Introduction to Phnom Penh (Cambodia)

Phnom Penh Municipality (PPM) is the capital city of the Royal Kingdom of Cambodia with a total land area of 376.95 Km^2. It is equal to 0.20% of the total land area of the country. Administratively, PPM is divided into 7 districts (up to 2008) but now one more district has been determined, 76 communes, 689 villages and 4,320 groups. The population of the city is approximately 1,080,519 consisting of 188,769 households out of which 43% live in urban area and 57% in rural area. Population growth in the city is 3.92%.

Double-digit economic growth rates in recent years have triggered an economic boom in Cambodia, with new hotels, restaurants, and residential buildings springing up around the PPM. Due to improved living standards, globalization, international trade, and tourism, the consumption of electrical and electronic equipment (EEE) has rapidly increased in the urban centers in the country. Since Cambodia does not have manufacturing base for electrical and electronic equipment (EEE), it is importing both brand new and second hand EEE to cater to existing demand. This is leading to generation of E-waste and its management as a major issue in cities/ urban centers in Cambodia. According to the CEA survey report of E-waste in Cambodia, it was found that there exists some environmental and human health concerns though the utilization of second hand EEE/ Used EEE. Therefore, there is a need to further consider strengthening, monitoring and managing imported EEE with reasonable and useable conditions.

Baseline Data (2008)

Methodology

Globally, five methods have been used to determine E-waste inventory. Each of these methods use "Material Flow" model for assessment of inventory. This chapter describes the preferred method for inventory estimation, its application, constraints, advantages, data requirements and sources of data.

The five methods, which have been used to assess the E-waste inventory globally, are given below.

1. The time step method
2. The market supply method
3. The Carnegie Mellon method
4. Approximate 1 formula
5. Approximate 2 formula

The key to apply any method is the availability of data and its quality. The type of data required to apply any methodology is given below.

- Saturation level of EEE at household and industry level
- Number of households
- Sales data related to export/ import/ manufacturing/production
- Stock data related to private and industry
- Average lifetime of EEE
- Data related to storage of EEE
- Data related to reuse and recovery
- Data related to landfill

Data Requirement and Data Sources

E-waste trade value chain in PPM forms the basis of data requirement and data source. This trade value chain has been described in figure 3.5 of chapter 3. The salient features related to data requirement and sources, which emerged out of the analysis of E-waste trade value chain, are given below.

1. EEE import, sales and consumption is in formal sector

2. Part of E- waste generation and E- waste treatment falls in semiformal sector

3. Part of E-waste treatment and entire disposal falls in informal sector

The trade chain beyond blue line on the right hand side falls in the informal sector. Therefore, possibility of data availability related to import, sales and consumption appeared high through published government and private sources. However, a need appeared for carrying out limited sampling to collect data related to E-waste generation, treatment and disposal. The strategy to collect this data is shown in figure 4.1.

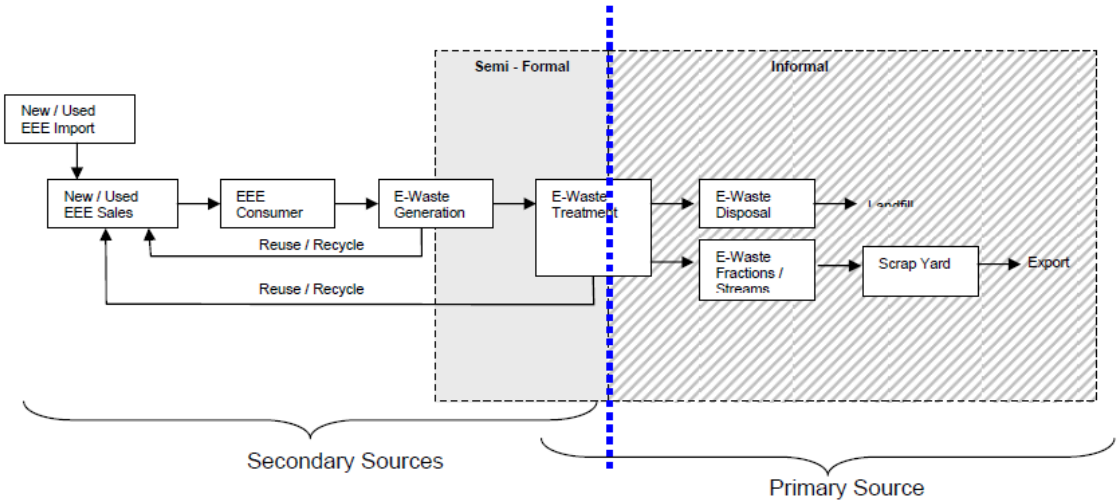

Figure 4.1: Tentative sources for data collection

The availability of above mentioned data was checked for PPM by referring to a number of sources including government and private as described in table 4.1.

Table 4.1: Tentative Sources of data collection

Data Source/ Item	National/ Local Government Agencies	Industry/ Trade/ Recyclers/ Waste Disposal Operator's Association/ NGO (Reports/ Published Data)	Market Research Agencies/ other published sources (Reports/ Published Data)
Saturation Level Household	√ (census data)		√
Saturation Level Industry/ commercial	√ (census data)	√	√
Number of Household	√ (census data)		
Export Data	Not available due to informal sector		
Import Data	√ (Cam Control/ Customs)	√	
Manufacturing/ Production	Not available due to absence of EEE manufacturing base in Cambodia		
Stock Data Private	Data not available		
Stock Data Industry/ commercial	Data not available		
Average Life Time		√	√
Storage Data	Data not available		
Reuse		√	√
Recycle		√	
Landfilled		√	

Application of Methodology

The application of any of the five methodologies on the basis of figure 4.1 and table 4.1, tentative sources of data collection have been assessed as per the constraint matrix given in table 4.2. The data required for applying each methodology has been described in table 4.2. The yellow mark indicates the availability of data for PPM. It can be concluded that Carnegie Mellon Method, a modified version of market supply method can be applied to carry out E-waste inventory assessment in PPM.

