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Estimation and Material Flow Analysis of Waste Electrical and Electronic Equipment (WEEE) - A Case Study of Mangalore City, Karnataka, India

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ABSTRACT

Waste Electrical and Electronic Equipment was earlier perceived to be a problem confined to developed countries and developed cities. Due to the globalization and changing economic scenario, nowadays-waste electrical and electronic equipment is also growing as a major problem in developing countries and developing cities. In this paper estimation and management of Waste Electrical and Electronic Equipment in one such developing city, Mangalore is presented. Market supply method is best suited for the estimations of Waste Electrical and Electronic Equipment in the country like India due to constraints in gathering the data. The city of Mangalore is estimated to generate about 3750 tonnes of Waste Electrical and Electronic Equipment in the year 2015, as compared to present generation of 228 tonnes. Management policy considering strategy of extended producer responsibility and recycling is developed for the management of WEEE in the city of Mangalore.

Keywords*: WEEE, Market supply method, Consumption and use method, Mangalore, Extended Producer Responsibility, SMACRO*

1.0 INTRODUCTION

Electronic waste comprises of discarded and unused equipments and components of electrical and electronic goods such as computers, television, refrigerator, cell phones and other house hold appliances. The growth rate of the IT and electronics industry in India is increasing every year (MAIT, 2007). This has in turn led to the increased consumption of electronic items and computer hardware. Initially this development was confined to only large metropolitan cities and the tier I cites. As the metropolitan and tier 1 cities are reaching their threshold capacity in almost all resources, the big players in Information technology and electronic industries are turning up to tier II cities such as Gurgoan, Jaipur, Indore, Mohali, Mysore, Mangalore, etc. (The economic times, 2006). This has immensely contributed towards the increased consumption of Electronic appliances in these tier II cities. This paper attempts to quantify Waste Electrical and Electronic Equipment (WEEE) in tier II cities by taking the example of one such tier II city, Mangalore, as well as to present a policy for the management of generated WEEE. The estimations world wide showed that WEEE mainly comprises of large house hold electronic equipment such as televisions, PCs, Refrigerators, Cell phones and Washing machines. (Wilkinson et al. 2001; Crowe et al. 2003; Darby and Obara 2004; Liu et al. 2005; Widmer et al. 2005, John and Laurence 2006; Kang and Schoenung 2006; Lee et al. 2007). So an

assumption was made that, the WEEE generated in a developing city like Mangalore will also comprise of PCs, Televisions, Refrigerators, Cell phones and Washing machines. The study area was limited to city boundaries of Mangalore. Market supply methods and the estimate method are used to quantify the generation of Waste Electrical and Electronic Equipment in the city of Mangalore. A management policy based on producer responsibility and recycling is proposed.

2.0 METHODOLOGY

Estimations are carried out by using market supply methods and estimate method.

Average weight and life span of different equipment required for the estimations of Waste Electrical and Electronic Equipment are shown in Table1. Average life span was assumed based on the responses of consumers Mangalore, where as average weight was obtained from the previous studies carried out by Toxics link (Toxics link, 2007)

Table 1. Average Weight and Life Span of Electronic Equipment

Type of electronic equipment	*Average Weight (kgs)*	*Average useful life span (Years)*
Television	24	10
Personal computer(PC)	27.2	5
Refrigerator	30	10
Cell Phone	0.12	3
Washing Machine	27	12

2.1 Market Supply Method

WEEE risings are extrapolated based on sales data statistics and the average life span. The method assumes that equipment sold in a particular year will turn out as waste equipment after completion of its useful life time. The other assumption is that there is negligible change in the variance of the average life span of electronic equipment (Wilkinson et al. 2001). The estimation using market supply method is shown in Table 2.

