006	11,845,900.00
6	F6	Nasik	2001	26,794,860.13
7	F7	Nanded	2009	6,600,000.00
8	F8	Chandrapur	2005	1,000,000.00
9	F9	Panvel	2003	3,252,000.00
10	F10	Miraj	2003	5,000,000.00
11	F11	Solapur	2004	7,300,000.00
12	F12	Ratnagiri	2008	8,200,000.00
13	F13	Amravati	2003	9,000,000.00
14	F14	Nagpur	2005	5,670,234.00
15	F15	Ichalkaranji	2004	4,000,000.00
16	F16	Kolhapur	2001	3,000,000.00
17	F17	Kudal	2008	1,500,000.00
18	F18	Satara	2007	4,500,000.00
19	F19	Gondia	2005	3,000,000.00
20	F20	Talegaon	2004	7,500,000.00
21	F21	Akluj	2005	5,500,000.00
22	F22	Karad	2009	1,800,000.00
23	F23	Uran	2005	4,500,000.00
24	F24	Pimpri_Chinchwad	2006	8,000,000.00
25	F25	Baramati	2004	7,400,000.00
26	F26	Udgir	2006	135,000.00
27	F27	Latur	2003	3,000,000.00
28	F28	Aurangabad	2003	11,500,000.00
29	F29	Buldana	2007	8,500,000.00

2.5.2 Operation and Maintenance Costs

Data received regarding operation and maintenance costs was analysed for various associated factors.

The data reveals that, fuel cost for running incinerators is 28% and fuel cost for transportation is 15% of total monthly O&M cost. For CBMWTDF with incinerator, the fuel cost is most important component amounting to a total of 43% of the total O&M cost. Next most important component is person power cost, which covers approximately 31% of total O&M cost. Rest of the cost components covers approximately 11% of monthly O&M cost.

2.5.3 Revenues

Based on the number of members served and charging basis revenue for the CBMWTDFs was estimated and the results are given in **Table 2-3.**

Table 2-3 Revenues of CBMWTDFs

#	Facility no.	Location	Year estd.	Revenue (Rs./ annum) (2009 estimate)	Charge for bedded HCEs (Rs/bed/d)	Charge for non-bedded HCEs (Rs)
1	F1	Palghar	2004	424,710.00	3.63	300-5600/month
2	F2	Kalyan	2003	5,055,120.00	Rs. 17/kg	
3	F3	Thane	2003	6,624,000.00	4.00	1500-2000/yr.
4	F4	Ahmednagar	2004	4,140,000.00	3.52	110-660/month
5	F5	Jalgaon	2006	1,638,450.00	2.75-3	250-500/month
6	F6	Nasik	2001	14,760,000.00	4.00	250-600/month
7	F7	Nanded	2009	1,260,000.00	3.50	300-500/month
8	F8	Chandrapur	2005	39,048.00	0[#]	0
9	F9	Panvel	2003	18,250,000.00	25/kg	
10	F10	Miraj	2003	13,288,312.50	2.50 – 8.00	750-1500/yr
11	F11	Solapur	2004	2,605,200.00	Incinerable waste 14.00/kg, non-incinerable waste 2.00/kg	
12	F12	Ratnagiri	2008	1,489,950.00	3.85	n/a
13	F13	Amravati	2003	7,875,000.00	3.25	n/a
14	F14	Nagpur	2005	12,240,000.00	3.40	200-500/month
15	F15	Ichalkaranji	2004	1,017,000.00	Incinerable waste 16.00/kg, non-incinerable waste 10.00/kg	
16	F16	Kolhapur	2001	1,947,000.00	3.67	100-330/month
17	F17	Kudal	2008	526,500.00	6.50	250/month
18	F18	Satara	2007	3,701,565.00	Incinerable waste 39.17/kg	
19	F19	Gondia	2005	680,400.00	3.00	N/A[$]
20	F20	Talegaon	2004	1,270,800.00	Incinerable waste 16.00/kg, non-incinerable waste 3.00/kg	
21	F21	Akluj	2005	1,819,800.00	3.00	N/A
22	F22	Karad	2009	1,008,000.00	1-10 beds 300/d; >10 bed 350/d	200/-
23	F23	Uran	2005	2,802,600.00	Incinerable waste 85.00/kg, non-incinerable waste 195.00/kg	
24	F24	Pimpri Chinchwad	2006	7,801,920.00	34.40/kg	
25	F25	Baramati	2004	6,804,000.00	Incinerable waste 4.00/bed/d; non-incinerable waste 2.00/bed/d	
26	F26	Udgir	2006	138,600.00	3.25/bed/d	
27	F27	Latur	2003	1,454,400.00	Incinerable waste 20.00/kg	
28	F28	Aurangabad	2003	8,019,000.00	1-4 beds 378.56/month, >5 beds 3.30/bed/d	165.24 – 378.56/month
29	F29	Buldana	2007	1,856,250.00	3.75	N/A

Note : # F8 has clarified that they do not practice BMW treatment commercially

$ N/A - Not applicable

2.5.4 Economic Viability

The economical viability of the CBMWTDFs was worked out by calculating Net Present Value (NPV) and Internal Rate of Return (IRR).

Net present value (NPV) is defined as the total Present Value (PV) of a time series of cash flows. It is a standard method for using the time value of money to appraise economic viability of the projects. NPV is an indicator of how much value an investment or project adds.

$$NPV = \sum_{i=1}^{t} \frac{(cashin_i - cashout_i)}{(1+r)^t}$$

Where, NP V = net present value

Cash in = cash inflow for i^{th} years

Cash out = cash outflow for i^{th} year

r = annual discounting rate

t = Numbers of years

For economic viability of the project NPV must be positive.

The IRR of a potential investment is the annualized effective compounded return rate that can be earned on the invested capital. IRR is the discount rate that makes the NPV of all cash flows from a particular project equal to zero. Generally, the higher a project's IRR, more desirable it is to undertake the project.

The financial feasibility in terms of NPV and IRR is given in **Table 2-4**.

Table 2-4 NPV and IRR of CBMWTDFs

#	Facility_no.	Location	IRR	NPV
1	F1	Palghar	--	($11,839,028.41)
2	F2	Kalyan	15%	$3,682,436.64
3	F3	Thane	0%	($22,032,375.84)
4	F4	Ahmednagar	2%	($3,223,874.74)
5	F5	Jalgaon	--	($14,800,397.52)
6	F6	Nasik	0%	($8,861,600.03)
7	F7	Nanded	--	($12,608,253.86)
8	F8	Chandrapur	--	($7,601,177.65)
9	F9	Panvel	46%	$16,454,260.20
10	F10	Miraj	46%	$16,761,618.34
11	F11	Solapur	--	($13,806,858.37)
12	F12	Ratnagiri	--	($32,437,259.15)
13	F13	Amravati	--	($19,789,782.50)

14	F14	Nagpur	64%	$24,215,223.72
15	F15	Ichalkaranji	--	($14,995,149.65)
16	F16	Kolhapur	--	($10,285,115.51)
17	F17	Kudal	--	($9,090,791.52)
18	F18	Satara	--	($35,074,998.83)
19	F19	Gondia	-3%	($2,034,147.28)
20	F20	Talegaon	--	($40,943,717.73)
21	F21	Akluj	--	($29,493,747.45)
22	F22	Karad	--	($4,977,365.61)
23	F23	Uran	9%	($482,814.25)
24	F24	Pimpri_Chinchwad	-7%	($13,944,500.30)
25	F25	Baramati	1%	($13,284,892.42)
26	F26	Udgir	--	($1,742,427.10)
27	F27	Latur	--	($28,112,946.72)
28	F28	Aurangabad	--	($213,853,187.14)
29	F29	Buldana	-3%	($4,717,800.13)

Note: "--" denotes cases where the IRR is less than -10%.

NPV values within parenthesis represent negative NPV values.

It may be observed that out of 29 CBMWTDFs analyzed only 4 show case of IRR greater than 10%. For some CBMWTDFs (viz., F9, F10 and F14) IRR exceeds 40%, indicating high profitability. It is important therefore to understand the key factors that influence the economic viability of CBMWTDFs. **Figure 2-10** shows a relationship between IRR, capital cost and operation and maintenance cost (converted to present value).