Conclusion

The application of Carnegie Mellon method requires data on imports, average lifetime, reuse and recycling. These data available from different agencies is supported by primary survey carried out through questionnaire survey and tracer technique described in the following chapter.

Table 4.2: Constraint Matrix

Methodology/ Data Requirement	Saturation Level		Number of Household	Calculated Sales			Stock Data		Average Lifetime	Storage data	Reuse	Recycle	Landfill
	Household	Industry		Export Data	Import Data	Manufacturing/ Production	Private	Industry					
Time Step Method	√	√	√	√	√	√	√	√					
Market Supply Method				√	√	√			√				
Carnegie Mellon Method				√	√	√			√	√	√	√	√
Approximation 1	√	√	√				√	√	√				
Approximation 2				√	√	√							

For this study, a combination of two methods, “Carnegie Mellon Method” and “Tracer Technique” has been used to quantify E-waste inventory in PPM. These techniques are applied on respective parts of the E-waste trade value chain shown in figure 4.1 by using the data available from the source given in table 4.1. The following sections describe EEE items selected for quantifying E-waste inventory, conceptual approach, and application of methods to quantify the installed base of EEE, its projections, average lifetime, tracer technique and finally inventory.

E-Waste Inventory

Introduction

As per Basel Convention, "Report on the Survey of the Import and the Environmentally Sound Management of Electronic Wastes in the Asia-Pacific Region," E-waste release per annum is roughly calculated as 276 units of computer, 2,760 units of TV sets, 5,520 units of mobile phones and 690 units of fixed phones. This report also indicates that there is a rapid increase in the import of electronic equipment in the country. Moreover, with rapid increase in internet and information technology penetration and decrease in the retail prices of EEE, their end of life is getting reduced.
The study "Environmentally Sound Management of Electrical and Electronic Waste in Cambodia" in 2006-07 reported that E-waste estimation as of 2007, consisted mainly of 40,983.00 kg from TV, 13,318.80 kg from air conditioners, 2,016.24 kg from mobile phones and 1,310.40 kg from personal computers. It was also found that major quantities of E-waste are generated in Phnom Penh City. Further, the study indicated usage of low repairing/dismantling technology with inappropriate facilities in study areas, which threaten the environment and public health. In Phnom Penh, many small family workshops, within houses, have been established to recover reusable and recyclable materials from E-waste without proper precautions. The residual E-waste is disposed off as municipal solid waste in bins and landfill sites. Since EEE contain hazardous materials, these family level operations create a direct risk to workers and their families, to the community and to the environment, especially due to release of hazardous substances in soil, water and air.

Conceptual Approach

There are six items, which have been selected to quantify E-waste inventory. These include three items from ICT like TVs, PCs, mobile phones (MP) and three items from white goods like Refrigerator, Air Conditioner (AC) and washing machine (WM). These items have been selected considering their growth rate in PPM. There are four steps, which have been used to describe the conceptual approach.

Step 1: Establish the installed base of selected EEE items with future projections till 2020.

Step 2: Carry out the scenario analysis using assumed average life cycle of each EEE item.

Step 3: Confirm the average life cycle using "Tracer Technique".

Step 4: Quantify E-waste inventory with projections.

The projections both for installed base and E-waste inventory have been considered till the year 2019 since master plan for PPM urban agglomeration is being prepared till this year. The major constraints experienced during implementation of these steps are given below.

1. Figures for EEE sales computed by using EEE import data from department of Kam Control are available only at country level and not at city level.

2. Figures related to obsolescence rate/ average life of an electrical and electronic item provided by secondary sources of data differ due to storage and reuse of E-waste.

The above constraints are overcome by demarcating the E-waste trade value chain into two parts at a point where E-waste arrives at repair shop. This point has been taken considering the mixed business/ functional profile of these shops including repair, reselling and part dismantling in PPM. Therefore, the point of entry before repairing and reselling step in E-waste trade value chain has been taken to demarcate the chain for application of two different approaches. This is described below and shown in figure 5.1.

The four steps identified above have carried out and described in the following sections using this conceptual approach.

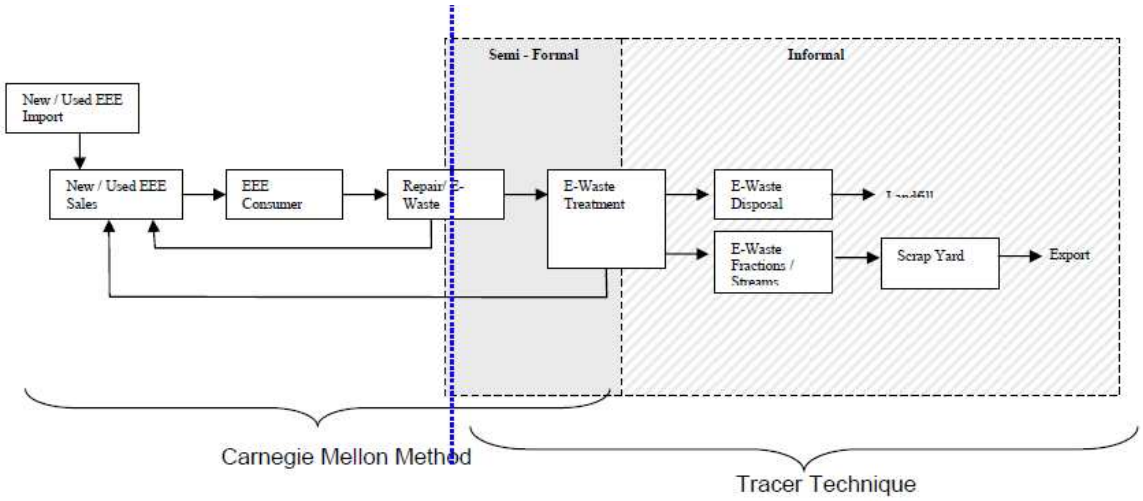

Figure 5.1: Application of two methodologies in the E-waste trade value chain

Establishment of installed base of selected EEE

Installed base of EEE in PPM has been established by using a number of inputs from diverse secondary data obtained from a number of sources/ agencies. Some of these sources include International Telecommunication Union (ITU), World Bank, ADB, UNESCAP, National Institute of Statistics of Cambodia, Municipality of Phnom Penh, Department of Kam Control, Academic institutions, CEA etc. Some of the major assumptions/ inputs used to estimate the installed base are given below.

