CHAPTER 4

RESULTS AND DISSCUSSION

This chapter presents five scenarios of the energy consumption of residential and small commercial sectors. The first scenario assigned as the Business As Usual (BAU) scenario was developed based on the electrical load forecast by sub-committee under the committee for administration of energy and policy. The second scenario forecasts the consumption of the sectors by assuming all activities reach saturation except the use of air-conditioners and water heaters. The third scenario examines an extreme case where the energy for cooking is only electricity. The fourth scenario is the case where fuel for cooking is shifted to LPG. The last scenario determines the reduction potential of the energy consumption when various energy conservation measures are implemented.

4.1 Situation of Energy Consumption of Residential and Small Commercial Sectors in Thailand

This study employed the four models described in Chapter 3 and the electrical load forecast by the sub-committee under the committee for administration of energy policy to assess the current situation of the electrical energy consumption of residential and small commercial buildings in Thailand.

Table 4.1 exhibits the electrical load forecast during 2010-2030. The load forecast separates the consumptions for residential houses and small commercial buildings. The load forecast shows that the consumption by these sectors in 2030 will increase more than twofold from 2010.

Table 4.1: The electricity demand forecasted by the electric load forecast sub-committee under the committee for administration of energy policy

Sector	2010	2011	2012	2013	2014	2015	2020	2025	2030
Residential	30,311	31,605	33,020	34,545	36,123	37,682	46,113	56,036	68,020
Small Commercial	12,645	13,313	14,061	14,892	15,766	16,704	21,949	28,754	38,053

Table 4.2 presents the proportion of electricity use of the four building categories in the sectors. The table shows that for all building categories, energy consumption for amenity shares the largest, more of less 50% of the total consumption. For houses or small commercial buildings in municipality, air-conditioner contributes about 50% of the energy consumption by amenity. However, for those outside the municipality, the share is about 7% from the total consumption. Examining the proportion of the energy use for lighting, cooking and entertainment, it would seem that in general the shares of the consumption are comparable (10-15%).

With the knowledge of the proportion of the electrical energy use as shown in Table 4.2, it is possible to determine of the share of electricity consumptions of the sectors at sub-level: the consumption by activities (lighting, cooking, entertainment, amenity and other) and by regions (within and outside municipality).

Table 4.2: Proportion of electrical energy consumption in residential and small commercial sectors

Activity		Residential		Small Commercial	
		In M	Out M	In M	Out M
Lighting		12.5	16.5	11.7	9.0
Cooking		11.1	14.3	7.2	7.1
Entertainment		16.6	17.8	19.3	9.9
Amenity	Other	25.9	35.5	36.7	52.9
	Air-conditioning	23.2	8.9	16.5	5.1
	Electric hot water	7.1	2.4		
Other		3.6	4.7	8.6	16.0
Total		**100**	**100**	**100**	**100**

Table 4.3 exhibits the total energy consumption estimated for the residential and small commercial sectors in Thailand in 2010. The figure of the electricity uses for amenity warrant a significant of this activity. The electricity consumption in the amenity category exceeded 50% of the total.

Table 4.3: The current situation of the energy consumptions of the residential and small commercial sectors in Thailand in 2010

Activity	Energy	Residential Sector		Small Commercial Sector		Total (2010)
		In M	Out M	In M	Out M	
Lighting	Electricity (GWh)	1,288	3,294	638	655	**5,875**
Cooking	Electricity (GWh)	1,149	2,852	391	514	**4,906**
	LPG (1000 tons)	443	1,452	164	301	**2,360**
	Fuel wood (1,000 tons)	172	4,573	10	231	**4,986**
	Charcoal (1,000 tons)	228	5,224	247	368	**6,067**
Entertainment	Electricity (GWh)	1,719	3,546	1,047	718	**7,030**
Amenity	Electricity (GWh)	5,817	9,346	2,891	4,208	**22,262**
Other	Electricity (GWh)	371	928	470	1,164	**2,933**

Table 4.3 also present the consumption of other energy sources including LPG, fuel wood and charcoal. The amount of fuel wood and charcoal consumptions for cooking was assumed to be constant since 2001. These fuel types have been used mainly for houses located outside municipality accounting for almost 90% of the total consumption. The total consumptions of the fuels for cooking were derived from the reference data in Table 4.4.

Table 4.4: Average annual energy demand for cooking each household

Energy source	Average annual cooking energy demand (Unit/household /year)				Unit
	Residential Sector		Small Commercial Sector		
	In M	Out M	In M	Out M	
Electricity	211	354	245	546	kWh
LPG	82	180	103	320	kg
Fuel wood	32	568	6	246	kg
Charcoal	42	649	155	390	kg

To determine the useful energy for cooking, the efficiencies of the equipment in Table 4.5 were employed. Table 4.6 exhibits the energy consumptions of different types

of fuel for cooking in residential and small commercial buildings in unit MJ/year/household.