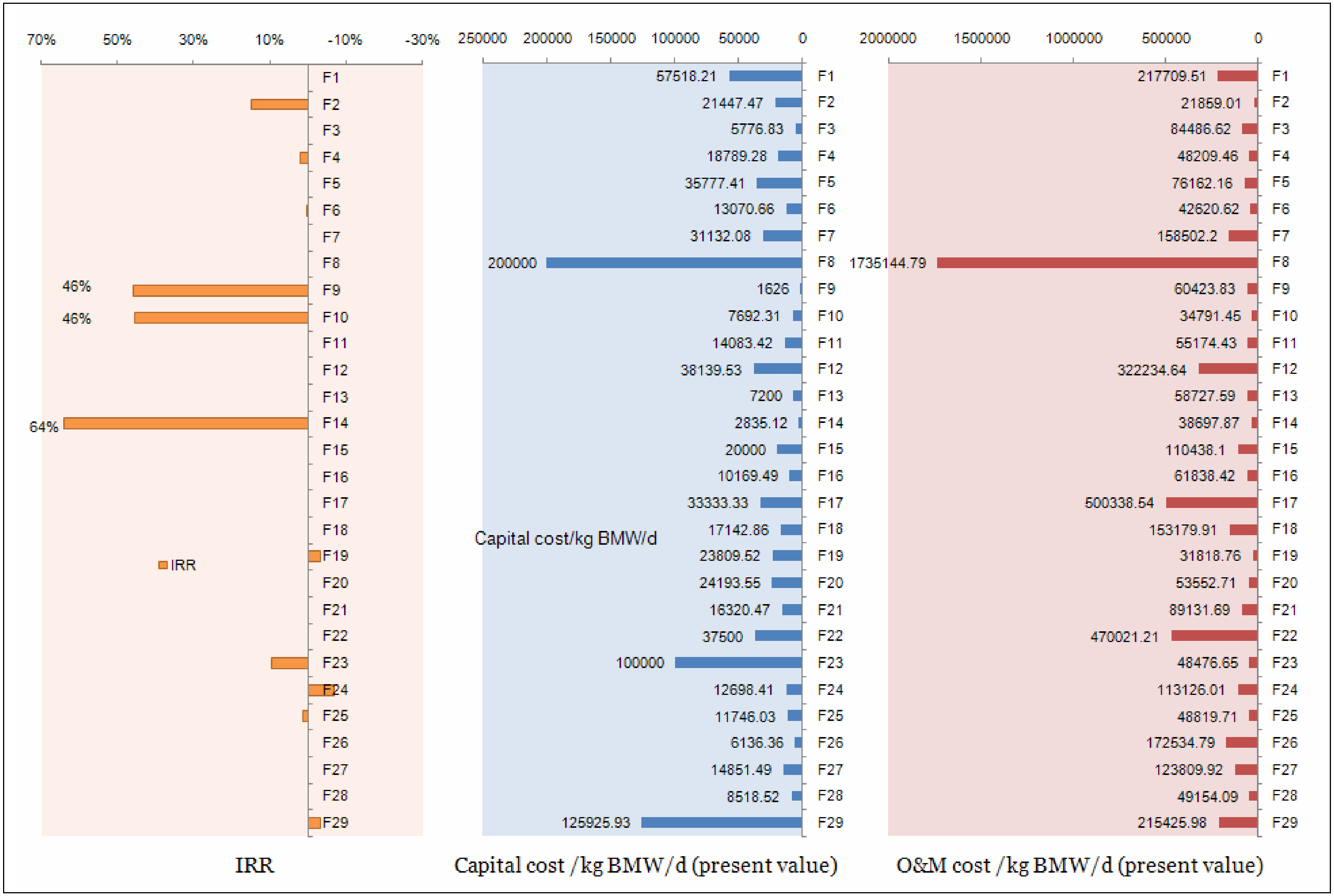


Figure 2-10 CBMWTDF wise IRR, present values of capital cost and operation and maintenance cost per kg BMW/d

From **Figure 2-10** it could be observed that,

- The CBMWTDFs having positive IRR (8 out of 29 cases) have low creesponding capital cost /kg BMW received/day.

- The higest normalized capital cost/kg BMW/d having a corresponding positive IRR is approx. Rs. 14851.

- Operation and Maintenance cost generally govern the economic vioability of CBMWTDFs.

- It was analyzed from the figure, that the ration between the capital cost and the normialized & accumulated (for the 10 yearly design period) O&M cost is approx. 30:70. This ratio has been used later in formulation of extension of rational charging policy.

2.5.5 Key Economic Factors

Key consideration for economic viability include:

- Optimum utilization of investment made (e.g. capacity and hours of operation of incinerators)

- Low Operation and Maintenance cost (e.g. not entails excessive transport cost)

- Rational charging policy (that ensures adequate revenues)

3. Model for Arriving At Policy for Charging

3.1 Need for Development of a Model

The data received through questionnaire survey helped to assess viability of 29 CBMWTDF with capacity from 130 to 8136 beds. In order to develop a suitable charging policy applicable to a wide range of situations such as, say, 500 to 15,000 beds, simulations were required to be performed around a 'Base Model'. This approach allows:

a. more comprehensive assessment of real world scenarios
b. less dependent on limited field data, that can have inconsistencies
c. allow sensitivity analysis and development of guidance material for application

3.2 Development of 'Base Model' and Simulation

For the purpose of realistic simulation, a Base Model was developed. This model was set to represent real life data obtained from 29 Numbers of CBMWTDF operators and transporters. In the Base Model, numbers of beds and proposed charge/bed/d were considered as key parameters. Capital cost was calculated based on (a) the amount of bio-medical waste generated from a given numbers of beds, (b) physical infrastructure (i.e. equipment required to treat that waste, and (c) cost data obtained from equipment manufacturers. Operation & Maintenance (O&M) cost was calculated based real life data on fuel, electricity and person power. For economic viability NPV and IRR were calculated. A cut off range of 10-20% IRR was the envisaged as most desirable. The Base Model was coded in MS Excel™ platform.

The assumptions made in the 'Base Model' are as given below:

3.2.1 Capital Cost of Equipment

Capital cost of equipment was obtained from various manufacturers. The capital cost for various capacities of incinerators, autoclaves and shredders are as given in **Table 3-1, 3-2** and **3-3** respectively.

Table 3-1 Incinerator Capacities and Capital Cost

Incinerator (kg/hr.)	Rate (Rs.)
20	1,800,000.00
25	1,920,000.00
30	2,400,000.00
50	3,125,000.00

75	3,562,500.00
100	4,000,000.00
200	6,000,000.00
300	7,800,000.00
400	8,970,000.00

Table 3-2 Autoclave Capacities and Capital Cost

Autoclave (L/d)	Rate (Rs.)
50	132,000.00
100	198,000.00
200	275,000.00
300	330,000.00
400	396,000.00
500	540,000.00
600	648,000.00
750	777,600.00
1000	933,120.00
1250	1,119,744.00
1400	1,343,693.00
1500	1,612,432.00
2000	1,854,296.80
2500	2,132,441.32

Table 3-3 Shredder capacities and Capital Cost

Shredder (kg/d)	Rate (Rs.)
50	132,000.00
100	220,000.00
200	275,000.00
300	385,000.00
400	418,000.00
500	467,500.00
600	504,000.00
750	604,800.00
1000	725,760.00
1250	870,912.00
1500	1,045,094.40
2000	1,201,858.56
2500	1,442,230.27

3.2.2 Accounting for Escalation in O&M cost

Fuel cost and labour (manpower cost) cumulatively cover more than 74% of the O&M cost. Hence price rise in fuel or labour significantly affect a CBMWTDF's viability. The fluctuations of diesel price in Mumbai were obtained from oil PSUs from year 2002 to 2009. It was assumed that diesel price remains fairly constant all over Maharashtra at any given time. The yearly % change in diesel price is given in **Figure 3-1**.It was found out the average yearly diesel price rise is approx. 7.72% over previous year's price.