1. EEE installed base is restricted to urban areas in Cambodia due to non availability of electricity in rural areas in the country.

2. Census data of PPM from National Institute of Statistics of Cambodia has been used. The population growth rate has been assumed to be 2.5% per annum.

3. A uniform GDP growth rate of 5.5% every year has been assumed considering conservative growth estimates.

4. Installed EEE base projections have been made based on electrified household in low, medium and high income group in PPM considering 5.5% GDP growth rate. This data is described in table 5.1and table 5.2. Further, power supply planning is aiming for

a 95% increase in the residential sector up to year the 2016 in Phnom Penh. This will translate into an annual growth rate of electrified households to be 2%. This data have been compiled from the report "Household Electricity Use Analysis and Forecasting: The case of Phnom Penh, Cambodia", A thesis submitted by Mr. Nou Sovanndara", Id: 0111090 as a part of the requirements for the degree of Master of Science, in Energy Technology, The Joint Graduate School of Energy and Environment, at King Mongkut's University of Technology Thonburi, Thailand, 2nd semester 2002 ISBN 974-465-408-3 based on Statistical Data of Ministry of Planning of Government of Cambodia, Year Book 2001.

Table 5.1: GDP Projection in Combodia from 2002 to 2012, [Billion Riels]

Year	GDP at 3%	GDP at 5.5%	GDP at 8%
2002	10,476	10,730	10,985
2003	10,790	11,321	11,863
2004	11,114	11,934	12,813
2005	11,448	12,600	13,838
2006	11,791	13,293	14,945
2007	12,145	14,024	16,140
2008	12,509	14,796	17,431
2009	12,884	15,609	18,826
2010	13,271	16,468	20,332
2011	13,669	17,374	21,958
2012	14,079	18,329	23,715

Table 5.2: Percentage of Electrified Households in the Case of GDP at 5.5%

Year	Low Income	Medium Income	High Income
2002	39.44	41.17	19.39
2003	39.17	41.37	19.46
2004	38.88	41.59	19.53
2005	38.58	41.82	19.60
2006	38.26	42.06	19.68
2007	37.92	42.31	19.77
2008	37.57	42.57	19.86
2009	37.20	42.85	19.95
2010	36.80	43.15	20.05
2011	36.38	43.47	20.15
2012	35.94	43.80	20.26

5. Data on the number of hotels in PPM from 2003 to 2007 was obtained from statistical data of PPM municipality. This data was extrapolated till 2019 based on best fit polynomial curve with $R_2 = 0.97$ as shown in figure 5.2.

6. Data on number of companies/ offices in PPM from 2003-2007, obtained from statistical abstract of PPM was extrapolated till 2019 based on 5.5% GDP growth rate.

7. Percentage ownership of TVs, PCs, MPs, refrigerators and air-conditioners among households, hotels and offices have been taken from table 11, table 12, table 13, table 14 and table 15 of technical report on report "Technical Report on National Inventory of Used EEE in Cambodia" prepared by CEA and are summarized in appendix 4.

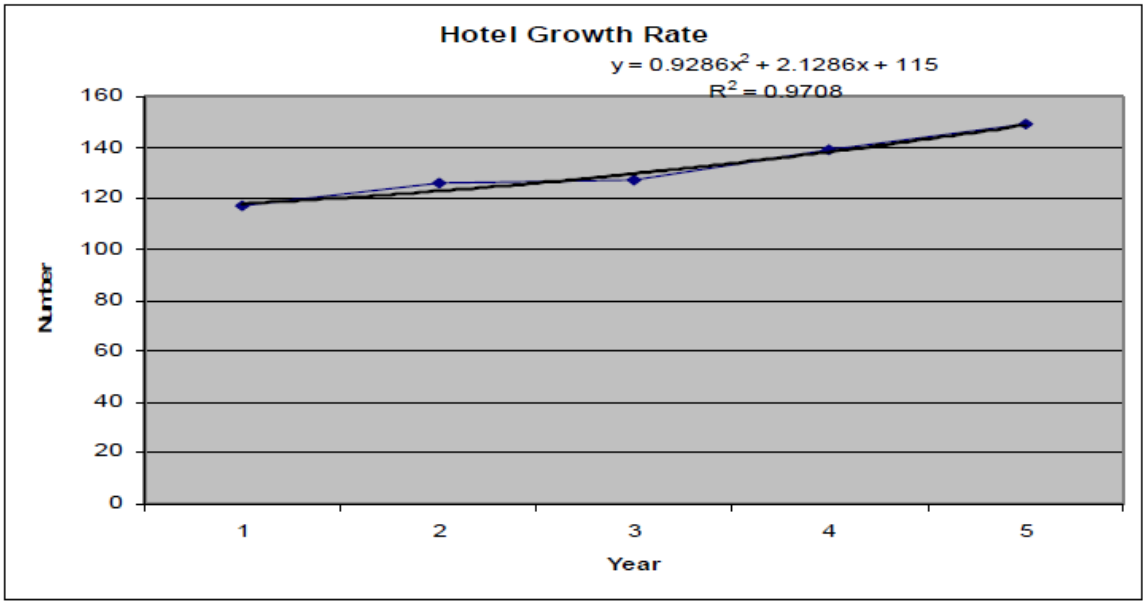

Figure 5.2: Projected number of hotels in PPM

8. Penetration rate of individual EEE for hotels and companies/offices have been estimated based on weighted average of their distribution given in table 11, table 12, table 13, table 14 and table 15 of technical report "Technical Report on National Inventory of Used EEE in Cambodia" prepared by CEA and are summarized in appendix 4. These penetration rates have been described in table 5.3 given below. It has been assumed that washing machines are used only in households in PPM.