Table 4.5: Efficiency of cooking energy assumptions

Fuel source	Equipment Performance (based year 2010)
Electricity	3.6 MJ/kWh, 100% Efficiency
LPG	49.3 MJ/kg, 49% Efficiency
Fuel wood	3.6 MJ/kg, 15% Efficiency
Charcoal	3.6 MJ/kg, 25% Efficiency

Table 4.6: Average annual useful energy for cooking each household

Energy source	Average annual cooking energy demand (MJ/household /year)			
	Residential Sector		Small Commercial Sector	
	In M	Out M	In M	Out M
Electricity	761	1,275	884	1,965
LPG	1,969	4,355	2,480	7,727
Fuel wood	76	1,362	15	590
Charcoal	303	4,684	1,119	2,818

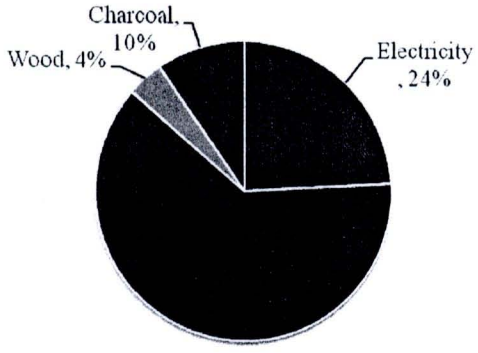
Figure 4.1 illustrates the shares of the useful energy for cooking in year 2010. It was found in general that LPG is used mostly as fuel for cooking. Electricity also performs its significance as the second energy source for cooking in municipality with a share of more than 20%. Outside municipality, charcoal is mostly used as fuel for cooking estimated 40% followed by LPG, fuel wood and electricity, respectively. The details of the fuel used for cooking in each building category can be described as follows.

As shown in Figure 4.1(a), LPG is the main fuel accounting for 63% of the total useful energy for buildings within the municipality. Electricity comes the second following by charcoal and fuel wood, respectively, in the proportions of 24%, 10% and 2%.

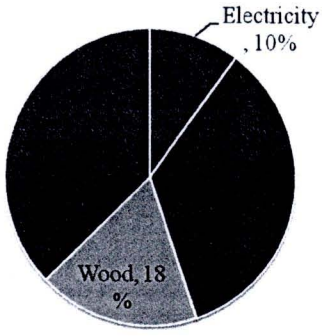
From Fig. 4.1(b), charcoal becomes the largest energy source for cooking in residential buildings outside municipal area with the share of 40%. However, LGP is still importance with a slightly lower share of 37%. Electricity come the third and follows by fuel wood. The shares of the last two types of energy sources are 11% and 2%, respectively.

Figure 4.1(c) illustrates the share of energy consumption for cooking in small commercial buildings within municipal area. The sequence of the types of energy used for cooking is LPG, electricity, charcoal and fuel wood. From the figure, the share of fuel wood is only 0.3%.

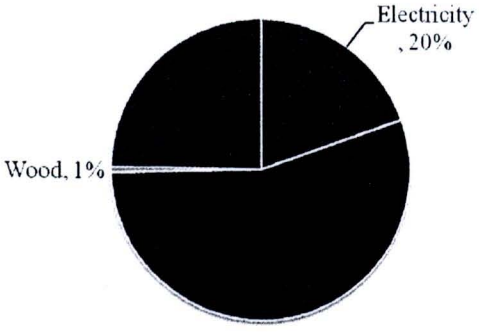
Examine Fig. 4.1(d), the sequence of the use of the fuels for cooking in small commercial buildings outside municipal area is identical to that of within municipal area. The shares of fuel wood increases from 0.3% to 5%.



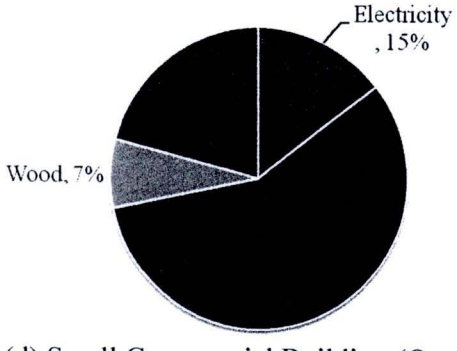
(a) Residential house (In M)



(b) Residential house (Out M)



(c) Small Commercial Building (In M)



(d) Small Commercial Building (Out M)

Figure 4.1: Proportion of useful heat consumption in residential and small commercial sectors

This study also attempted to estimate the number of existing appliances in household. The annual average energy consumption of each appliance was set followed the building energy consumption models. For residential and small commercial buildings, the annual average electricity consumption of a fluorescence lamp with conventional ballast was 37.47 and 52.39 kWh/year, respectively. The annual average consumption for an incandescence lamp was 39.51 and 49.43 kWh/year for residential and small commercial buildings.

