ENERGY SAVING POTENTIAL IN INDIAN HOUSEHOLDS FROM IMPROVED APPLIANCE EFFICIENCY

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ENERGY SAVING POTENTIAL IN INDIAN HOUSEHOLDS FROM IMPROVED APPLIANCE EFFICIENCY

INTRODUCTION

With growing concerns about the global environment and the country's own energy security, energy efficiency is attracting greater attention in India. Because there is an urgency to reduce energy use rapidly and resources are limited, it is important to ask how best to target energy efficiency (EE) efforts to achieve the largest reduction. In that context, we set about in this paper to estimate the saving potential from various end-uses or appliances in Indian households.

Our approach in this paper is based on two steps. First, we review the composition of energy consumption in Indian households to identify the more significant areas of consumption – the "big ticket" items. Second, for the areas of significant consumption, we estimate the potential savings from moving to more efficient appliances in the coming years. Forecasting energy use and sales of new appliances is fraught with uncertainty. Our focus in this paper is not to get precise estimates of energy saving potential but rather to get an understanding, with a reasonable degree of accuracy, of the relative importance of different end-uses and size of savings from various appliances.

BACKGROUND

Several researchers have looked at the contribution of various end-uses or appliances to electricity consumption by Indian households. In 2000, the International Energy Initiative (IEI) and the Centre for Monitoring Indian Economy Pvt. Ltd. (CMIE) carried out a detailed study to develop an integrated picture of the Indian energy sector including both the supply-side and the demand-side (IEI CMIE, 2000). As part of that work, they estimated the contribution of various end-uses and/or appliances to the electricity consumed in Indian households. However, the study did not look at the savings that could be achieved by shifting to more efficient appliances. The study was based on data for the years 1994-95.

Similarly, Murthy, Sumithra & Reddy (2001) developed estimates of the components of electricity consumption in households in Karnataka based on data obtained from several surveys carried out in 1994-95. They too did not estimate potential savings from shifting to EE appliances.

More recently, The Energy and Resources Institute (TERI) published a report that looked at eight scenarios for the Indian energy sector (TERI, 2006). Using data for 2001-02 as the baseline, TERI estimated the energy consumed by the various sectors for the period 2001-02 to 2031-32 for the various scenarios. While there was a scenario for high efficiency it did not explicitly look at the potential savings from energy efficiency for the electricity consumed by each sector. However, the report does contain data about electricity consumption and usage patterns for various appliances that we used to check our assumptions.

The most relevant work to this effort is a study carried out by Letschert and McNeil of the Lawrence Berkeley National Laboratory (LBNL) that estimated the potential savings in electricity by Indian households over the period from 2000 to 2030 (LBNL, 2007). Letschert and

McNeil use projected income to estimate the ownership of various appliances in Indian households. The savings per new appliance is calculated as the difference between the current consumption (business as usual - BAU) and an energy efficient model. They use data for 2000 to project the ownership patterns and saving potential. However, we find that their estimate for energy consumption in 2005 is greater than actual consumption reported by the Central Electricity Authority (CEA, 2007). Further, the total energy consumption for the residential sector in 2008 projected by LBNL (200 TWh) is much greater than CEA's forecast (148 TWh).

Seeing these differences and that most of the earlier work is based on fairly old data, we felt that it was useful to update the estimate of saving potential based on more recent data.

COMPOSITION OF THE ENERGY CONSUMPTION OF INDIAN HOUSEHOLDS

According to the Central Electricity Authority (CEA) the total end-use consumption of electricity in the domestic sector was projected at the time to be 148 billion kWh (TWh) in 2008 (CEA, 2007). Households mainly use electricity for lighting and electric appliances (fans, refrigerators, TVs, water heaters, air coolers etc.). For developing a picture of electricity consumption in households, we focus on consumption in the calendar year 2008. In order to estimate the contribution of each of these end-uses and the associated appliances to the total electricity consumption in households, we undertook two tasks: (1) we obtained estimates of the stock of appliances in households; and (2) we developed estimates of the consumption per appliance. The contribution of an end-use is then simply the product of these two estimates.

Stock of Appliances

Stock estimates are in most cases based on National Sample Survey Organization (NSSO) surveys. However, because the most recent NSSO survey for the relevant data was done in 2004, we could not obtain stock data for 2008 directly from the NSSO surveys. Instead, we first extracted the stock for 2004 and then used appliance sales data / estimates for the years 2005-2008 to arrive at the stock of appliances for 2008. Because NSSO survey results do not give the stock of appliances directly but instead give saturation levels for the different appliances, we calculated stock of appliances as the product of the saturation level, the number of households, and the number of units of each appliance used per household. While the number of units used per household is close to one for most appliances, it is about 1.8 per household for fans. NSSO surveys do not cover lighting. For lighting, we used data on sales from Electric Lamp and Component Manufacturers' Association of India (ELCOMA) to estimate the stock and future sales.

In order to get sales data for extending the stock data from 2004 to 2008, we used data mostly from the Consumer Electronics and Appliances Manufacturers′ Association (CEAMA) and TV Veopar Journal. We also used stock data from NSSO surveys in 1999, 2002 and 2004 to cross-check sales estimates based on changes in stock. While using sales data to calculate additions to stock, we made appropriate corrections to account for the fact that a part of annual sales is used simply to replace "old" stock and therefore does not contribute to increase the stock of appliances. For details on how stock of appliances and sales were estimated, please see Annexure A. Table 1 gives the stock of each appliance in 2008 based on our calculations.

Consumption Data

In order to estimate the consumption we reviewed studies of Lawrence Berkeley National Laboratory (LBNL), The Energy and Resources Institute (TERI), International Energy Initiative (IEI) & Centre for Monitoring Indian Economy Pvt. Ltd (CMIE) and an analysis of the Karnataka Survey from 1994/1995 by Murthy, Sumithra & Reddy. (for more details see Annexure B)

For many of the appliances, there is a large variation in size and type of appliance used in Indian households. All the studies that we reviewed, calculated an average consumption for the appliances. Table 1 gives the stock, consumption per year and total consumption in TWh of the most commonly used appliances in Indian household in 2008. The total consumption in all households of almost 152 TWh in Table 1 is reasonably close to the total of 148 TWh estimated by CEA for 2008, giving us some confidence in the validity of the assumptions we have made in our calculations.

Table 1 - Stock & Consumption (In kWh/Year & Total) Of Each Appliance Type In 2008

Type of appliance	**Stock in million**	**kWh/year**	**Total TWh**
Fan	246	112	27.60
Incandescent bulb	302	80	24.22
Refrigerator	37	588	21.95
Television (TV)*	99	175	17.27
Tube light	280	107	30.08
Air conditioner	5	1199	6.05
Room heater	9	555	5.00
Electric Water heating (Geyser)	10	438	4.58
Air cooler	19	195	3.70
Stand-by-power			3.06
Washing machine	15	185	2.77
Radio	60	33	1.96
Compact Fluorescent Lamp (CFL)	68	22	1.49
Tape recorder, CD player	37	34	1.24
Computer*	6	105	0.60
Set-Top Box*	11	22	0.24
DVD Players*	29	1	0.03
VCR VCP	3	2	0.01
Total			151.86

* without Stand-by-power

Components of Current Electricity Consumption in Households

In Table 1 we see that a major part of the consumption comes from: fans, lighting (incandescent bulbs and tube lights), refrigerators, ACs, air coolers, electric water heater, televisions (active mode) and stand-by power (incl. Set-Top-Boxes, DVD Players, TVs, and Computers). Together, these nine end-uses or appliances account for almost all the total consumption. From now on, we will focus on these nine appliances. We exclude CFLs, washing machines, VCRs/VCPs and music systems (incl. radios) because their contribution to total consumption is negligible.

Figure 1 shows graphically the share of the total consumption of the nine appliances we are focusing on. It is interesting that just four appliances / end-uses– lighting (incandescent bulbs and tube lights), fans, refrigerators and TVs– contribute 80% of the household consumption.