Table 2. Estimation of WEEE using Market Supply Method

WEEE estimation trend (market supply method)						
Total waste potential for five appliances (kgs)						
Year	*Refrigerator*	*P C*	*Phone*	*T V*	*W M*	*Total WEEE*
06-07	10620	137550.4	3018.24	96696	2565	250449.64
07-08	14550	218742.4	4814.52	132000	4023	374129.92
08-09	22500	275808	6049.44	168000	5805	478162.44
09-10	39720	547346	6600.96	223704	9504	826874.96
10-11	57690	823181	7308.6	297384	15444	1201007.6
11-12	83550	1088626	8406.24	363096	26244	1569922.24
12-13	122820	1389267	9368.76	417456	44307	1983218.76
13-14	152190	1641384	10384.08	504528	74277	2382763.08
14-15	603750	1900029	11057.16	958584	98334	3571753.96

2.2 Market Supply A Method

This method is same as market supply method in extrapolations but for the average life span. The difference is the variance in average life span as the market supply A method assumes that there is a considerable variance in life span of electronic equipment. This variance occurs as a distribution around the average life span. The distribution of the variance is obtained by the survey of the consumers (Wilkinson et al. 2001). The estimation of WEEE using market supply A method is shown in Table 3.

Table 3. Estimation of WEEE using Market Supply A Method

WEEE estimation trend (market supply A method)						
Total waste potential for five appliances (kgs)						
Year	*Refrigerator*	*P C*	*Cell Phone*	*T V*	*W M*	*Total WEEE*
06-07	3306.3	178345.232	2362.2	22370.4	2099.52	207217.35
07-08	9381.6	252304.752	3423.846	63294	6693.84	328894.04
08-09	22345.2	409617.856	5018.018	125658	15982.92	565658.39
09-10	32543.4	622880.272	6531.956	211612.8	32628.42	895998.65
10-11	56416.2	871315.824	7648.326	304777.2	54562.68	1270847.4
11-12	117680.4	1142513.424	8703.329	427650	90545.58	1725828.5
12-13	202114.2	1412087.728	9861.614	559875.6	151006.7	2250512
13-14	348383.4	1677997.104	11045.85	730816.8	243670.7	2865644.6
14-15	3306.3	1942222.8	12236.44	938560.8	598602.7	3840006.1

Sales data for the two methods was obtained by conducting a study of market sales.

2.3 Estimate Method or Consumption Use Method

The estimations are obtained by considering the stock levels of electronic equipment in households. Stock levels are divided by the average life to obtain the amount of WEEE generated. Stock levels are obtained by considering the penetration level and number of households. Number of households in Mangalore is about 125000 (MCC, 2007). Penetration levels were obtained by the report (NCAER, 2005**).** Penetration of computers in households as well as Industries was not available hence computers were not considered for the estimations. Estimations are carried out only for the year 2007(Wilkinson et al. 2001).

3.0 RESULTS AND DISCUSSIONS

As observed from Table 2, 3 and 4, Market supply methods give lower estimations of WEEE when compared to estimate method. By adapting a conservative approach the estimations from the market supply methods were taken as the probable amount of WEEE generated from the city of Mangalore. Further the estimations from both market supply methods are in similar range up to year 2011and differs only by 200 tonnes. So an average of estimations from the two market supply methods gives a realistic value of WEEE generated.

Table 4. Estimation of WEEE using Estimate Method

Installed Base	*Penetration per 1000 household*	*Total base installed (stock)*	*Weight of individual appliances*	*Average Life span*	*Total weight of WEEE (tonnes)*
Television	795.4	94925	24	10	227.82
Refrigerators	492.5	61562.5	30	10	184.69
Washing Machines	316.4	39550	27	12	88.99

Mangalore city at present i.e. in the year 2007 generates about 228 tonnes of WEEE. These are domestically generated and there is no import of the WEEE from other areas. Present amount of WEEE generated in terms of weight is of less significance when you compare with the other Indian cities. Per capita WEEE generation at present is about 0.418 kg/year. The WEEE accounts for 0.23% of the total municipal waste (91250 tonnes) generated in Mangalore. It is estimated that generation of WEEE in the Mangalore city will reach 1200 tonnes in year 2010 and 3500 tonnes in year 2015. WEEE generation per capita in Mangalore will be about 1.4 kg/year in 2010 and 3.1 kg/year in 2015.