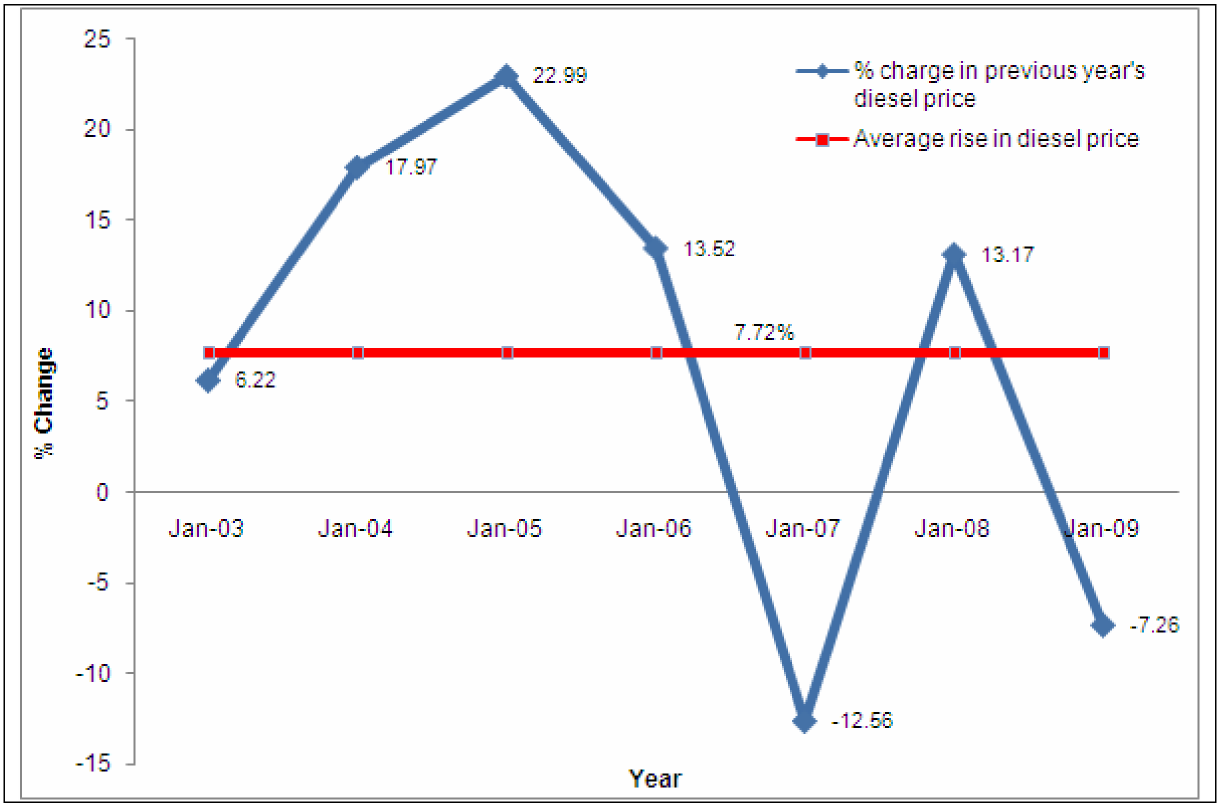


Figure 3-1 % Increase in Diesel price (in Mumbai) over last year's price

Change in labour price indices, was determined from the data obtained from the Ministry of Labour, Govt. of India. Commodity Price Index (CPI) for industrial workers (IW) was used as a benchmark for addressing the change in labour rate. CPI data for 10 years (1995 -2005) in locations like Mumbai, Pune, Nasik, Nagpur and Solapur was used. It was found out that all over Maharashtra, labour rate has grown by approx. 6% of the previous year. **Figure 3-2** shows the % change in Consumer Price Index, in Mumbai between year 1995 and 2005.

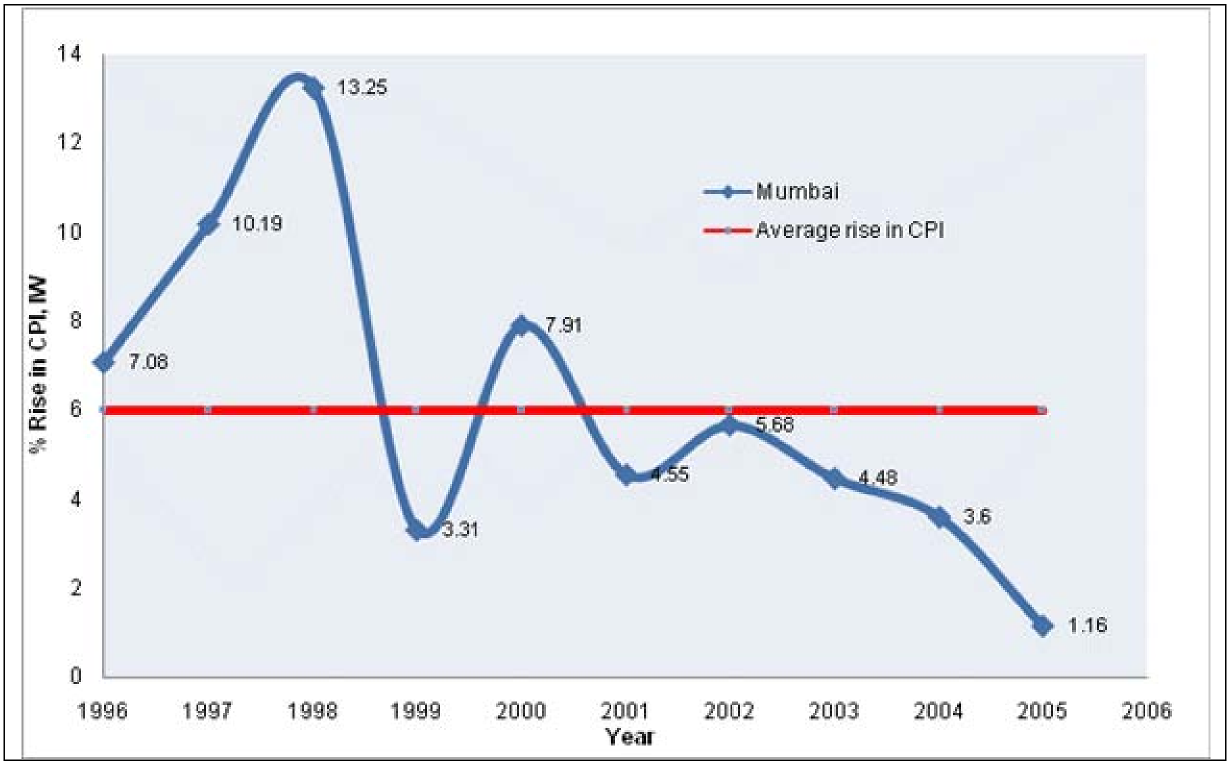


Figure 3-2 % increase in CPI (in Mumbai) over last year's price

Apart from these, chemical (mostly bleaching powder, commercially available phenyl & floor cleaners and hypo chloride solution) cost was assumed to increase @ 2% over previous year's price. Electricity cost was also assumed to increase @ 5% per unit over previous year's price.

For calculating the overall price rise in the O&M cost, weighted average increase was calculated. It was found from the analysis of Operation & Maintenance cost data submitted by CBMWTDFs, that approx. 75% of the O&M cost is allocated for person power and fuel cost.

The relative weightage factor used for individual components of the O&M cost are as given in **Figure 3-3** and has been used in **Table 3-4**. It could be seen from the Figure that person power cost is approx. 31.19% of the total O&M cost/month; and the percentage rise in person power is approx. 6% per annum. Similarly, the fuel price constitutes approx. 42.22% (= 28%+15%) of the total O&M cost/month and it registers approx. 7.72% rise/annum. So, these rises/annum are normalized by multiplying with relative weightage, viz. weighted rise in person power is approx. 1.87% (= 31.19% x 6%/100%) and for fuel is 3.26% (= 42.22% x 7.72% /100%). Similarly relative rise in cost of chemicals, maintenance cost and other miscellaneous cost was worked out.

Addition of these normalized prices we get approx. +6.37% rise over last year's O&M cost. Thus, by rounding up, an approximate rise of 6.5% /annum in O&M cost has been used in the model.

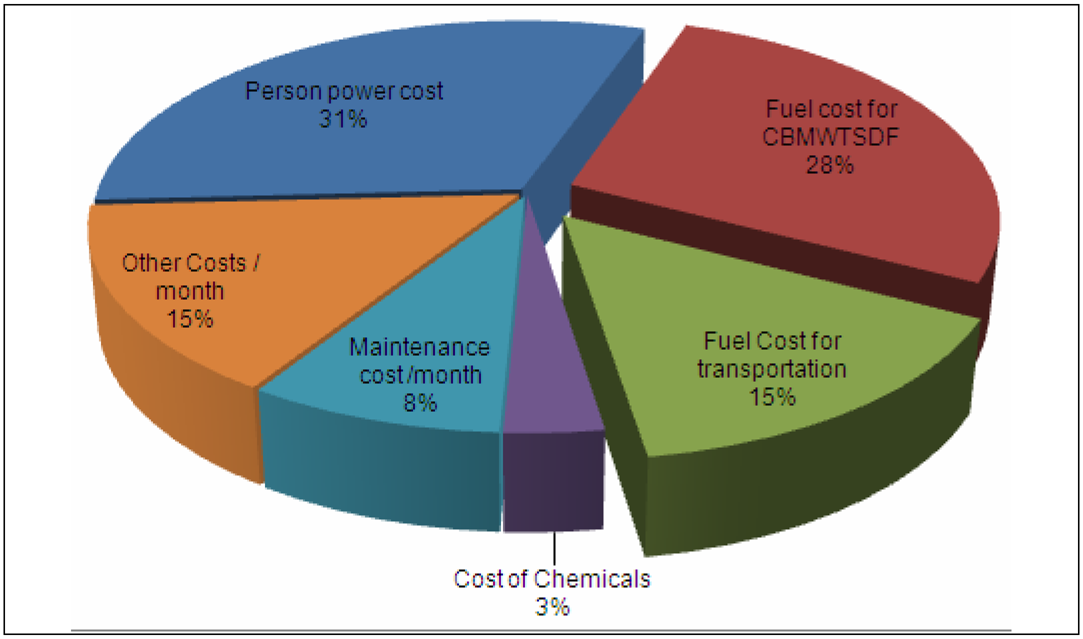


Figure 3-3 Break-up of Monthly O&M Cost for CBMWTDFs with Incinerators

Table 3-4 Component of Percent increase in O&M cost

	Person power cost	**Fuel cost**	**Cost of Chemicals**	**Mainte-nance cost /month**	**Other Costs / month**
Weightage factor#	31.19	42.22	3.19	8.26	15.14
Component wise estimated rise	6.00	7.72	2.00	5.00	5.00
Normalized % rise	1.87	3.26	0.064	0.41	0.76
Overall weightage	6.37 (or say, 6.5)				

Note: # Derived from analysis of data collected from CBMWTDFs. Could be related to Figure No. 3-3.