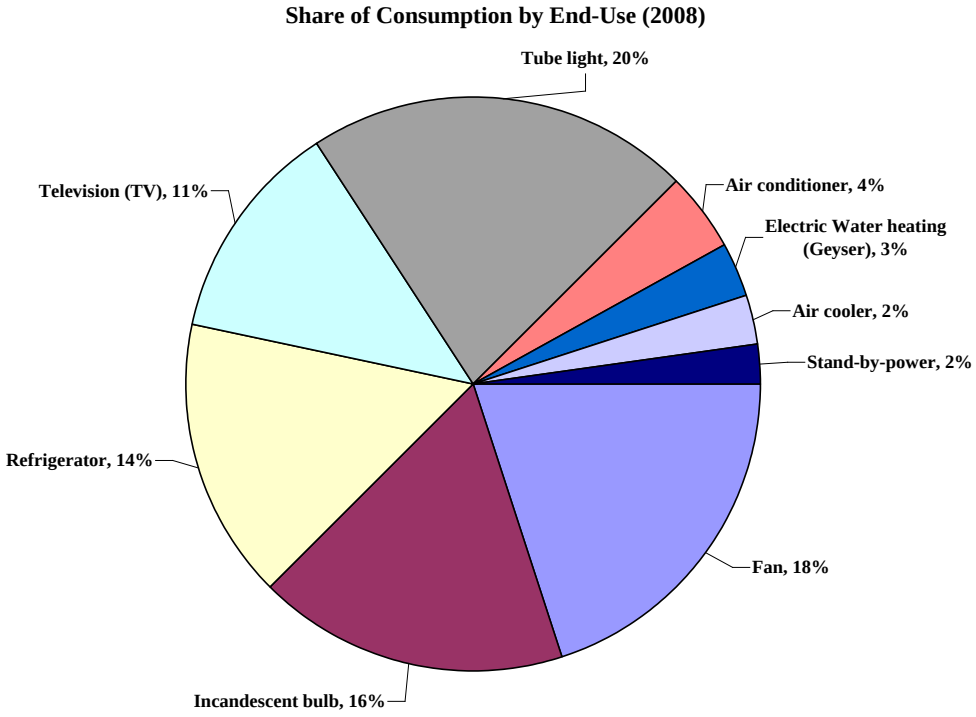

Figure 1 - Focus Areas and Their Share of Total Consumption In 2008

SAVING POTENTIAL

We now calculate the potential for energy saving for our focus end-uses/appliances for the next five years. In calculating the potential we focus only on future sales of appliances, and calculate the potential as the difference in energy consumption between a BAU case and a 100% EE case[2]. The BAU case assumes that for the following 5 years the purchasing pattern would remain mainly on lowest first-cost basis, that is only the cheapest model will be bought. For lighting where data on purchasing patterns with respect to efficiency was available the BAU scenario assumes an unchanged purchasing pattern. In contrast, the 100% EE scenario assumes a shift of all sales to the most efficient appliance (technical potential), that is only energy efficient appliances will be bought. Thus, we first determine how many new appliances are going to be sold over the next five years, and then determine the difference in consumption between the average appliance bought under BAU and an EE appliance. We recognize that both BAU and EE scenarios are hypothetical scenarios. Neither will people buy only the cheapest model in the BAU case nor the most efficient one in the EE case. However, since many of the future purchases will be made by those households that are now poor or not electrified, they will be highly price sensitive, and therefore the assumption of the cheapest model in the BAU case is appropriate.

Our analysis will overestimate the saving potential to the extent that some consumers will buy energy efficient appliances instead of cheap models. However, the aim of this paper is to identify the major saving areas. The fact that some consumer may choose a more efficient appliance is unlikely to change the priority areas – the primary conclusion of the paper.

[2] We use the term 100% EE case to indicate that we assume that all appliances bought in the future will be of the most energy efficient models. We recognize that this is hypothetical because in reality there would be a transition period as consumers moved to more efficient models.

Sales Estimates

In order to estimate future sales, an analysis of the past sales is conducted. As discussed earlier we used from CEAMA and TV Veopar to arrive at sales growth rates for the period 2004 to 2008. Based on this data and our judgment we developed estimates for the period 2009 to 2013. For simplicity, we assume that the growth rate remains constant. Since sales are reported for all sectors and not just households, an estimate of the household share is applied. For more details on how the sales growth rates were calculated, please see Annexure A. Table 2 shows the result for our focus areas.

Table 2 - Sales In 2009 And 2013, Growth Rate And Household Share

	Sales in 2008	Sales in 2013	Growth rate	% of sales HH sector
Fan	30.00	48.32	10%	85%
Incandescent bulb	734.00	774.12	1%	80%
Refrigerator	5.46	10.99	15%	85%
Television (TV)	16.50	31.08	14%	85%
Tube light	186.00	196.46	1%	66%
Air conditioner	2.63	8.01	25%	60%
Electric Water heating (Geyser)	1.70	3.12	13%	85%
Air cooler	0.90	0.70	-5%	95%
Set-Top Box	5.00	12.44	20%	95%
Computer	7.80	19.41	20%	20%
DVD Players	8.00	11.22	7%	95%

Technical Potential Savings

To simplify our analysis we do not look at individual sizes of appliance, but instead use either an average size or the most common type and size for each appliance. We do not expect that this simplification in the analysis will seriously bias the results of the analysis in either direction, because the impact will be off-setting to some extent. For example, larger savings from bigger appliances will be off-set by smaller savings from smaller appliances. We also exclude technological change that is likely to lower, to some extent, the consumption of the cheapest as well as the most efficient appliance.

To collect data on the energy performance of the cheapest model, we conducted market research on several Indian comparison-shopping websites (naaptol, compareindia, pricesbolo, open2save) and also visited shops selling appliances. To estimate the technical saving potential a review of both, appliance efficiency studies (LBNL, 2005, 2007) and star labeling information for high efficient models according to BEE (EMT, 2009a, 2009b) was conducted (for more details see Annexure B)

Table 3 shows the average wattage of the cheapest model in comparison to the wattage of the most efficient appliance.

Table 3 - Average Wattage of the Cheapest and Most Efficient Model

Appliance	Cheapest model	Energy efficient model	Savings
	W	W	In %
Incandescent bulb to CFL	55	15	73%
Direct Cool Refrigerator	350 kWh	179 kWh	49%
Flat Screen TV	73	51	30%
Fan	70	50	29%
Tube light T12 to T8[3]	49	36	27%
Window AC	1892	1406	26%
Air cooler	162	125	23%

Special Cases

We now discuss standby losses and water heating for which the potential for savings is calculated in a different manner from that discussed above. .

Stand-by losses

Stand-by loss is defined as the electricity consumption of an appliance when it is actually not in use. There are a variety of stand-by/off modes that still consume electricity. For our analysis we include the stand-by losses of Set-Top-Boxes, DVD Players and TVs. We add the off mode of computers (including screens) because the transformer causes a significant consumption in some models even in off modes. That means if the main supply is not switched off a desktop computer and its screen will continue to consume power. For each appliance the stand-by consumption is estimated based on a small pilot study being carried out by Prayas. Table 4 shows the result (for more details see Annexure C)

Table 4– Stand-By Consumption

Appliance	Stand-by hours / day	Days / year	Stand-by Watt	Stand-by kWh/year	% of appliances on stand-by
Set-Top-Box	16	365	10	58	85%
TV	16	365	7	41	50%
Computer[4]	22	365	9	72	30%
DVD Player	23.5	365	6	51	25%

Assuming that 1W becomes the international standard[5], we have assumed in our calculations that the stand-by loss of all appliances can be reduced to 1 W or less. If the future sales from 2009 - 2013 were limited to 1 W stand-by consumption that would result in a reduction of the 2013 household consumption of about 4.5 TWh. We further assume that an awareness campaign about switching off appliances could reduce the stand-by consumption of the 2008 stock by 50% (1.5 TWh).

[3] We have not opted for T-5, as we do not think it is possible as well as economical or desirable to change all tube lights by T-5 in next five years.

[4] Although in several cases the soft switch-off of the computer keeps the monitor on, and some people keep their computers on for much longer than required; we have not considered these. Only the transformer losses in CPU and monitor are considered

[5] EU has already set standards for standby loss to be a maximum of 1W by 2010 and 0.5 W by 2013 for all appliances. We have used 1W as the standard in our calculations, but using 0.5W will not change the results significantly.

Water heating

Water heating offers another significant saving potential. So far electric geysers were the most common way of heating water apart from burning wood. However, gas or solar water heating is more efficient than electric water heating. Thus a shift to gas or solar water heaters can effectively reduce electricity consumption. If 35% of the 2008 water heater stock was replaced by solar or gas until 2013 this would reduce household consumption by around 3.22 TWh.[6]

Results for Potential Savings

The results of our calculations for the reduction in consumption in 2013 if all future additions of appliances were of the most energy efficient model available today[7] are shown in Figure 2 and Table 5.

Table 5- Potential Savings in TWh in 2013

Appliance	Savings in 2013 TWh
Incandescent bulb	18.58
Tube light	8.43
Refrigerator	6.16
Stand-by-power	6.02
Fan	5.48
Television (TV)	5.04
Air conditioner	4.24
Water heaters	3.22
Air cooler	0.15
Total	**57.32**

We also estimated the reduction in the requirement for new capacity associated with the shift to efficient appliances and the savings of 57 TWh by 2013. As shown in Table 6, based on the annual usage hours and peak coincidence factor for the various appliances, and accounting for T&D losses of 15% and average availability of 90% for new capacity, the potential reduction in capacity requirement is over 25,000 MW by 2013. This is equivalent to avoiding more than one ultra-mega power plant every year for five years.