At present wastes from Personal Computers (PC) are the leading contributor to the WEEE in the city with a share of 55% and wastes from Television comes next with a stake of 39%. WEEE from other appliances are comparably less at present this may be due to the fact that average useful life of PC at present in Mangalore is about 5 years which is much lower than the other appliances such as washing machine (12 years), refrigerator(10 years)and television(10 years).Even though television has an average useful life of 10 years its stake of 39% is due to an well established installation base (Assuming almost 80% of the house holds in Mangalore have possession of television) already present in Mangalore. Due to shorter average life span of cell phones which ranges from 6 months to 3 years the amount of obsolete cell phones entering the waste stream are about 25000 in the year 2006-2007. Even though the contribution of cell phones in terms of numbers to the waste stream is high, due to its lower average weight (150 grams), contribution in terms of weight towards the WEEE of Mangalore city is of lower significance(less than 1%). It is estimated that in year 2015 obsolete PC's will still dominate with a stake of 53%, less by 2%from the year 2010.the next two place will be acquired by wastes from televisions (27%) and refrigerators (16%).There will be a significance increase (12%) in wastes from refrigerators from year 2007.The rest of the scenario will be pretty much the same as was the case in the year 2007.

3.1 Management of WEEE in Mangalore at Present

At present in Mangalore, there are only 5 dealers dealing with waste arising from electronic equipments and they have been in operation only for the past three years. These dealers keep a constant eye on the auctions related to electronic equipment from government offices, educational institutions and financial institutions. They carry out various activities of recycling such as sorting, dismantling, segregation and recovery of copper wires. Traders from Delhi, Mumbai, Bangalore, Goa turn up here to collect the PCB's, CRT's, plastic and metal casings. One of the methods of recycling is recovery of metals from WEEE. Which is practiced in all the major recycling cities across India is not done within Mangalore area. The waste generated at present in the study area is contributing to the WEEE stream generated in Delhi, Mumbai, Bangalore and Goa as the WEEE generated within the study area is finally ending up in these cities in various forms such as PCB's in Delhi, plastic casings in Bangalore, metals in Goa and CRT monitors in Mumbai.

3.2 Management Policy

Two models/policies are proposed one for the present (Figure 1) and other one for the future (Figure 2). In the first proposed policy i.e. for the present scenario manufacturers and importers of electronic waste are to be left out since there are no such generators presently in operation. In the second proposal the above said generators are included assuming that these generators will be present in the future. The basis of this policy is that the all individuals involved in the industry of electronic equipment (assemblers, manufacturer and service provider) has to be held responsible for the final disposal of the WEEE irrespective of who was the manufacturer WEEE. All the individuals in the industry of electronic equipment have to come together as a consortium and form an organization.

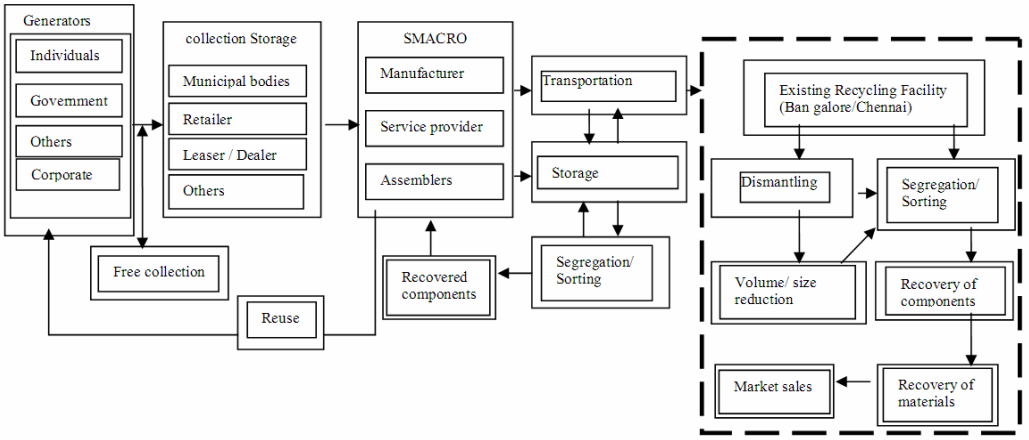

Figure 1 Policy for Management of WEEE for Immediate Implementation

This organization will be known as SMACRO (Service providers, Manufactures and Assemblers Collective Responsibility Organization), indicating the presence of all the individuals involved in the industry of electronic equipment.