3.2.3 Distance Travelled as a Function of Number of Beds

In the base model, the distance travelled has been considered as a function of the number of beds. In both CBMWTDFs with incinerators and deep burial facility, analysis of relationship between the km travelled/d and number of beds was conducted, and the results are described in the following sections.

3.2.3.1. Distance travelled in CBMWTDFS with Incineration

Relationship between the distances travelled/d by a CBMWTDF with Incinerator is provided by the equation $y = 0.281x^{0.885}$. This equation is derived from the following scatter plot. The equation has a coefficient of determination (R^2) of 0.515. This model has been used in the base model (and subsequent models) to derive the travel required to be undertaken by CBMWTDFs for a given numbers of beds.

3.2.3.2 Distance travelled in CBMWTDFS with Deep Burial Facility

In CBMWTDFs with deep burial facilities the km travel/d is also derived from the number of beds it serves. However, in this case, it was found that a single model could not describe the statistic well. So, in this case, two models have been used.

From 0 to 391 beds a linear model of the form $y = 0.362x + 6.230$ was used, whereas from 392 and beyond a logarithmic model of the form $y = 310.9\ln(x) - 1708$ was used. While the linear model has a coefficient of determination (R^2) of 0.567, that of the logarithmic model was approximately 0.756. Graphical representation of the two models and the changeover at 391 beds is show in **Figure 3-4**.

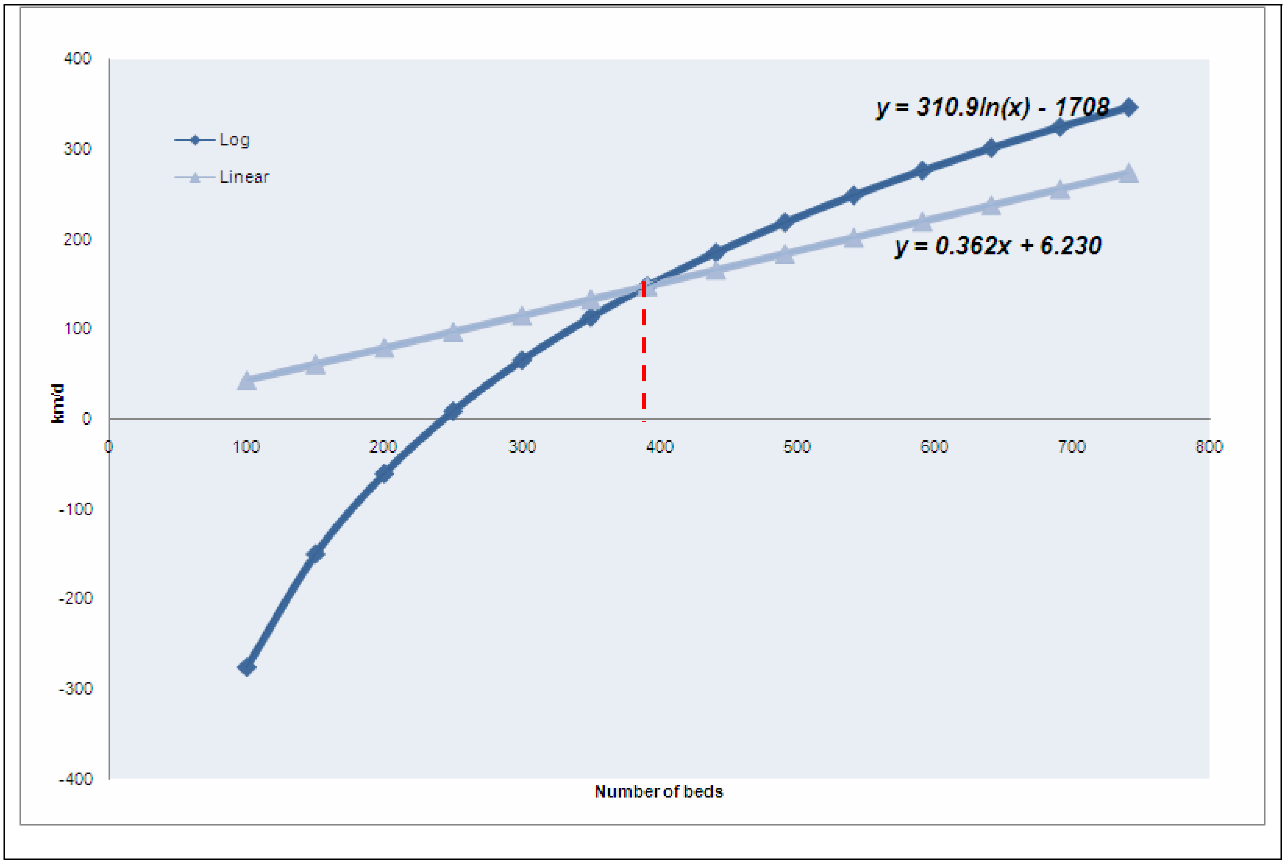
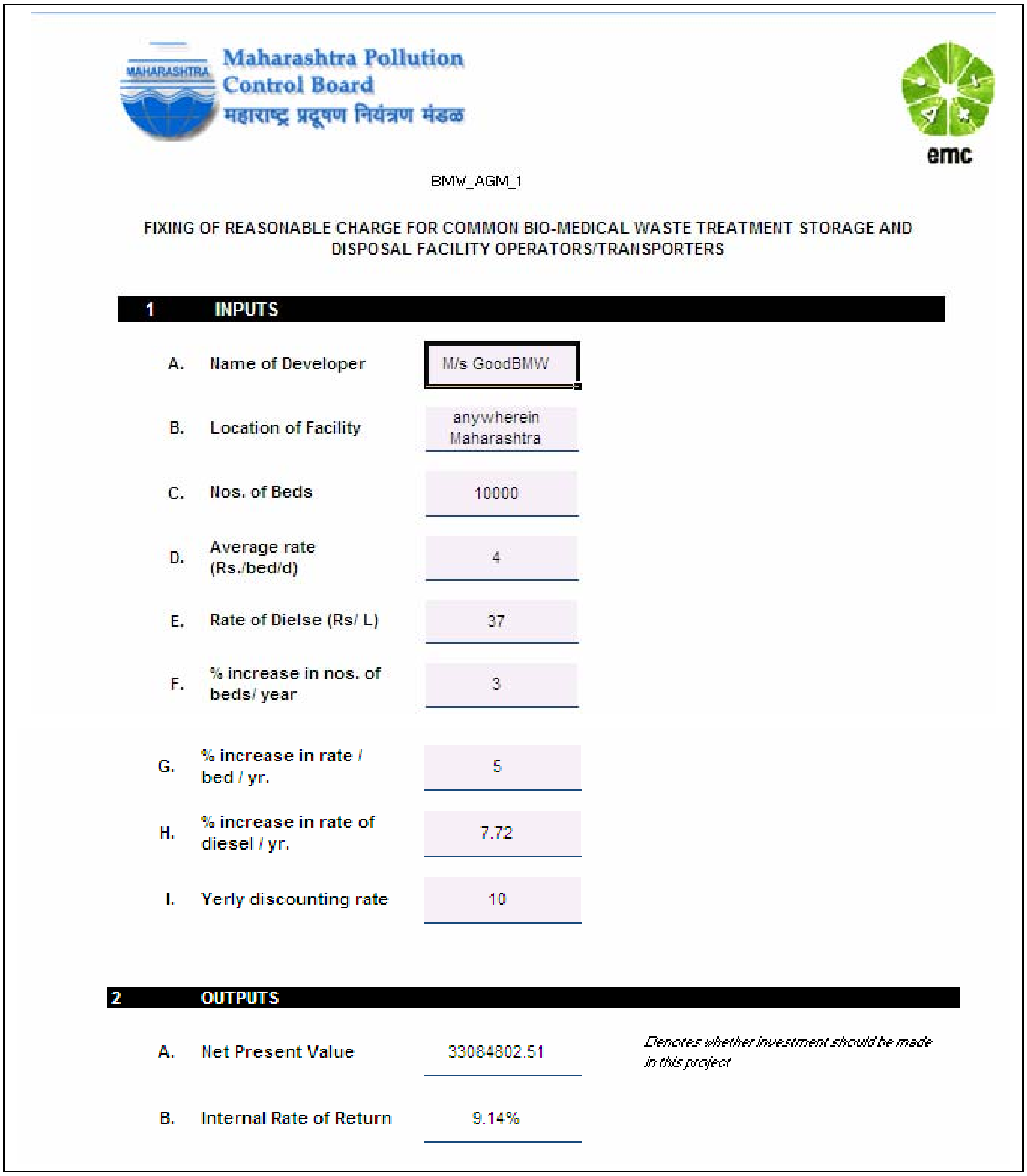


Figure 3-4 Use of Linear and Logarithmic Models to describe Relationship between km Travel/d and Number of Beds in CBMWTDFs with Deep Burials

3.2.4 Input to 'Base Model'

The input data to the Excel based base model as well as outputs or results are shown in **Figure 3-5**. The results of the simulation are presented in **Figure 3-6**.