[6] A more detailed study on this topic is being done by LBNL and PEG.

[7]. Note: The figures only displays the savings in consumption in the year 2013 if a complete switch from cheap to EE sales from 2009 onwards is achieved PLUS the special saving potentials are applied. Excluded are savings from replacements of old appliances. Replacements can result in additional savings if the old appliance was less efficient than the cheapest new model.

Table 6- Reduction in New Capacity Requirements by 2013

Appliance	Energy Saved in 2013 (TWh/yr)	Usage days/yr	Usage hrs/day	Peak Coincidence Factor	Reduction in Capacity Reqmts (MW)
Refrigerator	6.16	365	24	1.00	919
Air conditioner	4.24	120	6	0.50	3849
Incandescent bulb	18.58	365	4	0.75	12476
Tube light	8.43	365	6	0.75	3773
Fan	5.48	200	8	0.50	2239
Television (TV)	5.02	365	6	0.75	2247
Electric Water heating (Geyser)	3.22	200	1.25	0.00	0
Air cooler	0.15	120	9.3	0.50	89
Stand-by-power					0
Set-Top-Box	1.90	365	16	0.80	339
TV	1.83	365	16	0.80	327
Computer	0.27	365	22	0.25	11
DVD Players	0.50	365	23.5	1.00	76
TOTAL	56				26345

Note: 1. Calculations assume T&D Loss of 15% and average availablity factor of generating capacity to be 90%

2. The total energy savings is less than 57TWh as calculated earlier because some of the appliances with very small savings are not included in the table

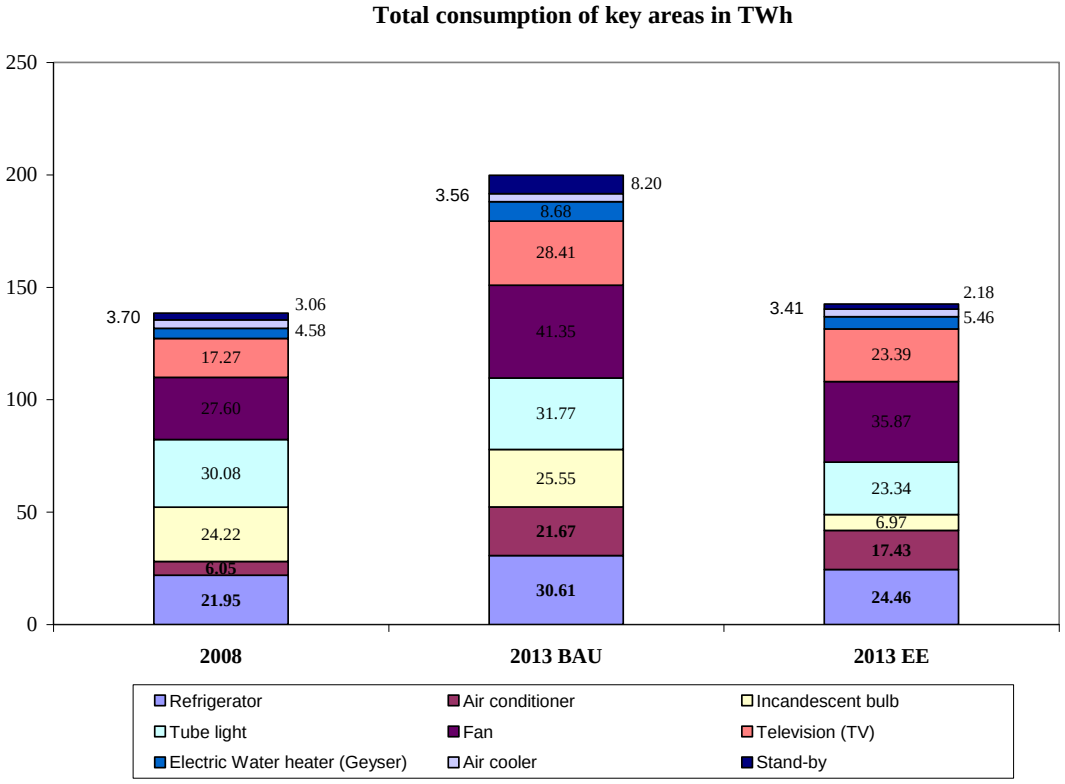

Figure 2 – Total Consumption of Key Areas in 2008 and for Both 2013 Scenarios

CONCLUSIONS

Our calculations show that nine end-uses or appliances contribute almost all the electricity consumption in Indian households. Furthermore, just four appliances / end-uses– lighting (incandescent bulbs and tube lights), ceiling fans, TVs, and refrigerators are responsible for 80% of the electricity consumption in households. In addition, shifting to the most energy efficient appliances available now for all future sales results in annual savings of about 57 TWh in 2013 which is about 30% of the additional annual consumption that would otherwise have happened under a BAU scenario in the year 2013. It should also be noted that our results indicate that if all new sales are of energy efficient appliances, then the consumption in 2013 will be similar to the 2008 consumption even though many more new appliances will have been added. These potential savings in energy would avoid more than 250,000 MW in generating capacity additions, equivalent to one ultra-mega power plant every year for five years. Our estimate of the savings potential is really the technical potential because we assume that all appliances from now on will be EE models. Clearly such a shift will occur over time and thus the actual savings achieved will be less. However, we only looked at a short time period of 5 years. A longer forecast and new developments in energy efficiency can increase the savings significantly.

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Annexure A: Estimates of Stock and Projection of Sales for Appliances

This Annexure estimates the stock of appliances in 2008. It also projects sales until 2013 for our focus areas. The analysis will be based on:

- Saturation data for the years 1999, 2002 and 2004
- Number of households
- Number of appliances per household
- Sales 2002 - 2008
- Sales 2009-2013

The stock of most appliances is based on data of the National Sample Survey Organisation (NSSO), Census and sales data. NSSO data reports the saturation of 1999, 2002 and 2004. In combination with the number of households the stock for these years was calculated. In order to get the 2008 stock an analysis of sales before 2008 was performed. For lighting, Set-Top-Boxes and DVD Players there was no NSSO saturation data available. The stock estimate of these appliances is based on sales figures only. To estimate the future saving potential we also projected the sales for the years 2009-2013.

Stock of Appliances 1999, 2002 and 2004

Saturation Data

NSSO reports saturation rates of household appliances in three surveys (NSSO, 2007, Appendix A-402; NSSO, 2005, Statement 18, 20, 21; NSSO, 2001, Appendix A-436).

For the 1999/2000 and the 2004/2005 survey the data collection took place from July to June (e.g. June 2004 to July 2005). We interpret the result as the saturation at the end of the earlier year (e.g. for the 2004/2005 data collection = end 2004). The 2002 survey collected data from July – December 2002. Also for this survey we use the result as the saturation at the end of the year 2002.

The sample size of the surveys was 120,309 (99/00) 97,882 (2002) and 124,664 (04/05) households. The surveys cover a slightly different set of appliances; that means not for all appliances the saturation of all years was available. For example washing machines and water heaters are only reported in 2002.[8]

We also reviewed the Indian Human Development Survey (IHDS, 2005). It is a nationally representative, multi-topic survey of 41,554 households conducted by the University of Maryland and the National Council of Applied Economic Research (NCAER). IHDS numbers were collected from November 2004 to October 2005. The saturation of ACs and fans is similar to NSSO numbers. The refrigerator and TV and air cooler saturation in the IHDS Survey is much larger. We analyze these differences in the appliance part below.

Number of Households

Census reports 193.6 million households in India in 2001 (Census, 2003). It projects the 2006 number to be 209.9 million (144.5 rural / 65.4 urban). We calculated the growth rate (1.03%

[8] Even though saturation data was available for rural and urban areas for simplicity and because other data was not available separately for rural/urban areas our analysis does not differentiate between rural and urban areas.

rural; 3.04% urban) between 2001 and 2006 and consider it to be constant over the years. Based on this assumption the number of households for the years 1999, 2002 and 2004 was derived.

Number of Items per Household

The 1999/2000 NSSO Survey also reports the average number of each specific appliance possessed per household (NSSO, 2001). Due to lack of newer data the same number is also used for 2002 and 2004. This could underestimate the stock if the number of items per household has increased significantly. For computers, room heaters and geysers, where such data was not available we assumed that households possess only one if any.

Together with the saturation rate and the number of households the stock in 1999, 2002 and 2004 was calculated:

$$St_{99i} = Sa_{99i} * HH_{99} * No_{99i} \quad (1)$$
$$St_{02i} = Sa_{02i} * HH_{02} * No_{99i} \quad (2)$$
$$St_{04i} = Sa_{04i} * HH_{04} * No_{99i} \quad (3)$$

St = Stock of appliance
$_i$ = type of appliance
$_{99}$ = year (99 = 1999; 04 = 2004)
Sa = Saturation rate of appliance
HH = Number of households
No = Average number possessed per household of each specific appliance

Table A1 shows the result for those appliances that were reported by NSSO.