Table 5.3: Penetration rates of different EEE items in hotels and offices/ companies in PPM

Item	Penetration Rate per Hotel (Weighted Average)	Penetration Rate per Company (Weighted Average)
TVs	21.268938	1.612342
PCs	0.584597	10.00849
Air conditioners	24.504802	4.219652
Refrigerators	18.809034	0.877216
MP	2.581659	2.884594

9. The import statistics for TVs and PCs from 2000 to 2008 from department of Kam Control for Cambodia have been compiled and shown in table 5.4.

Table 5.4: Import Statistics of different EEE items (numbers/units)

Year	TVs	PCs
2000	157,096	26,342
2001	162,557	1,863
2002	163,663	1,990
2003	114,390	1,852

Year	TVs	PCs
2004	126,755	1,514
2005	95,269	9,381
2006	86,438	3,115
2007	60,529	5288
2008	48,373	4654

Source: Department of Kam Control

10. As per CEA household survey carried out in 2006-07, penetration rate of TV at the household level in urban areas has been taken as 1.5 per household. This penetration rate in PPM is achieved if it is assumed that 22% of the imported TVs each year are added to the previous year's installed base of TV. Using this assumption, the installed base and penetration rate of TV in PPM from the year 2000 to 2008 has been calculated and summarized in appendix 5. Future penetration rate has been projected by extrapolating the penetration rate data till 2019 based on best fit polynomial curve with R_2 = 0.99. Using the projected penetration rate, the projected installed base of TV in PPM has been estimated and summarized in appendix 5.

11. As per CEA household survey carried out in 2006-07, penetration rate/ ownership ratio of PC in urban areas is 0.12/ person for a population above 13 years old (Approximately 74% of the total population as per PPM municipal data). This penetration rate in PPM is achieved if it is assumed that 32% of the imported PCs each year are added to the previous year's installed base of PC. Using this assumption, the installed base and penetration rate of PC in PPM from the year 2000 to 2008 has been calculated and summarized in appendix 5. Since no significant correlation was obtained for the penetration rate/ ownership ratio data starting from 2000 to 2008, a uniform penetration rate/ ownership ratio of 0.12 was adopted to project the future installed base and summarized in appendix 5. This penetration rate represents the most conservative scenario of business as usual considering that there will neither an increase nor decrease in penetration rate. The projected PC installed base till 2019 shows a significant correlation with R_2 = 0.99 for the best fit polynomial curve as shown in appendix 5.

12. Import statistics of MP obtained from department of Kam Control does not match the increase in installed base of MP in Cambodia for the year 2000 to 2005 as per MoPT data summarized in appendix 5. Therefore, the installed base of MP in PPM has been derived based on the CEA household survey and data from market research agencies. As per CEA household survey carried out in 2006-07, penetration rate/ ownership ratio of MP in urban areas is 0.53/ person for a population above 13 years old (Approximately 74% of the total population as per PPM municipal data). As per this penetration rate, the total installed base of MP in PPM has been estimated to be 412,976 units. As per market research agency quoting government sources, a growth rate of 15% has been recorded in MP sector during 2007-08. Assuming 15% growth during the lean period as conservative figure, installed base of MP in PPM from the year 2005 to 2009 has been estimated. This further extrapolated backward till the year 2000 based on percentage distribution of installed base of PPM with respect to Cambodia. Thereafter, the installed base has been has been estimated till the year 2019 based on best curve fit with significant correlation of R_2 = 0.99.

13. According to Cambodia socio-economic survey 2004, the installed base of refrigerator in PPM is about 17.8 per 100 households. As per CEA household survey carried out in 2006-07, penetration rate/ ownership ratio of refrigerators in urban areas is 0.38 units per household, where 80 percent of the households are electrified. This penetration rate/ ownership ratio has been further divided as per low, medium and high income group households. Using the same penetration rate and the projected population with expected percentage of electrified households given in table 5.2, the installed base of refrigerators in PPM till 2012 has been estimated and summarized in appendix 5. This installed base of refrigerators in PPM from 2004 till 2012 has been further extrapolated till 2019 using best fit logarithmic curve with significant correlation R_2 = 0.97. Further, installed base estimation from 1993 till 2003 have been made using the penetration rate/ ownership ratio of 2004 with corresponding electrified household estimates. These estimates have been summarized in appendix 5.

14. According to Cambodia socio-economic survey 2004, the installed base of air conditioners in PPM is about 8 per 100 households. As per CEA household survey carried out in 2006-07, penetration rate/ ownership ratio of air conditioners in urban areas is 0.33 units per household, where 80 percent of the households are electrified. This penetration rate/ ownership ratio has been further divided as per low, medium and high income group households. Using the same penetration rate and the projected population with expected percentage of electrified households given in table 5.2, the installed base of air conditioners in PPM till 2012 has been estimated and summarized in appendix 5. This installed base of air conditioners in PPM from 2004 till 2012 has been further extrapolated till 2019 using best fit logarithmic curve with significant correlation R_2 = 0.97. Further, installed base estimation from 1993 till 2003 have been made using the penetration rate/ ownership ratio of 2004 with corresponding electrified household estimates. These estimates have been summarized in appendix 5.

15. The penetration/ ownership of any white good depend on the availability of electricity, income and consumer behavior. The electrified households in PPM as per low, medium and high income groups are summarized in table 5.2. Ownership ratio of washing machine with refrigerator has been identified as an indicator of consumer behavior for ownership of washing machine in PPM based on the field survey of electricity consumption in residential sector for low, medium and high income groups in the year 2002[2]. This ownership ratio has been applied to the refrigerator ownership in the low, medium and high income group as per CEA household survey in 2006. The tentative washing machine ownership ratio in the year 2006 is summarized in table 5.5.