Based on **Figure 3-6**, **Figure 3-7** was developed limiting to data points only in the "Feasible IRR" region. For each number of bed, feasible charging policy were identified using the shaded region and by doing interpolation. Simulation were performed around the Base Model by varying number of beds to 500 to 15,000 (at increment of 250) and charge/bed/d were varied from Rs. 2 to 15 (at increment of 0.5 Rs.). For each combination NPV & IRR were computed. A total of 1593 simulations were assessed out of which, 63 combinations (approx. 4%) were found to be between IRRs of 10% to 20%. **Figure 3-5** shows the results.



Maharashtra Pollution Control Board
महाराष्ट्र प्रदूषण नियंत्रण मंडळ

emc

BMW_AGM_1

FIXING OF REASONABLE CHARGE FOR COMMON BIO-MEDICAL WASTE TREATMENT STORAGE AND DISPOSAL FACILITY OPERATORS/TRANSPORTERS

1	INPUTS	
A.	Name of Developer	M/s GoodBMW
B.	Location of Facility	anywherein Maharashtra
C.	Nos. of Beds	10000
D.	Average rate (Rs./bed/d)	4
E.	Rate of Dielse (Rs/ L)	37
F.	% increase in nos. of beds/ year	3
G.	% increase in rate / bed / yr.	5
H.	% increase in rate of diesel / yr.	7.72
I.	Yerly discounting rate	10

2	OUTPUTS		
A.	Net Present Value	33084802.51	*Denotes whether investment should be made in this project*
B.	Internal Rate of Return	9.14%	

Figure 3-5 Input Panel of Base Model

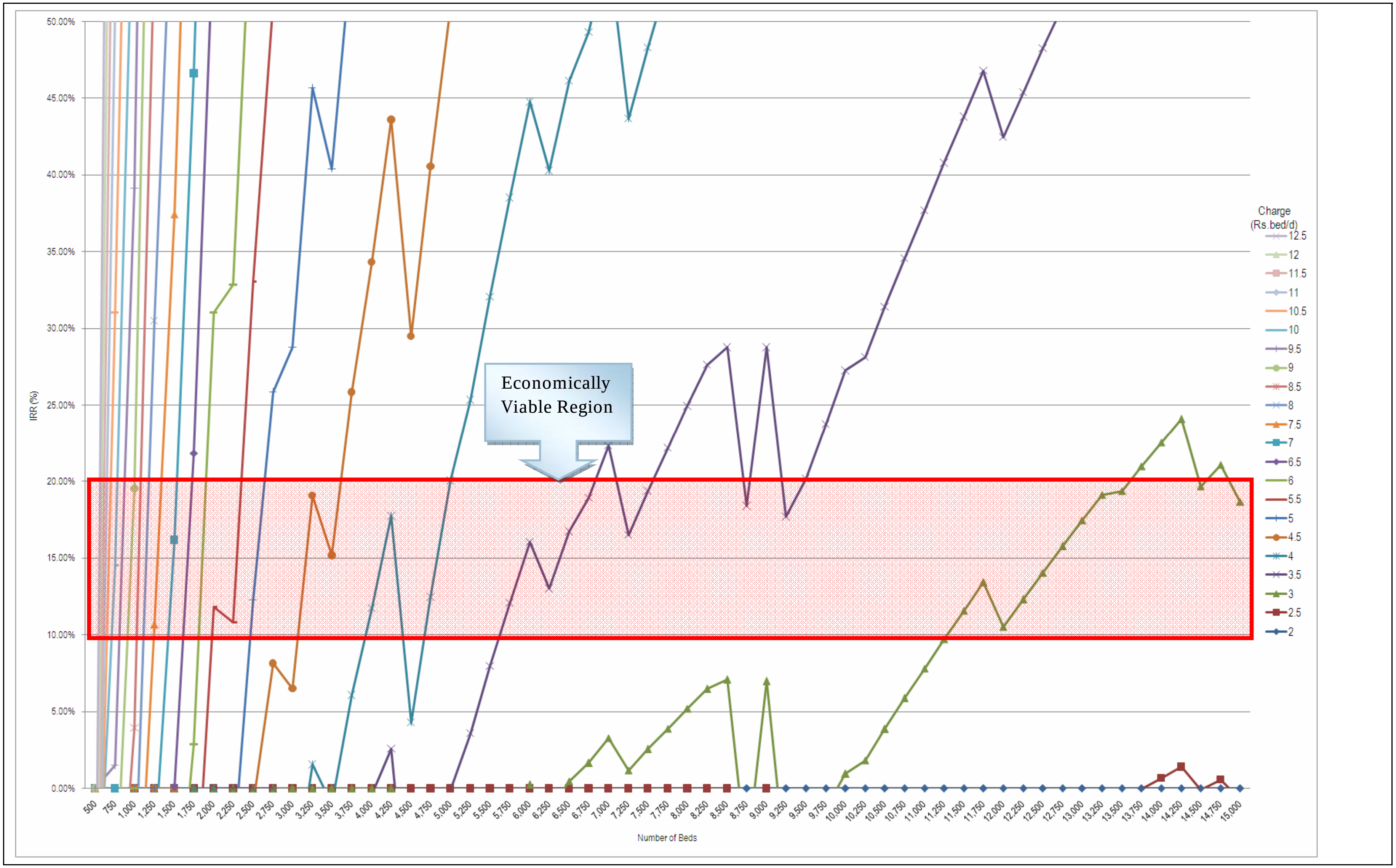


Figure 3-6 Relationship between Number of Beds & IRR for various Charging Policies for CBMWTDFs with Incinerators