Table A 1 - Stock of Appliances in Indian Households in 1999, 2002, 2004

Appliance Type	Saturation				Stock		
	1999	2002	2004	Items household	1999	2002	2004
	in %	in %	in %		in million	in million	in million
Refrigerator	8.41%	10.84%	12.73%	1.04	16.33	22.09	26.78
Air conditioner		0.63%	1.08%	1.20		1.69	2.98
Fan	38.22%	48.94%	51.55%	1.78	133.42	178.58	193.99
Television	30.23%	37.79%	37.87%	1.02	58.00	76.07	78.73
Geyser		2.64%		1.00*		5.20	
Washing machine	2.94%	3.58%		1.01	5.68	7.24	
Tape recorder, CD player	14.38%				28.20		
Sewing machine	11.04%	14.42%	13.83%	1.05	21.73	29.76	29.48
Radio	31.73%		28.51%	1.03	61.21		59.71
Air cooler	4.30%	6.30%	7.54%	1.20	10.61	16.33	20.21
VCR VCP	1.40%			1.02	2.74		
Computer		1.34%		1.00*		2.63	
Room heater		3.23%		1.00*		6.35	

* Prayas assumption

Sales of Appliances

In order to estimate the 2008 stock an analysis of past sales figures has been conducted. If 2004 saturation was available sales from 2005 to 2008 were estimated. If only 2002 saturation was reported the sales from 2003 to 2008 were estimated.
However, sales do not equal stock addition, because a share of sales replaces old appliances. Therefore, we assumed a replacement rate of the old stock for each appliance. It indicates the share of the old stock (2002 or 2004) that has been replaced by new appliances. For instance, at a 10% replacement rate, 40% of the old appliances are replaced in 4 years. The replacement rate is based on assumptions about the life time of appliances. E.g. for refrigerators, air conditioners, fans and air coolers we assumed a life time of 20 years and replacement rate of 5%. In our study it is only relevant for the 2008 consumption. The energy saving from 2009 – 2013 is not affected by whether a new purchase is a replacement or an addition.

We have also used replacement rate or life-time of bulbs and FTLs to estimate the number of light points (and hence stock) of these items. In our calculations for savings from EE lighting measures, we have assumed that all sales are for replacing bulbs/tubes at existing light points. This approach does have problems; however, given the lack of data on replacement sales versus new sales, there was no better way to estimate the savings. Our assumption leads to a conservative estimate of savings from replacing incandescent bulbs and an optimistic estimate of savings from replacing tube-lights. Given that the savings from incandescent bulbs is much larger than from FTLs, the overall estimate of savings is therefore conservative.

By using sales figures another precautions has to be taken in consideration. Often sales figures are reported across all sectors. Therefore it needs to be known how many of the appliances are bought by the domestic sector. We assume a household sector rate for each appliance (for savings across all sectors see Annexure D). Both the replacement rate and the household share percentage are assumed to remain constant (except for ACs where the household share increases).

Furthermore, to estimate the future saving potential of the focus areas we projected the sales from 2009 – 2013. This projection is based on the growth rate of sales in the past.

<u>Refrigerator</u>
IHDS reports 17.8% saturation which equals 36.75 million refrigerators in 2005, whereas NSSO reports 26.78 million (12.7%). This discrepancy can not be explained. However, an analysis of the 2002 to 2004 sales scenario backs the lower numbers. In 2002 NSSO reports 22.09 million fridges. The stock addition until 2004 was 4.69 million fridges. If we assume a lifetime of 20 years (replacement rate of 5%) and an 85% household sector share the sales must have been 8.12 million to arrive at this stock addition. The reported sales were even lower (7.6 million). Unfortunately there is only one data point from IHDS available. So the stock of 36.75 million can not be verified.
In this paper the NSSO 2004 stock and CEAMA sales assumptions are used to estimate the stock increase from 2005 to 2007. For 2008 a sales growth rate of 15% of applied.

Table A 2 - Refrigerator Sales in Million

2003	2004	2005	2006	2007	2008	Future growth	Source
				4.6			BEE (2008)
3.7	3.89		4.2	4.85			TV Veopar
3.7	3.9	4.1	4.4	4.75	5.5*		CEAMA (2008)
		4.1	4.2	4.75	5.46**	15%	Assumption for this study

* CEAMA projection; ** 15% growth from 2007

Future sales: CEAMA reports an average sales growth rate of 6.44% from 2003 to 2007. However, it is assumed that sales growth rate accelerated in recent years. The 2008 sales are projected to be 16% more than 2007. TV Veopar sales for 2008 were not available, but they also assumed acceleration. From 2006 to 2007 they report a sales growth of 15%. Thus it seems the sales growth rate of refrigerators was accelerated in the last two years. To take this in consideration an increase of the average growth to 15% is assumed for the years from 2007 onwards.

Household sector share and replacement rate: In accordance with TERI it is assumed that 85% of fridges are going into the household sector (TERI, 2006). A 5% replacement rate of the old stock (2004) is applied which equals a life time of 20 years.

Air conditioner

TV Veopar numbers are used until 2007. For 2008 sales the future growth rate of 25% is applied.

Table A 3 - Air Conditioner Sales in Million

2003	2004	2005	2006	2007	2008	Future growth	Source
				1.73			BEE (2008)
0.98	1.23	1.5	1.85	2.1			TV Veopar
1	1.25	1.5	1.85	2.2	2.75*		CEAMA (2008)
0.98	1.23	1.5	1.85	2.1	2.63**	25%	Assumption for this study

* CEAMA projection; ** 25% growth from 2007

Future sales: The growth rate from 2003 to 2007 was 21%. However, the growth rate from 2006 to 2007 slowed down (TV Veopar 13.51%, CEAMA, 18.92%). Nevertheless CEAMA projects an accelerated growth rate of 25% for 2007 to 2008. We assume that this will take place and suppose that from 2007 onwards sales will grow continuously at a rate of 25% on average, since saturation of ACs is still very low.

Household sector share and replacement rate: LBNL predicts that the domestic sector share will rise from 25% in 2005 to 50% of the sales by 2010 (LBNL, 2005). Therefore it is assumed that 1/3 of sales were to residential consumers for the years 2005 to 2008. From 2009 onwards we assume 60% of ACs are bought by residential consumers. A replacement rate of 5% is applied which equals a life time of 20 years.

Fan

The Indian Fan Manufacturer Association (IFMA) estimates the Indian market at 30 million fans in 2008 (IFMA, 2009). In this paper it is assumed that sales have been growing at a rate of 8% since 2003. That would mean that sales grew from 20.42 in 2003 to 30 million in 2008.

We cross check this assumption with the saturation growth according to NSSO. The stock based on NSSO saturation data grew from 178.6 to 193.9 million between 2002 and 2004. Hence, the number of fans increased by 15.41 million. We assume that 5% of the old stock is replaced each year. That means that in the years 2003 and 2004 17.86 million fans were already replacements of old fans. Together with the sales addition 33.27 million fans were sold in the household sector. If the household share is 85% total sales would equal 39.14 million.

This supports our assumption of 8% sales growth rate since 2003. According to this rate sales were 42.47 million (36.1 million to the domestic sector) in the two years of 2003 and 2004.

Future sales: IFMA assumes a sales growth rate of 10% in the following years. We follow this assumption.

Household sector share and replacement rate: A 5% replacement rate is applied. We assume 85% of the fans being bought by the household sector.

Television

NSSO reports 78.73 million TVs (37.9% saturation) in 2004, whereas IHDS reports 56% saturation which equals 115.2 million TVs in 2005. Again we conducted an analysis of the sales figures to see if NSSO numbers are robust. From 2002 to 2004 stock increased by 2.66 million according to NSSO. If we assume a lifetime of 12.5 years (replacement rate of 8%) and an 85% household sector share the sales must have been 17.4 million to arrive at this stock addition. The reported sales were 17.5 million. So, the stock increase in the NSSO surveys is supported by the sales figures. Unfortunately there is only one data point from IHDS available. So the stock of 115.2 million can not be verified.

In this paper the NSSO 2004 stock and CEAMA sales assumptions are used to estimate the stock increase from 2005 to 2008.

Table A 4 - Television Sales in Million

2003	2004	2005	2006	2007	2008	Future growth	Source
8.5	9.25	10.25	11.75	14.5	16.5*		CEAMA
8.25	9.25	10.27		15.88	16.38		TV Veopar
8.25	9.25	10.25	11.75	14.5	16.5	13.5%	Assumption for this study

* CEAMA projection

Future sales: Sales grew by 14% on average from 2003 to 2008. Between 2007 and 2008 TV Veopar reports a growth of 3.15%, CEAMA predicts 13.5%. The TV Veopar figure seems too low in comparison to past growth rates and CEAMA numbers. We don't see any reason, why sales growth rates would slow down so dramatically. Thus, the CEAMA assumption of 13.5% growth is applied.