In the first policy (Figure 1) Collection is made by the municipal body, retailers and dealers. Since the authorization of the existing informal recyclers will take some time, they are not included in the model for collection of WEEE. The role of SMACRO (Service providers, Manufacturers and Assemblers Collective Responsibility Organization) in this model is restricted to the collection and transportation of WEEE to existing authorized recyclers based in Bangalore or Chennai. As shown in the first policy, the activities included in the dotted block will not be carried out in Mangalore

In the second policy (Figure 2), generators of WEEE are inclusive of manufacturer, assuming that there will be some operations of manufacturing, which may take place in near future. Former informal recyclers (who will be authorized by taking necessary steps by SMACRO) will be involved in collection as well as recovery of components and material. An additional responsibility of recycling of WEEE as well as finding the market for the recovered material has to be borne by the SMACRO. The activities of recycling which was not included in the first model are incorporated in the second model. Another difference is the collection of ARF^{A} (Advanced Refundable Fee) from the consumers of electronic equipment. Comparison of the first and second policy in terms of various stake holders responsibility, and involvement of stakeholders is shown in Table 5.

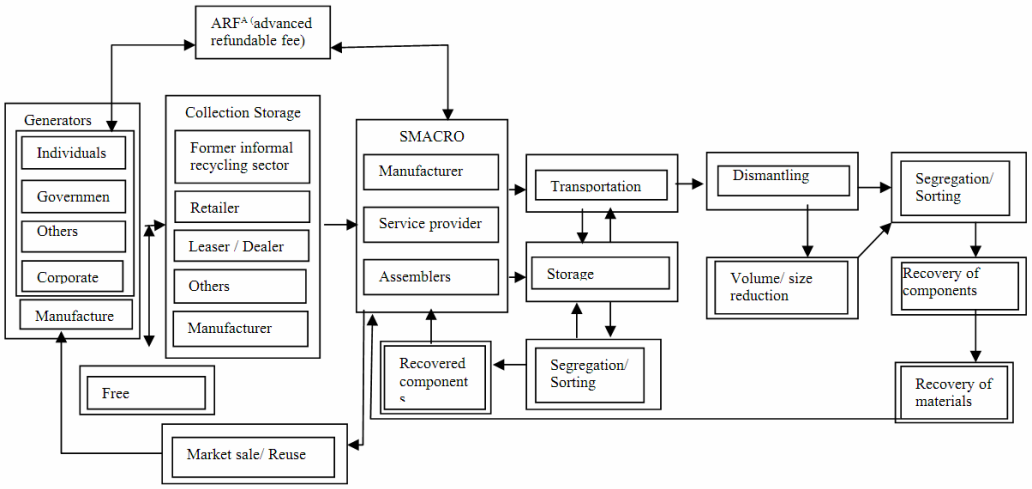

Figure 2 Policy for Management of WEEE for Future Implementation

Table 5. Comparison of the Two Policies Proposed

	Model 1	*Model 2*
Generator	Includes individuals, corporate, governments,	Includes individuals, corporate, governments, Manufacturer
Responsibility of Collection/ storage	Retailer, Leasers and dealers	Retailer, Leasers, dealers, Former informal recyclers and manufacturer
Responsibility of SMACRO	Collection, funding, storing, transporting, finding a recycler and selling of recovery components	Collection, funding, storing, transporting, Recycling/ Finding a recycler, finding the market for recovered components/ materials and frequent checking of the recyclers processing methods
Recycling facility	Transporting the WEEE to a Authorized retailer (out side Mangalore)	Finding a authorized recycler within Mangalore Building a recycling facility if no authorized recycler is not found

4.0 CONCLUSIONS

As a result of rapid urbanization, the WEEE is drawing attention in the city of Mangalore. The generation of WEEE will increase rapidly at least up to 2015. This study offers the initiation to a long process of managing WEEE

1. The projected estimates of WEEE generated in the year 2015 would be 3705 tonnes as compared to present value of 228 tonnes. Even though there is less generation of WEEE at present but the city has a high potential for generation in future. This can be generalized to tier II cities in India since these cities are having the same pattern of consumption and usages of electronic equipment.
2. Producer take back of the WEEE is found to be the best option for management of WEEE. Producer take back should also accompany incentives to the WEEE generator to motivate them to

recycle WEEE generated.

3. The policy suggested is purely based on the responsibility taken by the manufacturer, assembler and service provider. Hence the model has to be imposed by a proper legislation by the administrating body. The funding of the model has to be bared collectively by the manufacturer, assembler and service provider

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