Table 5.5: Tentative ownership ratio of washing machine

Ratio	Low	Medium	High
Washing Machine / refrigerator (2002)	0.577778	0.923077	0.6054191
Washing Machine (2006)	0.028889	0.323077	0.5630398

Using the same penetration rate/ ownership ratio and the projected population with expected percentage of electrified households given in table 5.2, the installed base of washing machine in PPM from 2002 to 2012 has been estimated and summarized in appendix 5. This installed base of washing machine till 2012 has been further

extrapolated from 1993 till 2019 using best fit exponential curve with significant correlation R_2 = 0.99. These estimates have been summarized in appendix 5.

16. The total installed base of EEE items in hotels and companies in PPM is summarized in appendix 5.

The total installed base of the six EEE items in household sector in PPM has been estimated and summarized in table 5.6. Therefore, the total installed base of EEE consisting of households, hotels and companies is summarized in table 5.7.

Table 5.6: Installed Base of EEE in households in PPN (number)

Year	Population	Installed Base (TV)	Installed Base (PC)	Installed Base (Mobile Phone)	Installed Base (Refrigerator)	Installed Base (Air Condition)	Installed Base (Washing Machine)
1993	717300	**26851**	77629.24		13789.38		24058.47
1994	793817	**37142**	78217.28		15825.53		25221.26
1995	814171	49505.10	78910.02		16811.00	7555.51	26440.24
1996	822993	63939.60	79707.46		17579.13	7900.73	27718.14
1997	822304	80445.90	80609.60		18149.89	8157.26	29057.81
1998	999804	99024.00	81616.45		22779.53	10237.99	30462.22
1999	936767	103052.00	82728.00		22010.28	9892.26	31934.51
2000	952429	137613.12	79762.65	83200.00	23056.40	10362.43	33477.96
2001	963165	172174.24	88192.09	138543.96	24002.07	10787.45	35096.00
2002	1005632	207936.78	88788.25	189756.39	25776.36	11584.88	36641.73
2003	1042108	243942.64	89425.05	269227.20	27453.29	12338.56	39244.08
2004	1050616	269108.44	90017.69	330980.65	28425.47	12775.49	40882.70
2005	1063856	296994.54	90502.17	380627.75	40325.61	34596.49	42764.64
2006	1052974	317953.72	93504.09	412976.40	58859.39	55597.03	43713.90
2007	1072258	336970.08	95196.25	474922.86	61706.93	62411.91	45971.00
2008	1080519	350286.46	96685.53	546161.29	63984.34	64742.04	47835.54
2009	1107532	443232.12	99102.67	628085.49	67456.36	68278.35	50630.73
2010	1135220	488596.25	101580.24	722298.31	71106.38	72002.48	53596.48
2011	1163601	535202.34	104119.74	775737.80	74925.88	75895.84	56736.49
2012	1192691	583143.96	106722.74	851637.30	78935.37	79992.70	60075.64
2013	1222508	632508.29	109390.80	929820.20	80412.60	83814.74	61836.09
2014	1253071	683378.03	112125.57	1010286.50	82547.46	86485.42	64824.73
2015	1284398	735832.90	114928.71	1093036.20	84496.42	88923.57	67957.82
2016	1316507	789950.63	117801.93	1178069.30	86289.30	91166.45	71242.33
2017	1349420	845807.74	120746.98	1265385.80	87949.25	93243.03	74685.59
2018	1383156	903480.20	123765.65	1354985.70	89494.62	95176.27	78295.27
2019	1417735	963043.88	126859.80	1446869.00	90940.21	96984.71	82079.41

Table 5.7: Total Installed Base of EEE (households, hotels, companies) in PPN (number)

Year	Population	Installed Base (TV)	Installed Base (PC)	Installed Base (Mobile Phone)	Installed Base (Refrigerator)	Installed Base (Air Condition)	Installed Base (Washing Machine)
1993	717300	**31183**	98755.68		16464.02	**16169.09**	24058.47
1994	793817	**41746**	100505.69		18676.82	**17670.87**	25221.26
1995	814171	54398.75	102424.34		19851.35	18736.18	26440.24
1996	822993	69142.10	104515.15		20821.86	19741.84	27718.14
1997	822304	85977.85	106781.85		21609.34	20699.28	29057.81
1998	999804	104907.47	109228.35		26471.10	23524.00	30462.22
1999	936767	109310.61	111858.79		25950.54	23968.12	31934.51
2000	952429	144272.21	110495.94	83200.00	27263.19	25276.98	33477.96
2001	963165	179260.95	120616.08	138543.96	28494.58	26592.70	35096.00
2002	1005632	215480.22	122996.01	189756.39	30575.25	28336.24	36641.73
2003	1042108	251974.02	125514.78	269227.20	32580.81	30095.06	39244.08
2004	1050616	277661.25	128093.01	330980.65	33905.56	31600.06	40882.70
2005	1063856	306104.71	130672.39	380627.75	46184.10	54556.21	42764.64
2006	**1052974**	**327659.82**	**135884.57**	**412976.40**	**65124.09**	**76763.43**	**43713.90**
2007	1072258	347328.58	139911.21	474922.86	68420.98	84878.56	45971.00
2008	1080519	361299.89	143862.16	546161.29	71143.02	88542.52	47835.54
2009	1107532	454964.75	148877.13	628085.49	75109.10	93518.57	50630.73
2010	**1135220**	**501110.51**	**154096.04**	**722298.31**	**79300.60**	**98788.01**	**53596.48**
2011	1163601	548561.95	159528.23	775737.80	83709.68	104335.52	56736.49
2012	1192691	597413.96	165183.52	851637.30	88357.57	110198.89	60075.64
2013	1222508	647755.11	171072.21	929820.20	90522.79	115903.45	61836.09
2014	1253071	699669.60	177205.12	1010286.50	93396.04	120576.56	64824.73
2015	1284398	753238.71	183593.63	1093036.20	96134.64	125141.12	67957.82
2016	1316507	808541.81	190249.69	1178069.30	98769.30	129638.71	71242.33
2017	1349420	865657.18	197185.84	1265385.80	101324.12	134102.87	74685.59
2018	1383156	924662.61	204415.29	1354985.70	103818.46	138561.36	78295.27
2019	1417735	985635.91	211951.88	1446869.00	106268.16	143037.77	82079.41