For cooking, the average annual consumption of a conventional stove follows the figures in Table 4.5.

Air-conditioners and electric water heaters were assumed to increase each year about 718,980 and 200,000 units, respectively. The annual average electricity demand of conventional air conditioners (EER = 10) was 1,854 kWh/year which is 1.5 times of the consumption in 2001 (1,236 kWh/year). The annual average electricity demand of electric water heater was 1,084 kWh which is 1.5 times of the consumption in 2001 (723 kWh/year). This new numeric figure is more reasonable for the current situation.

Table 4.7 exhibits the number of appliances in households in 2010 in units of million. The numbers of air-conditioners were estimated in aggregation for residential houses and small commercial buildings. Do not segregate to sub-level of within and outside municipality. Number of electric hot water heater was calculated for the whole sector.

Table 4.7: Number of appliances in households in 2010 (Unit: million)

Appliance	Residential Sector		Small Commercial Sector		Total
	In M	Out M	In M	Out M	
Fluorescent lamp	36.6	38.3	12.9	6.0	93.7
Incandescent lamp	2.7	3.0	0.5	0.3	6.4
Air conditioner	7.3		1.8		9.0
Water heater	2.1				2.1
LPG stove	3.8	13.2	1.1	2.0	20.1
Charcoal stove	0.5	7.8	0.1	0.6	9.1

4.2 Scenario I: The Business as Usual I

This scenario aims to illustrate the trend of energy consumption of the residential and small commercial sectors in the next 20 years. This scenario assumed that there is no change of the efficiency of all appliances in the sectors, no change of behavior of the use of equipment, etc. The energy use models and the load forecast by the sub-committee under the committee for administration of energy policy were employed for developing the energy consumption trend. The prediction of the energy consumptions of Scenario I in each sector and sub-sector are shown in Tables 4.8 to 4.13.

Table 4.8: Prediction of energy consumption in the residential sector classified by end use activities (Scenario I)

Energy	Activities		2010	2011	2012	2013	2014	2015	2020	2025	2030
Electricity (GWh)	**Total electricity**		**30,311**	**31,605**	**33,020**	**34,545**	**36,123**	**37,682**	**46,113**	**56,036**	**68,020**
	Lighting		4,582	4,778	4,992	5,222	5,461	5,697	6,971	8,471	10,283
	Cooking		4,000	4,171	4,358	4,559	4,768	4,973	6,086	7,396	8,977
	Entertainment		5,265	5,490	5,736	6,001	6,275	6,546	8,010	9,734	11,816
	Amenity	Air-conditioning	4,184	4,363	4,558	4,768	4,986	5,201	6,365	7,735	9,389
		Electric hot water	1,220	1,272	1,329	1,390	1,454	1,516	1,856	2,255	2,737
		Other	9,759	10,176	10,632	11,123	11,631	12,133	14,847	18,042	21,901
	Other		1,300	1,355	1,416	1,481	1,549	1,616	1,977	2,403	2,917
LPG (10^3 tons)	Cooking		1,895	1,901	1,906	1,911	1,916	1,921	1,938	1,943	1,935
Fuel wood (10^3 tons)	Cooking		4,745	4,725	4,704	4,681	4,655	4,627	4,449	4,196	3,851
Charcoal (10^3 tons)	Cooking		5,453	5,432	5,408	5,383	5,355	5,324	5,126	4,844	4,458

Table 4.9: Prediction of energy consumption in the small commercial sector classified by end use activities (Scenario I)

Energy	Activities		2010	2011	2012	2013	2014	2015	2020	2025	2030
Electricity (GWh)	**Total electricity**		**12,695**	**13,365**	**14,117**	**14,951**	**15,828**	**16,771**	**22,036**	**28,868**	**38,203**
	Lighting		1,293	1,361	1,438	1,523	1,612	1,708	2,244	2,940	3,891
	Cooking		905	953	1,007	1,066	1,129	1,196	1,571	2,059	2,724
	Entertainment		1,764	1,858	1,962	2,078	2,200	2,331	3,063	4,012	5,310
	Amenity	Air-conditioning	1,265	1,331	1,406	1,489	1,577	1,671	2,195	2,876	3,806
		Other	5,835	6,142	6,488	6,871	7,274	7,707	10,127	13,267	17,557
	Other		1,633	1,719	1,816	1,924	2,036	2,158	2,835	3,714	4,915
LPG (10^3 tons)	Cooking		465	493	524	559	597	637	866	1,173	1,604
Fuel wood (10^3 tons)	Cooking		242	253	267	281	296	312	394	488	595
Charcoal (10^3 tons)	Cooking		615	653	696	744	794	849	1,168	1,601	2,218

Table 4.10: Prediction of energy consumption of the within-municipal residential sub-sector classified by end use activities (Scenario I)