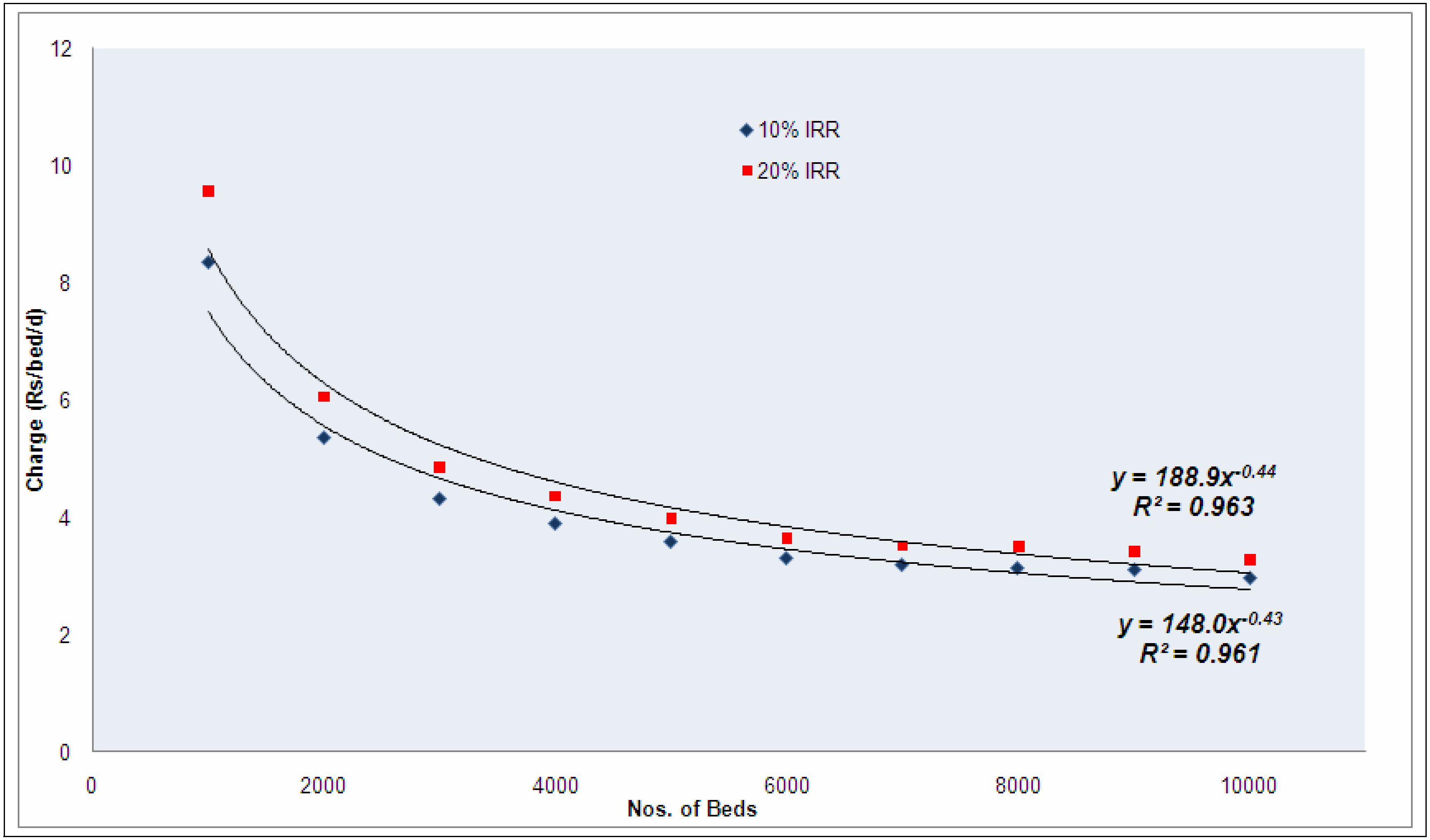


Figure 3-7 Charging Policy for CBMWTDFs with incinerators

Based on these above equations the range of charging policy can be worked out depending on the number of beds they serve. For a CBMWTDF with incinerators and with 5,000 beds, the charge /bed/day will need to be between approx. Rs. 3.79 and Rs. 4.45, for 10% and 20% IRR respectively. For 10,000 beds the charge/bed/day will be Rs. 2.82 and 3.28 respectively for 10% and 20% IRR respectively.

For the case of a CBMWTDF with deep burial facility, the range of simulation results are represented in **Figure 3-8**. In this case the desirable range of IRR has been selected as 10% to 15%. A simpler form is provided as **Figure 3-9**.

For a CBMWTDF with deep burial and with 1,000 beds, in order to obtain 15% and 10% IRR, the charge /bed/day will be approx. Rs. 80.15 and Rs. 33.18 respectively. The same for 5,000 beds will be approx. Rs. 22.47 and Rs. 9.15 respectively. The charges arrives through the model are high because of long transportation distance involved although the capital cost of investment are relatively low compared to incinerators. This observation underscores the fact that charges for waste treatment are significantly influenced by cost of transportation. It is not surprising therefore that out of the five deep burial facilities in Maharashtra, three facilities are either getting closed or shifting to incineration technology, with the hope that there will be possible increase in the number of beds that could be served.

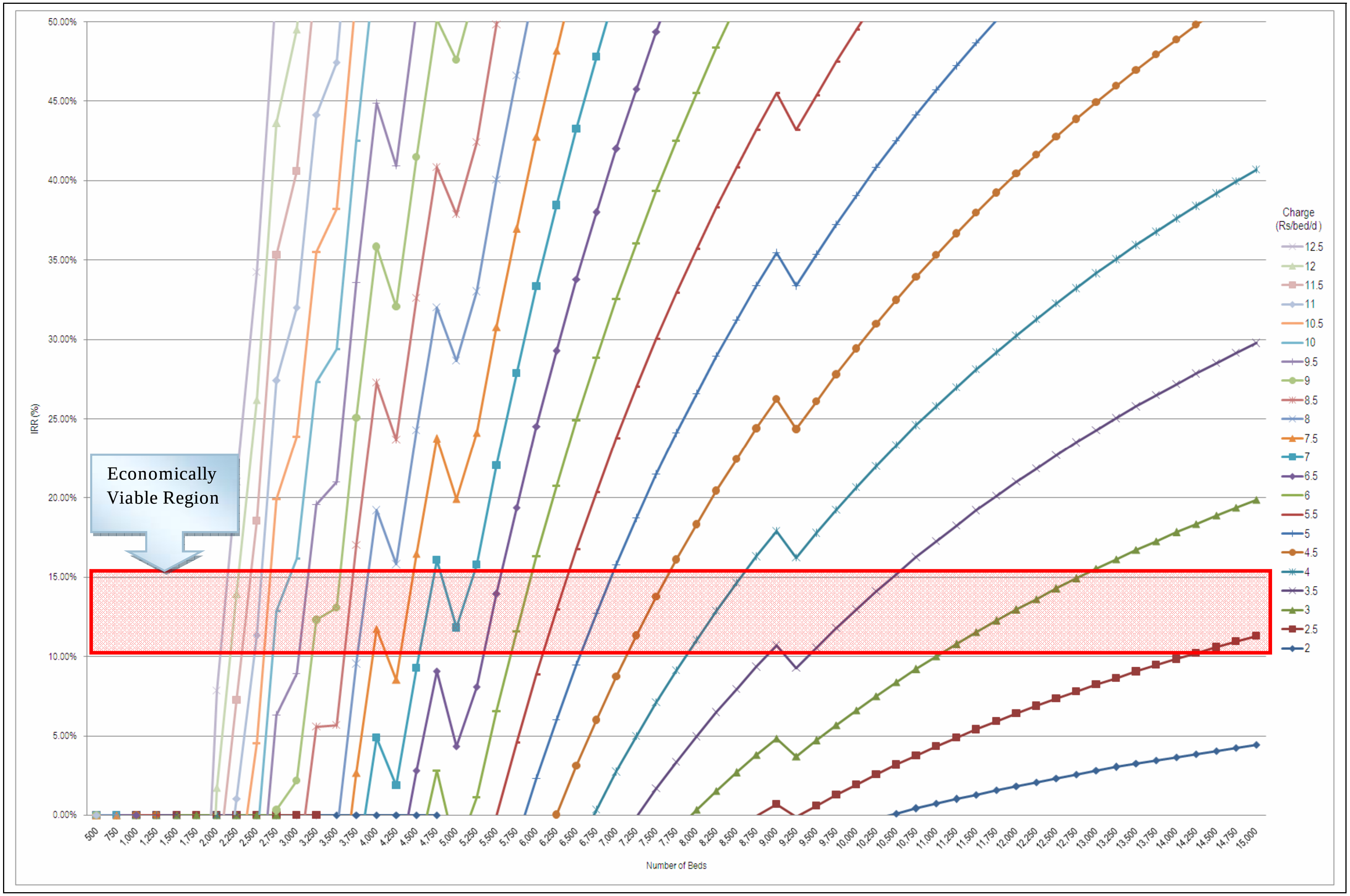


Figure 3-8 Relationship between IRRs and Numbers of Beds for Various Charges for CBMWTDFs with Deep Burials