Scenario Analysis – E-waste Inventory

Average lifecycle of each of selected EEE item has been taken from the report "Technical Report on National Inventory of Used EEE in Cambodia" prepared by CEA based on survey carried out in 2006 and summarized in table 5.8. A range of average life of selected EEE items can be fixed with an "upper limit" and "lower limit" as summarized in table 5.8. Scenario analysis of E-waste inventory for the selected EEE has been carried out using "upper limit" and "lower limit" and summarized in table 5.9.

Table 5.8: Average Life time of EEE

No.	EEE Product	Use Period (Year)	Scenario 1: Lower Period (Year)	Scenario 2: Upper Period (Year)
1	TV	10	9	13
2	PC	9	8	13
3	Mobile Phone	7	7	10
4	Refrigerator	12	11	13
5	Air Conditioner	12	11	13
6	Washing Machine	12	11	13

Scenario analysis assists to assess the time between point of discard of EEE and its arrival at repair/ dismantling stage. This will help in assessment of life cycle of EEE before it arrives for dismantling in a geographical context.

Life Cycle Assessment through Tracer Technique

Life cycle assessment has been carried out through tracer technique from the point at which it enters repair shops. It is at this point that EEE item enters the E-waste trade value chain in PPM. Further, the nature of E-waste market in PPM indicates that all the three functions of repair, reselling and dismantling are occurring with majority of retailers under one roof in PPM. The following steps were followed to carry out tracer analysis for six items in PPM.

Step 1: Identify the tracer item in each EEE

Step 2: Follow the tracer item in the trade value chain

Table 5.9: Scenario Analysis – E-waste Inventory

Year	Scenario 1: Inventory (TV)	Scenario 2: Inventory (TV)	Scenario 1: Inventory (PC)	Scenario 2: Inventory (PC)	Scenario 1: Inventory (MP)	Scenario 2: Inventory (MP)	Scenario 1: Inventory (Ref)	Scenario 2: Inventory (Ref)	Scenario 1: Inventory (Air Con)	Scenario 2: Inventory (Air Con)	Scenario 1: Inventory (WM)	Scenario 2: Inventory (WM)
1993												
1994												
1995												
1996												
1997												
1998												
1999												
2000												
2001												
2002												
2003												
2004							16464.02				24058.47	
2005							18676.82				25221.26	
2006	**104907.47**	**31183**	**111858.79**	98755.68	**83200.00**		**19851.35**	16464.02	**18736.18**		**26440.24**	24058.47
2007	109310.61	**41746**	110495.94	100505.69	138543.96		20821.86	18676.82	19741.84		27718.14	25221.26
2008	144272.21	54398.75	120616.08	102424.34	189756.39	83200.00	21609.34	19851.35	20699.28	18736.18	29057.81	26440.24
2009	179260.95	69142.10	122996.01	104515.15	269227.20	138543.96	26471.10	20821.86	23524.00	19741.84	30462.22	27718.14
2010	**215480.22**	85977.85	**125514.78**	106781.85	**330980.65**	**189756.39**	**25950.54**	**21609.34**	**23968.12**	**20699.28**	**31934.51**	**29057.81**
2011	251974.02	104907.47	128093.01	109228.35	380627.75	269227.20	27263.19	26471.10	25276.98	23524.00	33477.96	30462.22
2012	277661.25	109310.61	130672.39	111858.79	412976.40	330980.65	28494.58	25950.54	26592.70	23968.12	35096.00	31934.51
2013	306104.71	144272.21	135884.57	110495.94	474922.86	380627.75	30575.25	27263.19	28336.24	25276.98	36641.73	33477.96
2014	327659.82	179260.95	139911.21	120616.08	546161.29	412976.40	32580.81	28494.58	30095.06	26592.70	39244.08	35096.00
2015	347328.58	215480.22	143862.16	122996.01	628085.49	474922.86	33905.56	30575.25	31600.06	28336.24	40882.70	36641.73
2016	361299.89	251974.02	148877.13	125514.78	722298.31	546161.29	46184.10	32580.81	54556.21	30095.06	42764.64	39244.08
2017	454964.75	277661.25	154096.04	128093.01	775737.80	628085.49	65124.09	33905.56	76763.43	31600.06	43713.90	40882.70
2018	501110.51	306104.71	159528.23	130672.39	851637.30	722298.31	68420.98	46184.10	84878.56	54556.21	45971.00	42764.64
2019	548561.95	327659	165183.52	**135884.57**	929820.20	775737.80	71143.02	65124.09	88542.52	76763.43	47835.54	43713.90

The tracer in each EEE item is described in table 5.1. Further, the tracer item has been tracked as shown in appendix 6 and amount calculated based on field survey carried out by project team on sample basis as summarized in appendix 7. An average amount for each item is calculated and correlated back to E-waste inventory summarized in table 5.9 to assess the average life cycle. This correlation for each item has been described below.

Table 5.10: Tracer Item

S. No.	Item	Tracer
1.	TV	CRT
2.	PC	CRT
3.	MP	LCD
4.	Refrigerator	Compressor
5.	Air Conditioner	Compressor
6.	Washing Machine	Motor

TV

Results of tracer analysis for TV are summarized below.