Household sector share and replacement rate: An 8% replacement rate is applied. We presume 85% of TVs are purchased by the household sector.

Electric Water heating (Geyser)

There are no official sales figures available for water heaters. According to Financial Express the sales were 1.5 million in 2007 (Financial Express, 2008). LBNL assumes that electric water heaters have the same ownership trend as washing machines (LBNL, 2007). Therefore, the same

sales growth rate as for washing machines (13%) is used. This rate is extrapolated to 2003 and until 2013 for our analysis. That means that sales grew from 0.92 million in 2003 to 1.69 million in 2008.

Future sales: A constant growth rate of 13% is applied for the 2009 to 2013 period. Sales will grow from 1.7 in 2008 to 3.12 in 2013.

Household sector share and replacement rate: We assume that 85% of the sales are in the residential sector. Since usage of water heaters was not very wide spread in the past it is likely that the stock build-up happened more recently. This means the stock contains few old geysers which would result in a lower replacement rate. Thus, only 4% replacement rate is applied.

Washing machine

We apply TV Veopar sales for this paper.

Table A 5 - Washing Machines Sales in Million

2003	2004	2005	2006	2007	2008	Future growth	Source
1.4	1.5	1.7	1.85	2.1	2.25*		CEAMA
1.36	1.55	1.67	1.88	2.2			TV Veopar
1.36	1.55	1.67	1.88	2.2	2.49**	13%	Assumption for this study

* CEAMA projection ** extrapolation of 13% growth rate

Future sales: From 2003 to 2007 sales grew by 12.8%. In the year 2007 to 2008 TV Veopar reports 17.02% growth, whereas CEAMA projects 13.5% for 2008. We assume a continued growth rate of 13%.

Household sector share and replacement rate: It is assumed that 85% of the sales are in the residential sector. Since usage of washing machines was not very wide spread in the past the same logic as for water heaters applies. We suppose a replacement rate of only 4%.

Tape recorder/CD player

NSSO reports the saturation for Tape recorder/CD Player to be 14.38% in 1999 (28.2 million) (NSSO, 2001). No sales figures were available for tape recorder/CD Player. Therefore, a stock growth rate (3%) from 1999 onwards is applied. This results in a stock increase of 8.6 million to 36.80 million appliances in 2008.

Sewing machine

NSSO reports the saturation sewing machines to be 13.86% (NSSO, 2007). That equals a stock of 29.79 million sewing machines in 2004. However, there was no growth in comparison to the last survey (2002). IHDS reports a saturation of 27% in 2005 (54.9 million). This discrepancy can not be explained. Since we don't know how many sewing machines are electric and their usage pattern is also unclear we exclude them from our consumption analysis.

Radio

No sales figures were available for radios. According to NSSO the saturation had decreased from 31.74% in 1999 to 28.53% in 2004. However, the NSSO survey in 2002 reported an increase. We assume the stock to remain stable at the 2004 level (59.71 million).

Air cooler

NSSO reports a saturation of 7.54% in 2004 (stock = 20.21 million), whereas IHDS indicates 13% saturation (26.6 million). Sales figures over the earlier years were not available for air coolers, thus this discrepancy can not be explained.

According to Financial Express sales in 2006 were around 1 million (Financial Express, 2007). The market is assumed to have de-grown at 5-10% over the last 2 years due to large shifts to air conditioners. We follow this assumption and extrapolate -5% growth rate to derive the sales figures of 2005 and 2007 onwards.

Future sales: The assumption of de-growth of 5% per year is assumed to continue until 2013.

Household sector share and replacement rate: A replacement rate of 5% is applied. Our assumption is that 95% of sales are going into the household sector.

VCR VCP

No sales figures were available for VCR/VCPs. Since these appliances have been mainly replaced by DVD players, we suppose that the stock remains stable at the 2002 level (2.74 million).

Computer

According to NSSO 1.34% of the Indian households owned a computer in 2002 (NSSO, 2005). That equals 2.63 million computers.

Forbes reports a shipment raise by 20% to 6.5 million in 2007 (Forbes, 2008). The Ministry for Communications and Information Technology estimates sales to grow to 7.25 million in 2007/2008 (Ministry of Communications and Information Technology, 2008).

Table A 6 - Computer Sales in Million

2003	2004	2005	2006	2007	2008	Future growth	Source
			5.42	6.5		20	Forbes
				7.25			Min. IT
3.14*	3.77*	4.52*	5.42	6.5	7.80*	20%	Assumption for this study

*Extrapolation of 20% growth

We apply the Forbes number and assume that the past growth has been steady at 20% since 2003.

Future sales: We assume the computer sales to continue to grow at a rate of 20%.

Household sector share and replacement rate: It is supposed that 15% of computers are bought by the domestic sector until 2008. From 2009 to 2013 we suppose 20% of the purchases are by residential consumers. A replacement rate of 10% is applied.

Room heater

According to NSSO 3.23% of the Indian households owned a computer in 2002 (NSSO, 2005). No sales figures were available for Room heaters. We therefore assume a stable stock growth rate from 2002 onwards (6%). This results in a stock increase of 2.66 million to 9.01 million appliances in 2008.

Stock Estimate of Appliances without Saturation Data

Incandescent bulb

The Bureau of Energy Efficiency (BEE) reports in its CDM scheme *BACHAT LAMP YOJANA* a number of 400 million incandescent bulbs in use in Indian households (BEE, 2009a). The Electric Lamp and Component Manufacturers' Association of India (ELCOMA) reports 734 million incandescent bulbs sold in the country (ELCOMA, 2009). If the average lifetime is 750 hours at a usage pattern of 4 hours/day a lamp would last for 0.51 years. We assume that 90% of the bulbs are being sold in the household sector. That would result in 301 million bulbs in use in 2008.

Future sales: Since 2006 the number of incandescent bulbs manufactures stagnated around 750 million. It is supposed that in the BAU scenario incandescent bulbs sales will grow by 1% each year. The low growth assumption is due to the fast growing market of CFLs.

Tube light

ELCOMA reports ~188 million FTLs manufactured in India each of the last two years (2007 and 2008) (ELCOMA, 2009). If the average lifetime is 5000 hours at a usage pattern of 6 hours/day a lamp would last 2.3 years. We assume 2/3 of FTLs are bought by the domestic sector. That results in 280 million FTLs in the household sector in 2008.

Future sales: Since 2005 the number of tube lights manufactures stagnated around 188 million. It is supposed that FTLs sales will grow by 1% each year.

Compact Fluorescent Lamp (CFL)

The BEE estimates that CFLs have grown from 20 million in 2003 to around 200 million in 2008. However, the usage is dominated by the commercial sector where penetration is very high. The household penetration is assumed to be only 5-10% (BEE, 2009a). ELCOMA reports production of 100 (2006), 140 (2007) and 199 (2008) million CFLs in India over the last 3 years (ELCOMA, 2009). At a lifetime of 2000 hours and a usage pattern of 4 hours/day a lamp would last for 1.37 years. We assume that 25% are being sold in the household sector. That would result in 68 million CFLs in use in 2008.

We cross check this assumption with the BEE information. We assume a 10% penetration rate that means 21.6 million households use CFLs. If they have 2.5 CFLs on average this would result in 64.8 million CFLs which seems likely.

DVD Player

According to the Consumer Electronics and Appliances Manufacturers Association (CEAMA) there were around 30 million DVD-Players sold since 2003.

Table A 7 – DVD Player Sales in Million

2003	2004	2005	2006	2007	2008	Future growth	Source
1	2.5	4.5	6	7.25	8*		CEAMA
1	2.5	4.5	6	7.25	8	7%	Assumption for this study

* CEAMA projection

The sales before 2003 seem to be negligible; therefore, we suppose 30 million to be the 2008 stock.

Future sales: For the future a sales growth rate of 7% only is applied, since the saturation seems already very high.

Household sector share and replacement rate: It is assumed that 95% of the DVD Players are sold in the household sector. The 2008 stock is assumed to be still in use. Thus, only a 3% replacement rate is applied.

Set-Top-Boxes

According to In-Stat the Indian market had 9 million subscribers at the end of 2008. The number of subscribers had doubled from 4.5 million in 2007 (In-Stat, 2009). CEAMA reports sales growing from 1 million in 2005 to 5 million in 2008. The total sales were 11 million until 2008. CEAMA predicts sales of 7.5 (2009) and 10 (2010) million. We use the total CEAMA until 2008 as the stock (11 million).

Table A 8 – Set-Top Box Sales in Million

2004	2005	2006	2007	2008	Future growth	Source
				4.5		In-Stat
	1	2	3	5		CEAMA
	1	2	3	5*	20%	Assumption for this study

* CEAMA projection

Future sales: We suppose the sales will grow at a rate of 20% on average from 5 in 2008 to 12.44 million in 2013.