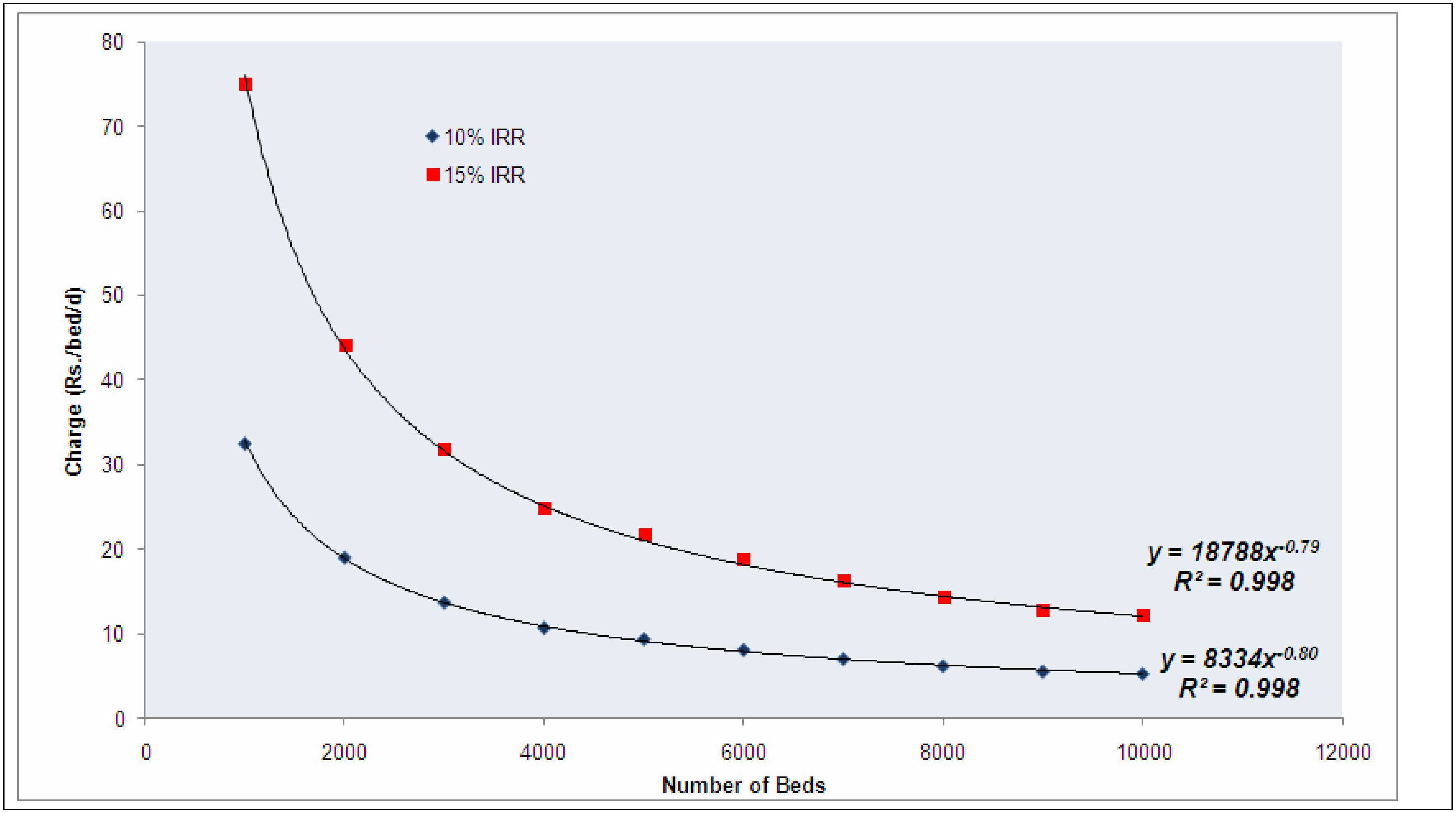


Figure 3-9 Charging Policy for CBMWTDFs with Deep Burial

Table 3-5 presents a comparison between existing charges and recommended charging policy. By using the above rational policies and applying them on the existing CBMWTDFs, the following rationalized charged could be arrived.

Table 3-5 Existing & Model Charges of CBMWTDFs

Sl. No.	Facility no.	Location	Beds served/day	Existing Charge for bedded HCEs (Rs/bed/d)	Model Charge suitable for 10% IRR	Model Charge suitable for 20% /15% IRR#	Remarks
1	F1	Palghar	1035	3.63	32.28	78	Non-feasible
2	F2	Kalyan	6430	3.40	3.53	4.07	Rs. 17/kg, converted into bed basis
3	F3	Thane	6612	4.00	3.49	4.02	
4	F4	Ahmednagar	5910	3.52	3.66	4.22	
5	F5	Jalgaon	4063	2.75 – 3.00	4.29	4.96	
6	F6	Nasik	8109	4.00	3.21	3.69	
7	F7	Nanded	1520	3.50	6.48	7.57	
8	F8	Chandrapur	130	Nil	18.19	21.8	Does not charge for treatment of waste
9	F9	Panvel	8176	5.00	3.19	3.67	25.00/kg, converted into bed basis
10	F10	Miraj	3250	2.50 – 8.00	4.71	5.46	
11	F11	Solapur	4783	~2.00	4.00	4.63	Incinerable waste 14.00/kg, non-incinerable waste 2.00/kg, converted into bed basis
12	F12	Ratnagiri	2161	3.85	5.59	6.51	
13	F13	Amravati	6566	3.25	3.50	4.04	
14	F14	Nagpur	8159	3.40	3.20	3.68	
15	F15	Ichalkaranji	1642	~2.60	6.27	7.33	Incinerable waste 16.00/kg, non-incinerable waste 10.00/kg
16	F16	Kolhapur	4489	3.67	4.11	4.75	

17	F17	Kudal	906	6.50	35.9	86.65	
18	F18	Satara	1714	7.83	6.16	7.19	Incinerable waste 39.17/kg
19	F19	Gondia	837	3.00	8.32	9.79	
20	F20	Talegaon	1645	~1.90	6.26	7.32	Incinerable waste 16.00/kg, non-incinerable waste 3.00/kg
21	F21	Akluj	876	3.00	8.16	9.60	
22	F22	Karad	1183	~1.00	7.19	8.44	1-10 beds 300/d; >10 bed 350/d
23	F23	Uran	275	28.00	93.19	222.23	Incinerable waste 85.00/kg, non-incinerable waste 195.00/kg
24	F24	Pimpri Chinchwad	6778	6.88	3.46	3.98	34.40/kg converted to charge/bed/d
25	F25	Baramati	1731	6.00	21.39	51.95	Incinerable waste 4.00/bed/d; non-incinerable waste 2.00/bed/d
26	F26	Udgir	300	3.25	86.92	207.46	
27	F27	Latur	1680	4	6.20	7.25	Incinerable waste 20.00/kg
28	F28	Aurangabad	3769	3.15 - 3.30	4.42	5.13	1-4 beds 378.56/month, >5 beds 3.30/bed/d
29	F29	Buldana	1004	3.75	7.71	9.05	

Note : #Upper limit of IRR has been limited to 15% for CBMWTDFs with deep burials, and 20% for CBMWTDFs with incinerators.

$N/A – not available

The above data is presented in **Figure 3-10** in graphical format.

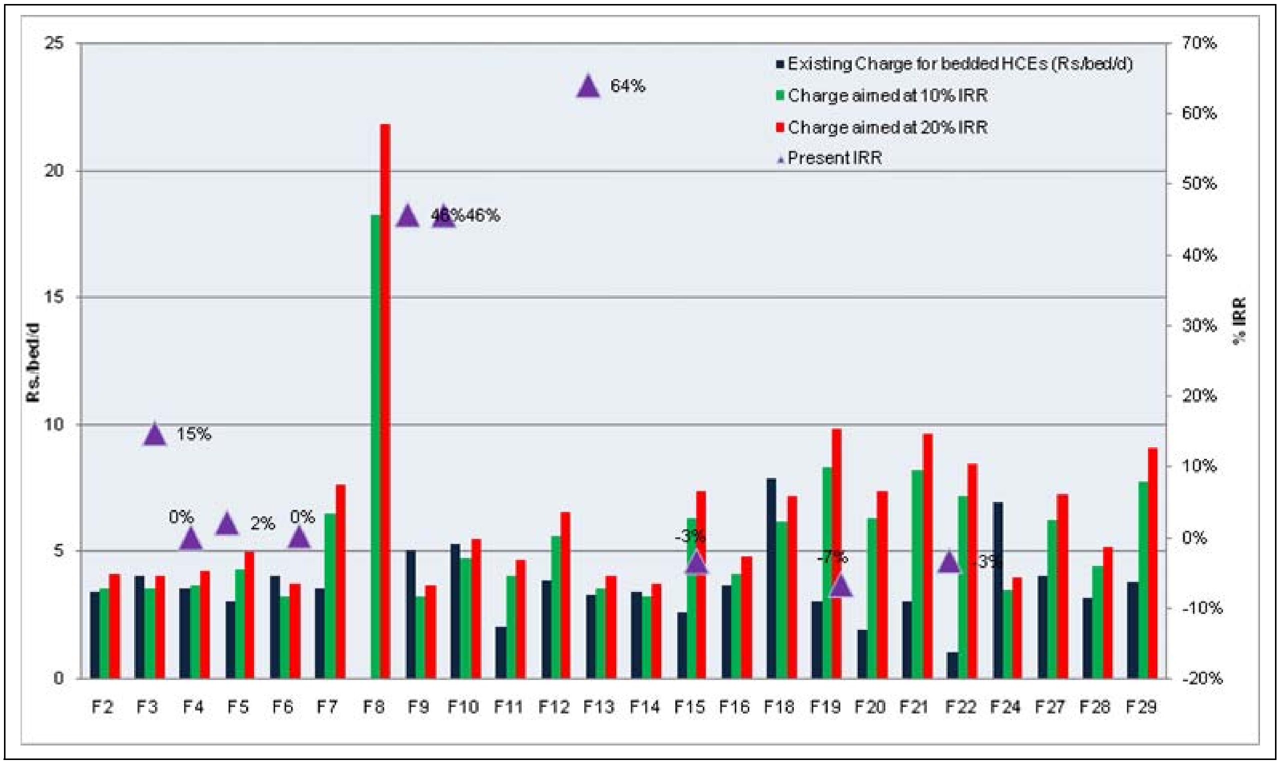


Figure 3-10 Existing charges, present IRR and charges aimed at securing 10% & 20% IRR for CBMWTDFs with incinerator

Figure 3-10 shows, the comparison between existing and proposed charges and financial viability of facilities in a graphical form.

3.3 Charging Basis for Non-bedded HCEs

Data for 28 Numbers of clinics/ dispensaries and 7 pathological laboratories were obtained from Regional Office, Mumbai. Average BMW generation in non-bedded HCEs ranges from 0.4 kg/month to 20 kg/month, with an average of 6 kg/month.

The waste generated from non bedded HCE was be converted to equivalent Numbers of beds by diving with BMW generated /month/d and 30. Thus, a clinic generating 6 kg/month is equivalent to;

6 kg BMW/clinic/month/[(0.2 kg BMW generated/bed/d)*(30 days /month)] = 1 bed

The clinics could be charged based on their bed the equivalents on monthly basis using the charging policy developed for bedded HCEs.