1. The survey of about 17 TV repair and dismantling shops carried out by project team shows that about 1152 units per month arrive for repair/ dismantling. This gives an average figure of about 68 units per month arriving at each shop.

2. There are about 40 repair and dismantling shops, which were surveyed by CEA during 2006. The total units expected to arrive at 40 shops per year are 32640.

3. On comparing the expected arrival of the TV sets at these shops with the figures for TV in table 5.9, the average life cycle of TV in PPM comes out to be about 13 to 14 years, which corresponds to figures in 2006-07. This also includes the storage period of the unit with different stakeholders.

PC

Results of tracer analysis for PC are summarized below.

1. The survey of 8 PC repair shops carried out by project team shows that about 525 units per month arrive for repair. This gives an average figure of about 66 units of PC per month arriving at each shop.

2. As per data of National ICT Development Authority, there were about 185 PC shops in Cambodia in 2006. PC shops surveyed in 2006 by CEA team in PPM constitute about 64 % of the total sample size. Using this percentage, the total PC shops in PPM have been estimated to be 118 in 2006. The units, which are expected to arrive at these shops for repair per year is about 93,456. As per CEA survey, the number of PCs arriving for repair constitutes about 89.85 percent (table 18 from CEA report), therefore, the total number of units expected to arrive at the se shops is about 102,941 units per annum in 2006.

3. On comparing 102,941 units per annum in 2006 with the figures for PC in table 5.9, the average life cycle of PC in PPM is estimated to be 11 years, which corresponds to an installed base of PC in 1995.

MP

Results of tracer analysis for MP are summarized below.

1. The survey of about 10 MP repair shops carried out by project team shows that an average of about 415 units per month arrive for repair at these shops.

2. There are about 32 MP repair shops, which were surveyed by CEA during 2006. The total units expected to arrive at these shops per year are 159,360 in PPM. These

constitute about 89.85 percent (table 18 from CEA report), therefore, the total number of units expected to arrive at the shops is about 170,515 units per annum in 2006.

3. On comparing 170,515 units per annum in 2006 with the figures for MP in table 5.9, the average life cycle of MP in PPM is estimated to be 5 to 6 years, which corresponds to an installed base of MP in 2001-02.

Refrigerator

Results of tracer analysis for refrigerator are summarized below.

1. The survey of about 19 refrigerators repair and dismantling shops carried out by project team shows that an average of about 33 units per month arrive for repair and dismantling at these shops.

2. There are about 43 refrigerator repair shops in PPM, which were surveyed by CEA during 2006. The total units expected to arrive at these shops per year are 17,028 in PPM.

3. On comparing 17028 units per annum in 2006 with the figures for refrigerator in table 5.9, the average life cycle of refrigerator in PPM is estimated to be 13 years, which corresponds to an installed base in 1993.

Air Conditioner

Results of tracer analysis for air conditioner are summarized below.

1. The survey of about 19 air conditioner repair and dismantling shops carried out by project team shows that an average of about 35 units per month arrive for repair and dismantling at these shops.

2. There are about 43 air conditioner repair shops in PPM, which were surveyed by CEA during 2006. The total units expected to arrive at these shops per year are 18060 in PPM.

3. On comparing 18060 units per annum in 2006 with the figures for air conditioner in table 5.9, the average life cycle of an air conditioner in PPM is estimated to be 12 to 13 years, which corresponds to an installed base in 1994.

Washing Machine

Results of tracer analysis for washing machine are summarized below.

1. Survey of about 9 washing machine repair and dismantling shops carried out by project team shows that an average of about 34 units per month arrive for repair and dismantling at these shops.

2. As per survey of such type of shops, it was informed that there are about 45 washing machine repair shops in PPM. Therefore, the total units expected to arrive at these shops per year are 18360 in PPM.

3. On comparing 18360 units per annum in 2006 with the figures for air washing machine in table 5.9, the average life cycle of washing machine in PPM is estimated to go beyond 13 years and is expected to be 18 years which corresponds to an installed base in 1987-88.

Projected E-waste Inventory

A conservative life cycle assessment of each of the EEE item has been fixed based on confirmation by "Tracer Technique" and summarized in table 5.11.

Table 5.11: Average Life Cycle of EEE item

S. No.	Item	Average Life Cycle (years)
1.	TV	14
2.	PC	11
3.	MP	6
4.	Refrigerator	13
5.	Air Conditioner	13
6.	Washing Machine	18

The projected E-waste inventory in terms of numbers and metric tons for the six EEE items starting from the year 2009 till 2019 has been estimated and summarized in table 5.12 and table 5.13.

Table 5.12: Projected E-waste Inventory (number)

Year	TV	PC	MP	Refrigerator	Air Conditioner	Washing Machine	Total
2008	41746.44	106781.85	189756.39	19851.35	18736.18	20881.99	**397754.20**
2009	54398.75	109228.35	269227.20	20821.86	19741.84	21891.25	**495309.25**
2010	69142.10	111858.79	330980.65	21609.34	20699.28	22949.29	**577239.44**
2011	85977.85	110495.94	380627.75	26471.10	23524.00	24058.47	**651155.11**
2012	104907.47	120616.08	412976.40	25950.54	23968.12	25221.26	**713639.87**
2013	109310.61	122996.01	474922.86	27263.19	25276.98	26440.24	**786209.90**
2014	144272.21	125514.78	546161.29	28494.58	26592.70	27718.14	**898753.71**
2015	179260.95	128093.01	628085.49	30575.25	28336.24	29057.81	**1023408.74**
2016	215480.22	130672.39	722298.31	32580.81	30095.06	30462.22	**1161589.01**
2017	251974.02	135884.57	775737.80	33905.56	31600.06	31934.51	**1261036.52**
2018	277661.25	139911.21	851637.30	46184.10	54556.21	33477.96	**1403428.03**
2019	306104.71	143862.16	929820.20	65124.09	76763.43	35096.00	**1556770.59**

The graphical representation of the inventory is shown in figure 5.3. The figure shows that the E-waste inventory in PPM is expected to grow exponentially with a significant correlation during the next decade. In terms of numbers, E-waste from mobile phones is expected to grow at a higher rate followed by TVs, PCs, refrigerator, air conditioners and washing machine.