Household sector share and replacement rate: It is assumed that 95% of Set-Top-Boxes are sold in the household sector. The 2008 stock is assumed to be still in use. Thus, only a 3% replacement rate is applied.

Table A9 shows sales until 2008. It gives the resulting stock of 2008.

Table A 9 – Sales Until 2008, HH Sector Share, Replacement Rate (%) and Stock 2008

Appliance Type	Sales				Stock
	2003 - 2008	2005 - 2008	in HH sector	Replacement rate	2008
	in million	in million	in %	in %	in million
Refrigerator		15.91	85%	5%	37.33
Air conditioner		2.66	33%	5%	5.05
Incandescent bulb					301.64
Tube light					280.27
CFL					68.15
Fan		91.22	85%	5%	246.41
Television		45.05	85%	8%	98.59
Geyser	7.66		85%	4%	10.46
Washing machine	7.00		85%	4%	14.97
Tape recorder, CD player					36.80
Sewing machine					29.48
Radio					59.71
Air cooler		3.71	95%	5%	18.93
VCR VCP					2.74
Set-Top Box					11.00
Computer		3.64	15%	10%	5.72
Room heater					9.01
DVD Players					29.25

For the saving analysis the future sales until 2013 have been projected. The projected is only made for our focus areas and is based on past sales growth rate. We extrapolated past growth rates to the future based on the assumptions described above. Table A10 shows the resulting sales assumptions for the years 2009 until 2013.

Table A 10 – Future Sales Projections for Focus Areas

	Sales in 2008 in million	Sales in 2013 in million	Growth rate in %	% of sales HH sector
Fan	30.00	48.32	10%	85%
Incandescent bulb	734.00	774.12	1%	80%
Refrigerator	5.46	10.99	15%	85%
Television (TV)	16.50	31.08	14%	85%
Tube light	186.00	196.46	1%	66%
Air conditioner	2.63	8.01	25%	60%
Electric Water heating (Geyser)	1.70	3.12	13%	85%
Air cooler	0.90	0.70	-5%	95%
Set-Top Box	5.00	12.44	20%	95%
Computer	7.80	19.41	20%	20%
DVD Players	8.00	11.22	7%	95%
Compact Fluorescent Lamp (CFL)	199.00	1221.50	44%	25%
Washing machine	2.49	4.58	13%	85%

Annexure B: Estimates of Energy Consumption by Appliance

Consumption of Appliances

This Annexure estimates three different levels of consumption for the typical models of the important appliances. The three different levels of consumption are:

- Average of the current stock
- Cheapest model
- Most energy efficient appliance

The average consumption of the current stock is multiplied by the stock of each appliance to estimate the total consumption of different appliances in year 2008.
The sales of appliances during 2009 to 2013, as estimated in Appendix A, are multiplied by the consumption of cheapest model to arrive at incremental consumption of these appliances. The estimated household consumption in the BAU scenario in 2013 is the sum of this incremental consumption and the 2008 consumption. However, some of the new sales were replacing old appliances of the 2008 stock. Thus for the 2013 estimates the 2008 consumption is reduced accordingly. The replacement rate for each appliance is derived in Annexure A.

Household consumption in 2013 for the EE scenario is calculated by assuming that all houses only buy the most efficient appliances. Hence, the difference between the 2013 BAU projection and the EE scenario – the technical saving potential – is the difference between energy consumption of the cheapest model and the most efficient model multiplied by the sales from 2009 - 2013. Additionally we assume (a) full replacement of incandescent lamps with CFLs, (b) full replacement of T-12 with electromagnetic ballasts with T-8 having electronic ballast (c) change of behavior of 50% of the households in relation to appliance stand-by and (d) 35% replacement of the stock of electric water heaters by either gas or solar water heaters.

Average Consumption of Current Stock

The consumption for the current stock of appliances is estimated using usage pattern and average wattage of appliance; based on a review of several studies and other sources. The average of different studies or the most likely consumption is used for our analysis as discussed later.

The consumption of each appliance depends upon its size, type and usage pattern. Some studies present average wattage and usage hours; whereas others report consumption per year. An interesting approach was applied by Murthy and colleagues for the analysis of a Karnataka Survey from 1994/1995 (Murthy, Sumithra & Reddy, 2001). They used different ways of estimating the energy consumption, a so called engineering approach and an appliance census approach (Murthy et. al. 2001). The engineering approach calculated the consumption of an appliance based on wattage and the people's answers to the survey concerning usage hours. However, the authors doubted the reliability of the people's estimates of operating hours. Thus, they proposed an appliance census approach. That means they calculated the increase in consumption resulting from the addition of one appliance of a certain category.

Consumption of the Cheapest Model

The consumption of the cheapest and most energy efficient appliance are estimated only for the seven most important appliances. For simplicity, we consider an average (or most common) appliance type and size for this analysis.

The typical models for the seven key appliances we consider are:

- For incandescent bulbs a replacement of a bulb of 55W by a CFL is considered

- For tube light a replacement of a T12 tube with electro-magnetic ballast by a T8 with electronic ballast is considered
- Direct cool refrigerators with a gross volume of 175-190 liters. Direct cool refrigerators account for 82% of the market (LBNL 2005, TERI, 2006).
- Window ACs with a cooling capacity of 1.5 t (5061 – 5275 W). According to LBNL (2005) this is the weighted average of all sold ACs.
- Ceiling fans with a size of 1200 mm sweep
- Flat screen televisions of 20-21 inch. According to Times of India slim and flat TVs constitute 70% of the market (Times of India, 2009)
- Air coolers with a cooling capacity of about 200 square feet

A market research on several Indian comparison-shopping websites (naaptol, compareindia, pricesbolo, open2save) was conducted to collect data on the average consumption of typical cheapest models in each category of appliance.[9]

Consumption of Energy Efficient Appliance

To estimate the energy consumption of the most efficient appliance a review of both, appliance efficiency studies (LBNL, 2005, 2007) and star labeling information for high efficiency models according to BEE (EMT, 2009a, 2009b) was conducted. The best performance was assumed to be the technical potential.

The following section describes information collected for each type of appliance from different sources, assumptions made for our study as well as the conclusions.

Major Appliances

Refrigerator

The refrigerator efficiency has steadily increased worldwide over the last thirty years. So average consumption of stock is a function of stock vintage, consumption of average model sold each year, size etc. But such detailed data is not available in India. Seven major studies were reviewed for refrigerator consumption and a small pilot study of 10 refrigerators was conducted:

Table B 1 - Average Consumption of Stock of Refrigerator

Hrs./ day	Days/ year	Compressor activity in %	W	kWh/ year	Source
24	365	38	*136*	452*	LBNL (2005)
24	365			528**	LBNL (2007)
24	365			540	Prayas (2000)
24	365	44	144	553	Prayas pilot study
24	350		230	*869*	IEI-CMIE (2000)
16	365		150	876	DERC (2006)
24	365		100		Murthy et al. (2001) Engineering approach
24	365			266	Murthy et al. (2001) Appliance census approach
24	365		1570	-	TERI (2006)
24	365		2400	-	TERI (2006)
24	365			588	Used in this study

[9] Only models which energy consumption was reported were included.

Figures in *Italics* have been calculated from the given information;

* Weighted average of new direct cool and frost free standard refrigerators according to LBNL (2007)

** 2010 consumption, based on the assumption that consumption is going to grow due to larger models in the future (494 kWh in 2000 to 657 kWh in 2030).

We use an average of the LBNL, IEI and Prayas studies; equal to 588 kWh per year. DERC, TERI and Murthy et al. were excluded from the average calculation. TERI seems to report maximum wattage, DERC compressor activity figures (16 hours) seem too high and Murthy et al. numbers are considered to be very low for the stock of old appliances.

Cheapest model and technical potential: For estimating the consumption of the cheapest model as well as the efficient model, a typical model (Direct cool, 175-190 liters storage volume) is considered.

Table B 2 – Energy Consumption of Cheapest Refrigerator Model

Brand	Model	Price in Rs.	kWh /year	Size in liters	Equivalent to*	Source
Haier	211RLC/GLC/BLC	6,990	330	190	4 Star	Compareindia
Videocon	S 192 DLX	7,232	405	190	3 Star	Naaptol
Godrej	No 1 - GDN 180 P	7,500	401	170	3 Star	Compareindia
LG	181PM4	7,700	299	175	4 Star	Naaptol
Videocon	S 192	7,900	405	190	3 Star	Compareindia
Godrej	GDA 19 B	7,990	318	181	4 Star	Naaptol
LG	LG 185 TP4	8,200	295	180	4 Star	Naaptol
	Average	7,644	350	182		Used in this study

* Star labeling acc. to BEE (EMT, 2009a)

Table B 3 – Energy Consumption of Efficient Refrigerator Model

W	kWh/year	Source
	179	LBNL (2005)
	208	LBNL (2007)
1115	-	TERI (2006)
67	234	EMT (2009a)
	179	Used in this study

LBNL analyses the technical saving potential for refrigerators. We follow this assumption and use the estimate 179 kWh / year.