For example, if a clinic generating 6 kg BMW/month is served by a CBMWTDF having a total of 5000 beds, then the charge to the clinic will be approx. Rs. 3.92/day (~117.60 per month) for achieving 10% IRR and will be Rs. 4.53/day (~ 135.90/month) for achieving 20% IRR. The rates fall quite in line with the charging policy that are presently in vogue.

3.4 Extension of the Bed Based Charging Policy to Reflect on Travel Distance

The charging policy developed this far is linked to total number of beds (or bed equivalent) by the CBMWTDFs. This policy is not dependant on the distance between the CBMWTDF and the HCE. In other words a HCE that is say, at a distance of 2 km from CBMWTDF will pay same charge as the one to be paid by the HCE which is at a distance of 10 km.

If the CBMWTDF is inclined to develop a charging scheme that recognizes the distance between the CBMWTDF and the HCE, then i is necessary to extend and adopt the bed based charging policy. This extension & adaptation is explained through an example below.

3.5 Example of Rational Charging Policy

Based on the figure, if a CBMWTDF levies a charge of Rs. 4.00/bed/day on the basis of 5000 beds it serves, could achieve an IRR of 20.14% over the 10 year horizon period. This could be obtained from the rational charging policy.

Now assume that the beds served by the CBMWTDF are distributed within 150 km, 100 km and 50 km radius belts. A graphical representation of this is given in **Figure 3-11**.

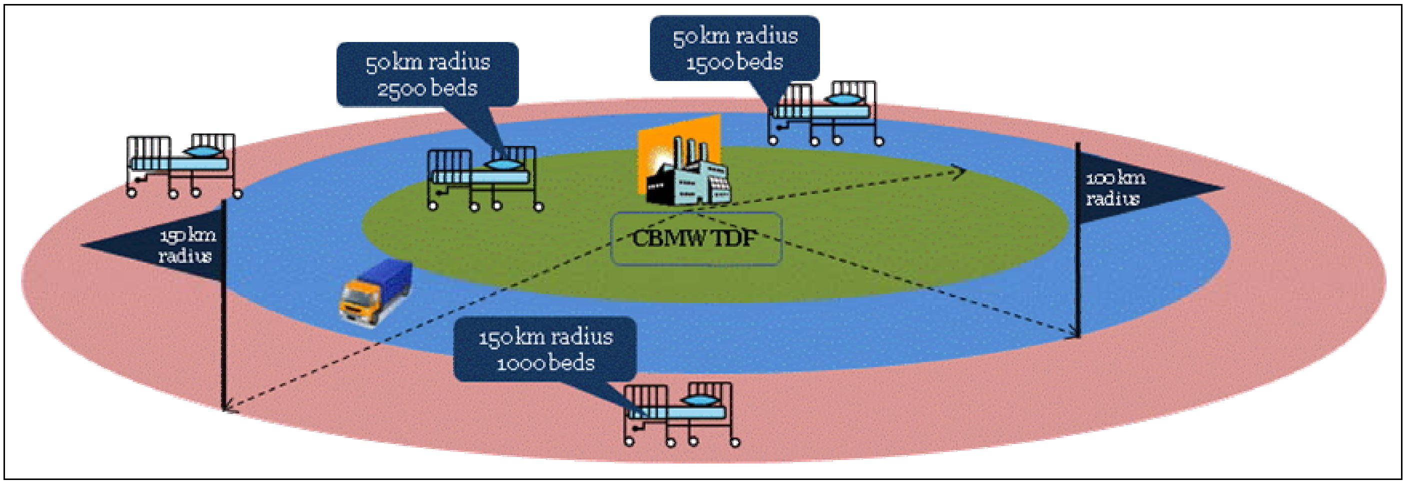


Figure 3-11 Distribution of beds in 75, 50 and 25 km radii with CBMWTDF in centre

Beds located in the 100 to 150 km radius belt will naturally entail more transport cost than those in 0 to 50 km radius belt. In view of this, we may customize the rational charging policy to accommodate for differing travel cost depending on zones. A fixed charge may be levied on all beds, along with a variable charge (based on the location of the bed and zone).

The division of charge could be undertaken in many ways. Analysis of the capital cost and the discounted accumulated operation & maintenance cost for the 29 CBMWTDF revealed that the proportion was roughly 30:70. Using this logic, the fixed cost/bed/d (which contributes to the capital cost) may be apportioned as approximately 30% and the rest may be covered by transport cost (which contributes to the variable operation & maintenance cost).

Now using the above example we could consider that approx. 30% of the charge (of 4 Rs./bed/d) is fixed (or Rs. 1.20/bed/d) and the other 70% (or Rs. 2.80/bed/d) is distributed in many ways, as depicted below:

Table 3-6 Various Options in Fixed and Variable Charging

Option	Fixed cost (Rs./bed/d)	Variable cost (Rs./bed/d)			Resultant IRR	Remarks
		50 km	100 km	150 km		
Option 1		2500 beds	1500 beds	1000 beds		Uniform charging across zones
	4	0.00	0.00	0.00	20.14%	
Option 2		2500 beds	1500 beds	1000 beds		Variable charging with radially decreased beds
	1.2	2.15	2.75	3.00	19.99%	
Option 3		1000 beds	2500 beds	1500 beds		Variable charging with radially incremental beds
	1.2	2.10	2.40	2.95	20.10%	
Option 4		1667 beds	1667 beds	1667 beds		Variable charging with radially uniform beds
	1.2	2.10	2.45	2.95	20.00%	

It could be seen from the Table 3-6, that the resultant IRR in each case is comparable. It is apparent from the above results, that there cannot be a rigid model for charging. The charges should be levied upon beds based on the travel distance, should vary according to the distribution of beds in different zones, varying from case to case.

3.6 Allocation of Grant / Subsidy to achieve Financial Viability of CBMWTDF based on Merit

Let us take up the case of another CBMWTDF, which serves approx. 3000 beds, and charges 4 Rs./bed/d. The facility could earn an IRR of approx. 3.34% after the design horizon period.

Under these circumstances, the facility may be given an *ex gratia* grant (as a percentage of capital cost) to increase its IRR up to 10% (i.e. to make it viable). With 3000 beds the facility will have a capital cost of approximately Rs. 68,65,950/-. If a grant of 27% of capital cost (or, Rs. 18,53,806/-) is conferred to the CBMWTDF the IRR rises to 9.99% and the facility may becomes viable.

Without the grant, any CBMWTDF, in order to become financially viable, may resort to two different recourses. In one hand, they may opt to charge higher to the HCEs. However, most of the CBMWTDF operators are appointed by the local municipal corporation/council, and have vowed for a bare minimum per bed per day cost. Even, this cost is very nominally revised per annum. Further, charging more may result into attrition of members and/or violation of BMW Rules from HCE's ends. On the other hand, in order to reduce its O&M costs, a CBMWTDF may resort to malpractices and gross violation of BMW Rules.

Thus, if a facility becomes unviable (on account of its capital intensiveness or because lower Numbers of beds it serves) the regulators are left with only two choices (a) to summarily disapprove the project or (b) to provide an ex gratia grant to make it viable. The distinction could be dependent on the % IRR achieved by the facility.

4.0 Conclusions and Recommendations

Data collected from CBMWTDFs in Maharashtra are analysed to identify the key variables, like no. of members served, nos. of beds served, distance travelled/day, charges/ bed/day, etc that influence the viability of facilities.

Economic analyses of each of the facilities are undertaken in terms of NPV and IRR. It was found that 8 nos. of facilities are un-viable out of 29 nos. It is found that cost of transportation contributes to 70% of total cost and O&M contributes to 30%. The HCEs are scattered in rural areas and that is the reasons of un-viability of facilities with deep burial system located in rural areas.

A 'Base Model' was developed based on the actual data received from the CBMWTDFs. Base Model is programmed to carryout viability assessment in terms of NPV and IRR, using Microsoft® Excel™. Many user defined parameters, including the growth and escalation parameters are used as input to the model, which are derived from actual experience of facility operators and market conditions. Economic viability assessment for both incineration facilities and deep burial facilities is performed for a design period of 10 years at the discounting rate of 10%. Because of the inclusion of the growth variables, the model has become a dynamic 'living' model. Simulation was carried out by varying the nos. of beds and charges in Rs./bed/day. Combinations of beds and charges (in Rs./bed/day) giving IRR values between 10% and 20% were considered as viable.

Base Model has been extended further to reflect the variation of distance on of changes to be levied on HCEs. There is the situation where facility may become economically unviable. To make facility economically viable the charges can be very high or non affordable to the HCEs. The Base Model has the provision of providing grant by the Government in turn MPCB to take care such unviable situation.

This Microsoft® Excel™ based model is user friendly, and could be used by MPCB, Urban Local Bodies and Operators of CBMWTDF for assessing the economic viability and decision making. A guidance note is prepared on how to run this Microsoft Excel based model and is appended as **Annex 4-1**.