Energy	Activities		2010	2011	2012	2013	2014	2015	2020	2024	2025	2030
Electricity (GWh)	**Total electricity**		**10,344**	**10,786**	**11,269**	**11,789**	**12,328**	**12,860**	**15,737**	**18,398**	**19,124**	**23,214**
	Lighting		1,288	1,343	1,403	1,468	1,535	1,601	1,959	2,290	2,381	2,890
	Cooking		1,149	1,198	1,252	1,310	1,370	1,429	1,748	2,044	2,125	2,579
	Entertainment		1,719	1,793	1,873	1,959	2,049	2,137	2,616	3,058	3,178	3,858
	Amenity	Air-conditioning	2,401	2,503	2,616	2,736	2,861	2,985	3,653	4,270	4,439	5,388
		Electric hot water	737	768	802	839	878	916	1,120	1,310	1,362	1,653
		Other	2,679	2,794	2,919	3,053	3,193	3,331	4,076	4,765	4,953	6,012
	Other		371	387	405	423	443	462	565	660	687	833
LPG (10^3 tons)	Cooking		443	457	470	485	500	515	599	676	697	812
Fuel wood (10^3 tons)	Cooking		172	177	182	188	194	200	232	262	270	315
Charcoal (10^3 tons)	Cooking		228	235	242	250	257	265	308	348	359	418

Table 4.11: Prediction of energy consumption of the outside-municipal residential sub-sector classified by end use activities (Scenario I)

Energy	Activities		2010	2011	2012	2013	2014	2015	2020	2025	2030
Electricity (GWh)	**Total electricity**		**19,966**	**20,819**	**21,751**	**22,756**	**23,795**	**24,822**	**30,376**	**36,912**	**44,806**
	Lighting		3,294	3,435	3,589	3,755	3,926	4,096	5,012	6,091	7,393
	Cooking		2,851	2,973	3,106	3,249	3,398	3,545	4,338	5,271	6,398
	Entertainment		3,546	3,697	3,863	4,041	4,226	4,408	5,395	6,556	7,958
	Amenity	Air-conditioning	1,783	1,859	1,942	2,032	2,125	2,217	2,713	3,296	4,001
		Electric hot water	483	504	526	551	576	601	735	893	1,084
		Other	7,080	7,382	7,713	8,069	8,438	8,802	10,771	13,089	15,888
	Other		928	968	1,011	1,058	1,106	1,154	1,412	1,716	2,083
LPG (10^3 tons)	Cooking		1,452	1,444	1,436	1,427	1,417	1,406	1,339	1,246	1,123
Fuel wood (10^3 tons)	Cooking		4,573	4,548	4,522	4,493	4,462	4,428	4,217	3,925	3,536
Charcoal (10^3 tons)	Cooking		5,224	5,197	5,166	5,133	5,097	5,059	4,818	4,485	4,040

Table 4.12: Prediction of energy consumption of the within-municipal small commercial sub-sector classified by end use activities (Scenario I)

Energy	Activities		2010	2011	2012	2013	2014	2015	2020	2025	2030
Electricity (GWh)	**Total electricity**		**5,437**	**5,724**	**6,046**	**6,403**	**6,779**	**7,182**	**9,437**	**12,363**	**16,361**
	Lighting		638	672	710	752	796	843	1,108	1,451	1,921
	Cooking		391	412	435	461	488	517	679	890	1,178
	Entertainment		1,047	1,102	1,164	1,233	1,305	1,383	1,817	2,380	3,149
	Amenity	Air-conditioning	896	943	996	1,055	1,117	1,184	1,555	2,037	2,696
		Other	1,995	2,100	2,218	2,349	2,487	2,635	3,462	4,536	6,003
	Other		470	495	522	553	586	621	815	1,068	1,414
LPG (10^3 tons)	Cooking		164	178	193	211	230	251	384	585	903
Fuel wood (10^3 tons)	Cooking		10	11	12	13	14	16	24	36	56
Charcoal (10^3 tons)	Cooking		247	268	292	318	347	379	579	883	1,362

Table 4.13: Prediction of energy consumption of the outside-municipal small commercial sub-sector classified by end use activities (Scenario I)

Energy	Activities		2010	2011	2012	2013	2014	2015	2020	2025	2030
Electricity (GWh)	**Total electricity**		**7,259**	**7,642**	**8,071**	**8,548**	**9,050**	**9,588**	**12,599**	**16,505**	**21,842**
	Lighting		655	689	728	771	816	865	1,136	1,489	1,970
	Cooking		514	541	571	605	641	679	892	1,169	1,546
	Entertainment		718	756	798	845	895	948	1,246	1,632	2,160
	Amenity	Air-conditioning	369	388	410	434	460	487	640	838	1,110
		Other	3,840	4,042	4,270	4,522	4,787	5,072	6,665	8,731	11,555
	Other		1,164	1,225	1,294	1,370	1,451	1,537	2,020	2,646	3,501
LPG (10^3 tons)	Cooking		301	315	331	349	366	385	482	588	701
Fuel wood (10^3 tons)	Cooking		231	242	255	268	282	296	371	452	539
Charcoal (10^3 tons)	Cooking		368	385	404	425	447	470	588	718	855

4.3 Scenario II: The Business as Usual II

This study developed another scenario of business as usual. Two factors influencing to the energy consumption of residential and commercial sectors are examined and try to account for in this scenario. Assumptions of this scenario were made differently from that of scenario I. This scenario adopts the energy end-use models but not the load forecast by the sub-committee of the energy policy development of Thailand. The details of the influencing factors and the assumption of this scenario business of usual II are described as below.