Air conditioner

Most studies assume a six months cooling season, when ACs are used for 20 days a month. This means 120 days of operation per year (LBNL, 2005). The efficiency of ACs is monitored as Energy Efficiency Ratio (EER) which is the ratio of *output* cooling in Btu/Hr and the *input* power in watts. Thus, an 18,000 Btu/Hr unit with an input wattage of 2000 W has an EER of 9. BEE is measuring the EER by converting the cooling capacity in Watt and dividing it by the energy input. Btu/hr. can be converted in Watt whereas 1 Watt is 3.41 Btu/Hr.

Table B 4 - Average Consumption of Stock of Air Conditioners

Hrs/ day	Days/ year	W	EER	Compressor activity in %	kWh/ year	Source
4	180	*2000*[*]	9		1191	LBNL (2005)
4	120	2200			*475*	IEI-CMIE (2000)
8	252	*2400*	*7.5*	75	3630	BEE (2009b)
8	120	2000				TERI (2006)
0.81	365	1500				Murthy et al. (2001) Engineering approach
6	-	2500				DERC (2006)
6	120	2220		75	1199	Used in this study

Figures in *Italics* have been calculated from the given information;

[*] For a 1.5 T AC (18,000 BTU/hr) model the study estimates EER of 9. This would require a compressor of 2000W (LBNL, 2005).

LBNL (2007) estimates that the AC consumption will grow continuously due to use of multiple units in a house, increase in unit cooling capacity, and increase in hours of usage. They assume the consumption per house owning an AC will go up from 2160 to 4620 kWh/year; between 2000 and 2030.

We calculate an average wattage of the studies, which is 2200 W. 720 usage hours per year with a compressor activity of 75% is assumed to arrive at annual consumption of 1199 KWh/yr. Murthy et al. is excluded, because the wattage seems too low for the average consumption of old appliances.

Cheapest model and technical potential: For estimating the consumption of the cheapest model as well as the efficient model, a typical model (Window AC, 1.5 t cooling capacity (~ 5278 W, 18,000 BTU/hr) is considered.

Table B 5 – Energy Consumption of Cheapest Air Conditioner Model

Brand	Model	Price in Rs.	Size in t	W	EER	Source
Electrolux	PREMIUM 1.5 T EA18WCRPW1	13,490	1.5	1850	9.7	Compareindia
Samsung	AWT 18 ZKA	13,590	1.5	2100	9	Naaptol
Sanyo	SA186GVI	13,755	1.5	1850	9.7	Compareindia
LG	LWA18G1AM1	14,358	1.5	1850	9.73	Naaptol
LG	LWA18G1AS1	14,500	1.5	1850	9.73	Naaptol
Haier	HW - 18CRVX	14,500	1.5	1850	9.73	Compareindia
	Average	14,032	1.5	1892	9.6	Used in this study

The average of all models is used in this analysis.

Table B 6 – Energy Consumption of Efficient Air Conditioner Model

W	EER	kWh/year	Source
1406	12.8	*759*	LBNL (2005)
1508	11.93[*]	*814*	EMT (2006)
1300	-		TERI (2006)
-	-	-	DERC (2006)
1406	12.8	*759*	Used in this study

Figures in *Italics* have been calculated from the given information;

* 3.5 EER (W/W) = 11.93 (Btu/Hr/W), BEE 5 Star requirement from Jan 2010 onwards (EMT, 2006)

We follow LBNL assumptions of 12.8 EER to be the technical potential, which equals 1406 W input.

Incandescent bulb

Table B 7 – Average Consumption of Stock of Incandescent Bulbs

Hrs./day	Days/year	W	KWh/year	Source
4	350	55	*77*	IEI-CMIE (2000)
4-5	365	55-60	*94*	TERI, (2006).
2-4	365			Murthy et al. (2001) Engineering approach
			72-86	Murthy et al. (2001) Appliance census approach
4	365	60	*87.6*	Prayas (2000)
10	-	100		DERC (2006)
4	365	55	80.3	Used in this study

Figures in *Italics* have been calculated from the given information;

We assume 55 W as the average wattage of incandescent bulbs in accordance with IEI CMIE and TERI. 4 operating hours per day is assumed.

Cheapest model and technical potential: The cheapest light bulb remains an incandescent bulb at 55W. In the EE scenario this would be replaced by a CFL which is 73% more efficient (15 W). In the EE scenario full replacement of all incandescent bulbs by CFL is assumed.

Tube light

It is assumed that mainly tube lights with magnetic ballast are used. ELCOMA data for 2008 shows that nearly 68% tube lights are T-12 lamps, remaining being T-8 (ELCOMA, 2009). The sales of T-5 are still negligible. A T12 with magnetic ballast consumes 50 W, whereas a T8 with magnetic ballast consumes 47 W. Therefore, we apply 49 W (the weighted average). Tube lights are usually installed in rooms, which are more frequently used like kitchens and living rooms. Thus, 5 usage hours per day is used.

Cheapest model and technical potential: We suppose that in the EE scenario all magnetic ballasts will be replaced by electrical ballasts and all T12 lamp can be replace by a T8 lamp. A T8 with electrical ballast will consume 36 W.

Fan

Table B 8 - Average Consumption of Stock of Fans

Hrs./day	Days/year	W	kWh/year	Source
6	200	70	*84*	IEI-CMIE (2000)
10	225	60	*94*	TERI, (2006)
4.5-6.6	365	100	*201*	Murthy et al. (2001) Engineering approach
3-5			107-180	Murthy et al. (2001) Appliance census approach
16	-	60	-	DERC (2006)
	-	68-86	-	CERC (2004)
	-	75	-	Business Standard (2008)
8	200	75	120	Used in this study

Figures in *Italics* have been calculated from the given information;

According to IFMA the average fan consumption is 75 W (Business Standard, 2008). This seems to be supported by the upper numbers. 8 usage hours per day are assumed.

Cheapest model and technical potential: Most of the fans found in online market research don't report their energy consumption. Only Bajaj fans reported energy consumption of 80W. In our analysis above we assumed 75 W as the average consumption. According to IFMA the 60% of the fans are manufactured in the organized sector (IFMA, 2009). It is assumed that the fans from the un-organized sector would be 15% less efficient and would consume around 86.2 W. The weighted average is 79.5 W. However, we assume that the new fans run at slightly lower speeds which reduces consumption. Therefore, only 70W is assumed in this study (112 kWh/year).

According to fan experts the new 5 Star labeled fans can reduce consumption to around 50 W. This assumption is used as the technical potential.

Television

Table B 9 – Average Consumption of Stock of Television

Hrs./day	Days/year	W	kWh/year	Source
3	350	80	*84*	IEI-CMIE (2000)
3.1	365	120	*135.8*	TERI, (2006)
3.6-3.9	365	100	*136.9*	Murthy et al. (2001) Engineering approach
2.73	*365*	*100*	86.68	Murthy et al. (2001) Appliance census approach
5	365	150	*273.7*	DERC (2006)
6	365	80	175	Used in this study

Figures in *Italics* have been calculated from the given information;

In a small pilot study of 20 households we found that average TV wattage did not exceed 80 W. However, the reported usage hours were much higher ranging from 6 to 10 hours per day. Therefore, we assume a lower wattage than the other studies but increased usage hours. Our assumptions are 80 W and 6 usage hours per day.

Cheapest model and technical potential: For estimating the consumption of the cheapest model as well as the efficient model, a typical model (Flat TV, 20-21 inch) is considered.

Table B 10 – Energy Consumption of Cheapest Television Model

Brand	Model	Price in Rs.	Size in inch	W	Source
Daenyx	Gold 20	5,800	20	80	Naaptol
Daenyx	Magic 20	5,800	20	80	Naaptol
Akai	Ninja	7,000	21	76	Retail shop
Sansui	Furato 21W	7,500	21	71	Retail shop
Videocon	200 W	-	21	65	Retail shop
Samsung	Plano DNIE	-	21	66	Retail shop
			21	73	Used in this study

We assume that 30% savings in comparison of the cheapest model should be easily possible (51 W). If a further shift towards LCD TVs will continue even lower consumption is possible.

According to the US energy star LCD TVs can come down to an energy consumption of 2 Watts per inch. We assume that 51 W for a 21 inch flat TV is realistic.

Electric Water heating

5 studies were reviewed concerning electric water heater consumption.