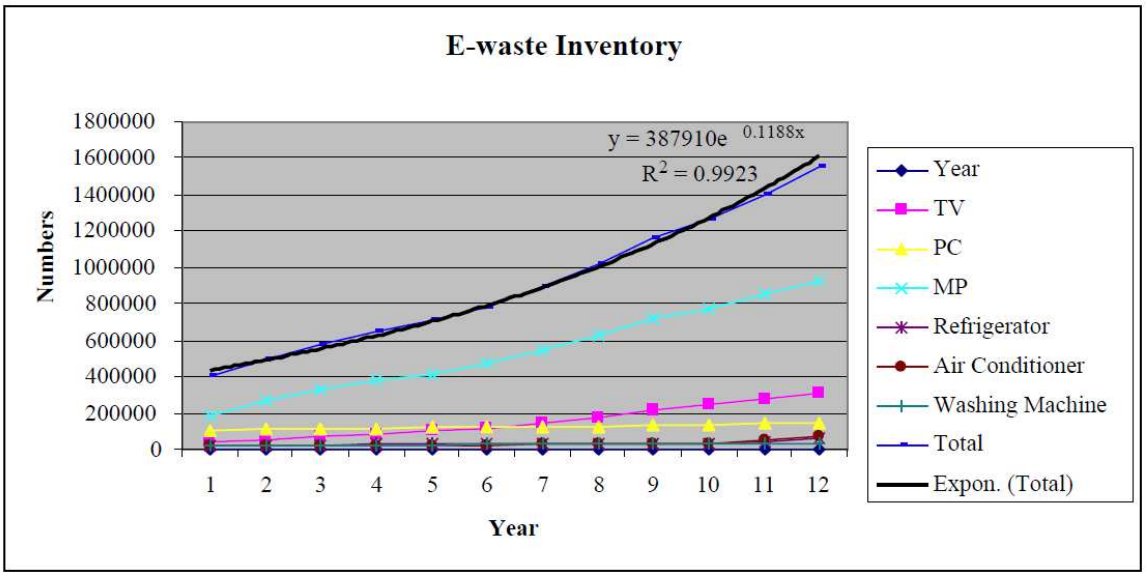

Figure 5.3: Projected E-waste inventory (numbers)

Table 5.13: Projected E-waste inventory (metric tons)

TV	PC	MP	Refrigerator	Air Conditioner	Washing Machine	Total
1461	2670	30	953	843	835	**6792**
1904	2731	43	999	888	876	**7441**
2420	2796	53	1037	931	918	**8156**
3009	2762	61	1271	1059	962	**9124**
3672	3015	66	1246	1079	1009	**10086**
3826	3075	76	1309	1137	1058	**10480**
5050	3138	87	1368	1197	1109	**11948**
6274	3202	100	1468	1275	1162	**13482**
7542	3267	116	1564	1354	1218	**15061**
8819	3397	124	1627	1422	1277	**16667**
9718	3498	136	2217	2455	1339	**19363**
10714	3597	149	3126	3454	1404	**22443**

The graphical representation of the inventory is shown in figure 5.4.

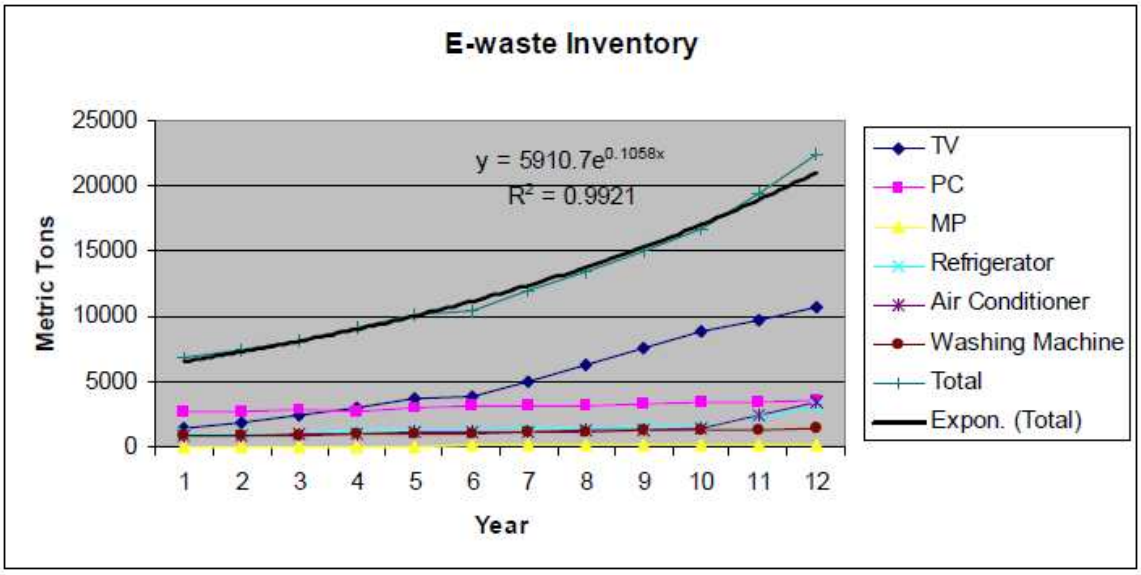

Figure 5.4: Projected E-waste Inventory (metric tons)

Figure 5.4 shows that the E-waste inventory in PPM is expected to grow exponentially with a significant correlation during the next decade. In terms of weight, E-waste from TV is expected to grow at a higher rate followed by PCs, refrigerator, air conditioners, washing machine and mobile phones.