4.3.1 Influencing factors to the energy consumption of residential and small commercial sectors

a) Change of number of households in municipality area

Although the energy consumption per unit of household is assumed to be non-changing, the overall consumption of energy of the whole country will vary with the change of the number of household units within and outside municipality areas.

Urbanization due to the immigration of people and the growth of the cities themselves increase the energy demand and consumption of a country. Complexity also increases due to behavioral changes in use of household appliances both within and outside municipality.

b) Saturation of energy used

The number of unit of appliances i.e. fluorescent lamp, incandescent lamp, microwave, electric kettle, TV, computer, air-conditioning, washing machine and refrigerator in each house reach saturation. The energy consumption of these appliances is rather small when compare to that air-conditioning and electric water heater which has increased each year about 718,980 and 200,000 units (KU, 2006), respectively. It is interesting to note that the increasing of air conditioning in Kasikorn Research (KRC, 2010) is around 1,090,000 to 1,150,000 units.

However the energy consumption per household would be stable but the whole energy consumption would increase due to the increasing of number of household.

In the case of energy for cooking, charcoal substitution by LPG will occur not for economic reasons, but for individuals' desire to improve quality of life, in the context of modernization (Sanga, A.G., 2005). Although number of household is increasing, the useful heat demand for cooking also reaches saturation but it was obvious that the use of electricity (such as electric stoves and microwave) and LPG (such as LPG stove) for cooking is increasing due to the energy substitution that lead to increase of some energy.

There are the three cases expected to occur in the future. The first case was called the second business as usual scenario (Scenario II). The second case was called high electricity demand scenario (Scenario III). The last case was called high liquid petroleum gas demand scenario (Scenario IV). There were assumptions shared in all three cases as following.

4.3.2 Assumptions of the Scenario II

- For residential buildings, the energy consumption for lighting, cooking, entertainment and amenity, except air conditioning and water heating, reach their saturation. In each year, the units of electric water heater will increase 200,000 units (KU, 2006). In average, an electric water heater consumes power 723 watts (KMUTT, 2003) for 1.5 hours a day and 8 months a year.
- Demand for air conditioning of both residential and small commercial buildings combination will be increasing 718,980 units of air conditioner each year (KU, 2006). An air conditioner (EER=10) consumed 1,854 kWh per year.
- For small commercial buildings, the rate of electricity consumption increases in line with the growth of all activities, similar to the BAU I.
- Number of residential and small commercial buildings within and outside the municipality in each year, as shown in Table 3.2.
- Implementation of the Minimum Energy Performance Standard (MEPs), Energy Labeling and High Energy Performance Standard (HEPs) for household appliances are assumed to be continued.

The consumption of the base year of this scenario is identical to that of scenario I. However, the energy growth is dependent on the two factors and the assumption mentioned above.

Comparing Scenario II to Scenario I, whole energy consumption in 2030 are 98,904 GWh and 106,223 GWh, respectively, or about 7% difference. The total electricity demand is estimated about 47,863 GWh and 98,904 GWh in 2010 and 2030, respectively. In the residential sector, the energy demand in 2030 for within and outside municipal areas is more than 2.2 times and 1.1 times in 2010, respectively. In the small commercial sector, the energy demand in 2030 is more than 4.9 times and 2.3 times in 2010 for within and outside municipal areas, respectively, as presented in Table 4.14. In this case, the electricity consumption for air conditioning and hot water were separated for clearly shown the growths of the two events were.

Table 4.14: The energy consumption of the residential and small commercial sectors in each category in 2010 and 2030 by Scenario II

Activity		2010		2030	
		In M	Out M	In M	Out M
Residential Sector					
Lighting (GWh)		1,288	3,294	2,360	2,548
Cooking	Electricity (GWh)	1,149	2,851	2,106	2,205
	LPG (kton)	443	1,452	812	1,123
	Wood (kton)	172	4,573	315	3,536
	Charcoal (kton)	228	5,224	418	4,040
Entertainment (GWh)		1,719	3,546	3,150	2,742
Amenity (GWh)	Other	2,679	7,080	4,909	5,475
	Air-conditioning	5,138	2,984	13,314	7,732
	Electric hot water	1,375	902	3,994	2,620
Other (GWh)		371	928	680	718
Small Commercial Sector					
Lighting		638	655	3,519	1,524
Cooking	Electricity (GWh)	391	514	2,158	1,196
	LPG (kton)	164	301	903	701
	Wood (kton)	10	231	56	539
	Charcoal (kton)	247	368	1362	855
Entertainment (GWh)		1,047	718	5,770	1,671
Amenity (GWh)	Other	1,995	3,840	10,998	1,206
	Air-conditioning	1,408	465	3,649	8,935
	Electric hot water				
Other (GWh)		470	1,164	2,590	2,708
Total electricity (GWh)		**48,611**		**100,475**	