Table B 11 – Average Consumption for Stock of Electric Water Heater

Hrs./day	Days/year	W	kWh/year	Source
			607	LBNL (2007)
1.5	250	2000	*750*	IEI-CMIE (2000)
1	150	1500	*225*	TERI (2006)
1.18	365	3000	*1292*	Murthy et al. (2001) Engineering approach
			667.89	Murthy et al. (2001) Appliance census approach
2		2000		DERC (2006)
1.25	200	1750	437.5	Used in this study

Figures in *Italics* have been calculated from the given information;

It is assumed that geysers are used for 1.25 hours/day about half of the year (200 days). An average wattage of 1750 W is applied.

For the BAU scenario no change in efficiency is assumed. We estimate that all new electric water heaters will continue to consume 437.5 kWh/year on average.

Cheapest model and technical potential: For the EE scenario a shift towards gas / solar is considered. Our assumption is that 35% of the new sales will be gas or solar water heaters. Additionally we suppose that 35% of the 2008 stock will shift to solar or gas.

Air cooler

Table B 12 – Average Consumption of Stock of Air Cooler

Hrs./day	Days/year	W	kWh/year	Source
10	120	450		IEI-CMIE (2000)
10				EMC (1990).
4.8		170		Murthy et al. (2001) Engineering approach
8		180		DERC (2006)
9.3	120	175	195	Used in this study

An average wattage of all sources is used for the study. IEI-CMIE wattage is excluded because it seems too high. The usage time is assumed to be 9.3 hours/day for 120 days/year.

Cheapest model and technical potential: For estimating the consumption of the cheapest model as well as the efficient model, a typical model (average cooling capacity of 150 to 250 square feet) is considered.

Table B 13 – Energy Consumption of Cheapest Air Cooler Model

Brand	Model	Price in Rs.	Cooling cap.	W	Source
Symphony	Surround	3,700	150	80	Naaptol
Kenstar	Vibrant CT 9924	4,300	150	130	Naaptol
Symphony	Hycool	4,667	250	160	Naaptol
Bajaj	COOLEST SB2003	4,890	200	210	Naaptol
Usha	Lexux oasis	5,000	220	125	Compareindia
	Average	4,767	194	141	

According to Financial Express (2007) 90% of air coolers are manufactured in the unorganized sector. It is assumed that these air coolers are less efficient (-15%). Therefore we assume that the average wattage for air coolers is 15% higher than the cheapest model (= 162 W).

The most efficient cooler for the average cooling capacity (Usha, 220 square feet) consumes 125 W. We assume 125 W to be the energy efficient model.

Room heater

CERC conducted a study about room heaters (CERC, 2004). The average wattage varied between 1700 W and 2000 W. We assume an average of 1850 W. It is supposed that room heaters run 5 hours/day for two months per year.

Washing machine

5 studies were reviewed for the energy consumption of washing machines.

Table B 14 – Average Consumption of Stock of Washing Machines

Hrs./day	Days/year	Av. wattage	kWh/year	Source
			125*	LBNL (2007)
			425**	LBNL (2007)
1	350	400	*140*	IEI-CMIE (2000)
0.5	200	1000	*100*	TERI, (2006)
0.71	365	325	*84.2*	Murthy et al. (2001) Engineering approach
			185	Used in this study

Figures in *Italics* have been calculated from the given information;
* Semi automatic; ** Automatic

We follow LBNL's assumptions. They assume that 80% of the market is semi-automatic. The weighted average is 185 kWh/year.

Others

Set-Top-Boxes

In a small pilot study of 10 Set-Top-Boxes the average wattage measured was 10 W. The same usage hours as for TVs are applied (6 hours/day, 365 days/year).

DVD Players

In a small pilot study of 10 appliances the average wattage measured was 15 W. It is supposed that DVD players are use for 3 hours and 25 days per year on average.

Computer

In a small pilot study 6 computers (including monitors) were measured. The average consumption was 140 W. We assumed 3 usage hours per day for 250 days a year.

Tape recorder/CD player

TERI assumes 1 usage hour for 200 days per year. 60 W average wattage is assumed (TERI, 2006). Murthy et al. estimate higher usage hours (1 to 5 depending on approach) and wattage between 20 and 50 W (Murthy et. al. 2001)
We assume 2.5 usage hours for 300 days at an average wattage of 45 W.

Radio

IEI-CMIE assumes 3 hours / day at 350 days/year usage pattern. The average wattage is considered to by 25 W (IEI-CMIE, 2000). Murthy et al. estimate 2.5 – 12 usage hours at an average wattage of 15 W (Murthy et. al., 2001)
We suppose 5 usage hours per day and an average wattage of 18 W.

VCR VCP

TERI assumes 3 usage hour for 25 days per year. 20 W average wattage is assumed (TERI, 2006). Murthy et al. estimate 2.1 -2.4 usage hours and wattage of 40 (Murthy et. al. 2001)
We assume 3 usage hours for 25 days in accordance with DVD players and apply average wattage of 30 W.

Table B 15 - Usage Pattern and Consumption of Appliances (Average / Cheapest Model / EE Model)

	Usage	Usage	Stock		Cheapest		Energy Efficient (technical potential)		Savings Cheap vs. EE	EE
	Hours/ day	Days/ year	Wattage	kWh/ year	Wattage	kWh/ year	Wattage	kWh/ year	kWh/ year	in %
Refrigerator	-	-	-	588	-	350	-	179	171	49%
Air conditioner	6	120	2220	1199	1892	1022	1406	759	262	26%
Incandescent bulb	4	365	55	80	55	80	15.0	22	58	73%
Tube light	6	365	49	107	49	107	36	79	28	27%
Compact Fluorescent Lamp (CFL)	4	365	15	22						
Fan	8	200	70	112	70	112	50	80	32	29%
Television (TV)	6	365	80	175	73	160	51	112	48	30%
Electric Water heating (Geyser)	1.25	200	1750	438	1750	438	to gas	to gas		
Washing machine	1	250	0	185						
Tape recorder. CD player	2.5	300	45	34						
Sewing machine										
Radio	5	365	18	33						
Air cooler	9.3	120	175	195	162	181	125	140	41	23%
VCR VCP	2.6	25	30	2						
Set-Top Box	6	365	10	22						
Computer	3	250	140	105						
Room heater	5	60	1850	555						
DVD Players	3	25	15	1						
Stand-by-power										
Set-Top-Box	16	365	10	58	10	58	1	6	53	90%
TV	16	365	7	41	7	41	1	6	35	86%
Computer	22	365	9	72	9	72	1	8	64	89%
DVD Players	23.5	365	6	51	6	51	1	9	43	83%

* 75% compressor activity.

Annexure C

Stand-By Losses

There are several appliances that consume stand-by power in a significant way. We consider Set-Top-Boxes, DVD Players, computers and TVs to be the major stand-by consumers.
We conducted a small pilot study of 15 households to estimate the stand-by consumption.

The stand-by time equals 24 hours minus usage time minus load shedding (2 hours/day). Not all consumers keep their appliances on stand-by. Some are switched off completely or even disconnected at the main supply. We assumed the share of each appliance that is on stand-by in contrast to those that are switched off completely.
All Set-Top-Boxes in our pilot study could not be switched off. Therefore, we assumed that 85% of the Set-Top-Boxes are on stand-by. For TVs it is assumed that only 50% are on stand-by because they often have a switch to be turned off completely. DVD players are rarely used and often only connected to the socket if in use. We suppose only 25% of the DVD players actually run on stand-by. Computers are often used with a spike guard, which will cut the consumption if switched-off after usage. Therefore only 30% of computers were assumed to be connected in off-mode.

Table C 1 - Stand-By Consumption

Appliance	Hours / day	Days/year	Watt	kWh/year	% of appliances in stand-by
Set-Top-Box	16	365	10	58	85
TV	16	365	7	41	50
Computer	22	365	9	72	30
DVD Player	23.5	365	6	51	25

Cheapest model and technical potential: It is assumed that there will be no changes in consumption in the BAU scenario. The stand-by loss of all appliances can be reduced to max. 1 W.
We further assume that an awareness campaign could reduce the stand-by consumption of the stock by another 50% The 2008 consumption was 3 TWh. This means savings of an additional 1.5 TWh are possible.

Annexure D : Estimates of Energy Savings from All Sectors

All Sectors

In the paper the saving potential for the household sector was calculated. However, an energy efficiency measure or policy would not affect the sales of the household sector only. If the efficiency of refrigerators or ACs improves all sectors which buy these products will be affected. Therefore, we calculated the saving potential if all sales shift from the cheapest to the most energy efficient. Table D1 shows the result.

Table D 1 - Potential Savings in TWh in 2013 for All Sales

Appliance	Savings in 2013 TWh
Incandescent bulb	23.22
Tube light	12.77
Stand-by-power	9.67
Refrigerator	7.24
Air conditioner	7.07
Fan	6.45
Television (TV)	5.91
Water heaters	3.02
Air cooler	0.16
Total	**75.51**