According to the Scenario II that no switching energy in the cooking category and the stove still same efficiency so the percent growth of all energy is the same but differences in each sub sector are due to changing number of houses. In 2030, for residential sector, although the energy demand for cooking within municipal area is expected to increase 83% from 2010 but outside municipal area is expected to decrease only 23%. For small commercial sector, within and outside municipal areas, the energy demand is expected to increase more than five and two times from 2010, respectively. Tables 4.15 to 4.20 show the prediction of energy consumption by Scenario II.

Table 4.15: Prediction of energy consumption in the residential sector classified by end use activities (Scenario II)

Energy	Activities		2010	2011	2012	2013	2014	2015	2020	2025	2030
Electricity (GWh)	**Total electricity**		**35,307**	**36,294**	**37,280**	**38,263**	**39,245**	**40,225**	**45,086**	**49,870**	**54,552**
	Lighting		4,582	4,604	4,625	4,646	4,666	4,686	4,777	4,853	4,907
	Cooking		4,000	4,020	4,039	4,059	4,077	4,096	4,181	4,254	4,310
	Entertainment		5,265	5,299	5,332	5,365	5,398	5,431	5,592	5,747	5,892
	Amenity	Air-conditioning	8,123	8,769	9,415	10,061	10,707	11,354	14,585	17,815	21,046
		Electric hot water	2,277	2,494	2,711	2,927	3,144	3,361	4,445	5,529	6,614
		Other	9,759	9,803	9,845	9,887	9,928	9,968	10,147	10,290	10,384
	Other		1,300	1,306	1,312	1,318	1,324	1,330	1,358	1,381	1,398
LPG (10^3 tons)	Cooking		1,895	1,901	1,906	1,911	1,916	1,921	1,938	1,943	1,935
Fuel wood (10^3 tons)	Cooking		4,745	4,725	4,704	4,681	4,655	4,627	4,449	4,196	3,851
Charcoal (10^3 tons)	Cooking		5,453	5,432	5,408	5,383	5,355	5,324	5,126	4,844	4,458

Table 4.16: Prediction of energy consumption in the small commercial sector classified by end use activities (Scenario II)

Energy	Activities		2010	2011	2012	2013	2014	2015	2020	2025	2030
Electricity (GWh)	**Total electricity**		**13,304**	**14,163**	**15,108**	**16,143**	**17,232**	**18,399**	**25,036**	**33,791**	**45,923**
	Lighting		1,293	1,378	1,473	1,580	1,693	1,817	2,544	3,560	5,043
	Cooking		905	963	1,027	1,099	1,175	1,258	1,740	2,403	3,354
	Entertainment		1,764	1,887	2,025	2,179	2,344	2,524	3,602	5,143	7,441
	Amenity	Air-conditioning	1,873	2,023	2,172	2,321	2,470	2,619	3,364	4,109	4,854
		Other	5,835	6,185	6,577	7,013	7,474	7,972	10,822	14,626	19,933
	Other		1,633	1,728	1,834	1,952	2,076	2,209	2,964	3,951	5,298
LPG (10^3 tons)	Cooking		465	493	524	559	597	637	866	1,173	1,604
Fuel wood (10^3 tons)	Cooking		242	253	267	281	296	312	394	488	595
Charcoal (10^3 tons)	Cooking		615	653	696	744	794	849	1,168	1,601	2,218

Table 4.17: Prediction of energy consumption of the within-municipal residential sub-sector classified by end use activities (Scenario II)

Energy	Activities		2010	2011	2012	2013	2014	2015	2020	2025	2030
Electricity (GWh)	**Total electricity**		**13,720**	**14,478**	**15,244**	**16,016**	**16,796**	**17,583**	**21,644**	**25,939**	**30,512**
	Lighting		1,288	1,327	1,367	1,409	1,452	1,496	1,739	2,025	2,360
	Cooking		1,149	1,184	1,220	1,257	1,295	1,335	1,552	1,807	2,106
	Entertainment		1,719	1,771	1,825	1,881	1,938	1,997	2,322	2,703	3,150
	Amenity	Air-conditioning	5,138	5,547	5,956	6,365	6,774	7,182	9,226	11,270	13,314
		Electric hot water	1,375	1,506	1,637	1,768	1,899	2,030	2,684	3,339	3,994
		Other	2,679	2,760	2,844	2,931	3,020	3,112	3,618	4,212	4,909
	Other		371	383	394	406	419	431	502	584	680
LPG (10^3 tons)	Cooking		443	457	470	485	500	515	599	697	812
Fuel wood (10^3 tons)	Cooking		172	177	182	188	194	200	232	270	315
Charcoal (10^3 tons)	Cooking		228	235	242	250	257	265	308	359	418

Table 4.18: Prediction of energy consumption of the outside-municipal residential sub-sector classified by end use activities (Scenario II)

Energy	Activities		2010	2011	2012	2013	2014	2015	2020	2025	2030
Electricity (GWh)	**Total electricity**		**21,586**	**21,815**	**22,036**	**22,247**	**22,449**	**22,642**	**23,442**	**23,930**	**24,040**
	Lighting		3,294	3,277	3,258	3,237	3,214	3,190	3,038	2,828	2,548
	Cooking		2,851	2,836	2,819	2,801	2,782	2,761	2,629	2,448	2,205
	Entertainment		3,546	3,527	3,507	3,484	3,460	3,434	3,270	3,044	2,742
	Amenity	Air-conditioning	2,984	3,222	3,459	3,697	3,934	4,171	5,358	6,545	7,732
		Electric hot water	902	988	1,074	1,160	1,245	1,331	1,761	2,190	2,620
		Other	7,080	7,042	7,001	6,956	6,908	6,856	6,529	6,078	5,475
	Other		928	923	918	912	906	899	856	797	718
LPG (10^3 tons)	Cooking		1,452	1,444	1,436	1,427	1,417	1,406	1,339	1,246	1,123
Fuel wood (10^3 tons)	Cooking		4,573	4,548	4,522	4,493	4,462	4,428	4,217	3,925	3,536
Charcoal (10^3 tons)	Cooking		5,224	5,197	5,166	5,133	5,097	5,059	4,818	4,485	4,040

Table 4.19: Prediction of energy consumption of the within-municipal small commercial sub-sector classified by end use activities (Scenario II)

Energy	Activities		2010	2011	2012	2013	2014	2015	2020	2025	2030
Electricity (GWh)	**Total electricity**		**5,949**	**6,446**	**6,993**	**7,594**	**8,238**	**8,936**	**13,173**	**19,321**	**28,684**
	Lighting		638	692	753	822	897	979	1,496	2,282	3,519
	Cooking		391	425	462	504	550	601	918	1,399	2,158
	Entertainment		1,047	1,135	1,235	1,348	1,471	1,606	2,453	3,741	5,770
	Amenity	Air-conditioning	1,408	1,520	1,632	1,744	1,856	1,968	2,528	3,088	3,649
		Other	1,995	2,164	2,355	2,570	2,803	3,061	4,676	7,131	10,998
	Other		470	510	555	605	660	721	1,101	1,679	2,590
LPG (10^3 tons)	Cooking		164	178	193	211	230	251	384	585	903
Fuel wood (10^3 tons)	Cooking		10	11	12	13	14	16	24	36	56
Charcoal (10^3 tons)	Cooking		247	268	292	318	347	379	579	883	1,362

Table 4.20: Prediction of energy consumption of the outside-municipal small commercial sub-sector classified by end use activities (Scenario II)

Energy	Activities		2010	2011	2012	2013	2014	2015	2020	2025	2030
Electricity (GWh)	**Total electricity**		**7,355**	**7,717**	**8,115**	**8,549**	**8,995**	**9,463**	**11,863**	**14,470**	**17,239**
	Lighting		655	686	720	758	796	837	1,048	1,278	1,524
	Cooking		514	538	565	595	625	657	823	1,003	1,196
	Entertainment		718	752	789	831	873	918	1,149	1,401	1,671
	Amenity	Air-conditioning	465	502	539	576	613	650	835	1,021	1,206
		Other	3,840	4,021	4,222	4,443	4,671	4,911	6,146	7,495	8,935
	Other		1,164	1,218	1,279	1,346	1,415	1,488	1,862	2,271	2,708
LPG (10^3 tons)	Cooking		301	315	331	349	366	385	482	588	701
Fuel wood (10^3 tons)	Cooking		231	242	255	268	282	296	371	452	539
Charcoal (10^3 tons)	Cooking		368	385	404	425	447	470	588	718	855

4.4 Scenario III: High Electricity Demand

In this case, there was no energy plan to improve energy efficiency in residential and small commercial buildings as same as the Scenario II. All of the useful heat consumption for cooking is identical with Scenario II but the useful heat demand of LPG, fuel wood and charcoal were substitution by electricity. The result is that the whole electricity consumption was 141,237 GWh in 2030 or higher than the Scenario III about 41%. Due to the nature of electricity as an energy form that cannot be stored, Scenario III is warning about the future expansion plan of electric generation. Energy consumption of Scenario III is shown in Table 4.21.

Table 4.21: Energy consumption of residential and small commercial buildings in various activities in 2030 of Scenario III

Sector	Activity Category	Type of Energy	Municipality		Total
			In M	Out M	
Residential	Lighting	Electricity (GWh)	2,360	2,548	4,907
	Cooking	Electricity (GWh)	8,644	20,603	29,247
		LPG (kton)	-	-	-
		Fuel Wood (kton)	-	-	-
		Charcoal (kton)	-	-	-
	Entertainment	Electricity (GWh)	3,150	2,742	5,892
	Amenity (Except air-conditioner and water heater)	Electricity (GWh)	4,909	5,475	10,384
	Amenity (Air-conditioner)	Electricity (GWh)	13,314	7,732	21,046
	Amenity (water heater)	Electricity (GWh)	3,994	2,620	6,614
	Other	Electricity (GWh)	680	718	1398.35499
Small Commercial	Lighting	Electricity (GWh)	3,519	1,524	5042.70332
	Cooking	Electricity (GWh)	11,121	8,060	19,180
		LPG (kton)	-	-	-
		Fuel Wood (kton)	-	-	-
		Charcoal (kton)	-	-	-
	Entertainment	Electricity (GWh)	5,770	1,671	7,441
	Amenity (Except air-conditioner)	Electricity (GWh)	10,998	1,206	12,204
	Amenity (Air-conditioner)	Electricity (GWh)	3,649	8,935	12,584
	Other	Electricity (GWh)	2,590	2,708	5,298
Total	Lighting	Electricity (GWh)	5,879	4,071	9,950
	Cooking	Electricity (GWh)	19,764	28,663	48,427
		LPG (kton)	-	-	-
		Fuel Wood (kton)	-	-	-
		Charcoal (kton)	-	-	-
	Entertainment	Electricity (GWh)	8,920	4,413	13,333
	Amenity (Except air-conditioner and water heater)	Electricity (GWh)	15,907	6,681	22,587
	Amenity (Air-conditioner)	Electricity (GWh)	16,963	16,668	33,630
	Amenity (water heater)	Electricity (GWh)	3,994	2,620	6,614
	Other	Electricity (GWh)	3,270	3,426	6,696
Total Electricity (GWh)					**141,237**

4.5 Scenario IV: High Liquid Petroleum Gas Demand

Identical to Scenario II, this scenario has no energy plan to improve energy efficiency in residential and small commercial buildings. However, all of the useful heat consumption of fuel wood and charcoal for cooking are substituted by LPG. The result is that the LPG consumption is equal to 6,075 thousand tons in 2030 or higher than that of Scenario II about 72%. Table 4.22 shows the energy consumption of Scenario IV in 2030.

Table 4.22: Energy consumption of residential and small commercial buildings in various activities of Scenario IV in 2030

Sector	Activity Category	Type of Energy	Municipality		Total
			In M	Out M	
Residential	Lighting	Electricity (GWh)	2,360	2,548	4,907
	Cooking	Electricity (GWh)	2,106	2,205	4,310
		LPG (kton)	974	2,742	3,716
		Fuel Wood (kton)	-	-	-
		Charcoal (kton)	-	-	-
	Entertainment	Electricity (GWh)	3,150	2,742	5,892
	Amenity (Except air-conditioner and water heater)	Electricity (GWh)	4,909	5,475	10,384
	Amenity (Air-conditioner)	Electricity (GWh)	13,314	7,732	21,046
	Amenity (water heater)	Electricity (GWh)	3,994	2,620	6,614
	Other	Electricity (GWh)	680	718	1398.35499
Small Commercial	Lighting	Electricity (GWh)	3,519	1,524	5042.70332
	Cooking	Electricity (GWh)	2,158	1,196	3,354
		LPG (kton)	1336	1023	2,359
		Fuel Wood (kton)	-	-	-
		Charcoal (kton)	-	-	-
	Entertainment	Electricity (GWh)	5,770	1,671	7,441
	Amenity (Except air-conditioner)	Electricity (GWh)	10,998	1,206	12,204
	Amenity (Air-conditioner)	Electricity (GWh)	3,649	8,935	12,584
	Other	Electricity (GWh)	2,590	2,708	5,298

Table 4.22: Energy consumption of residential and small commercial buildings in various activities of Scenario IV in 2030 (Cont')

Sector	Activity Category	Type of Energy	Municipality		Total
			In M	Out M	
Total	Lighting	Electricity (GWh)	5,879	4,071	9,950
	Cooking	Electricity (GWh)	4,264	3,401	7,665
		LPG (kton)	2,310	3,765	6,075
		Fuel Wood (kton)	-	-	-
		Charcoal (kton)	-	-	-
	Entertainment	Electricity (GWh)	8,920	4,413	13,333
	Amenity (Except air-conditioner and water heater)	Electricity (GWh)	15,907	6,681	22,587
	Amenity (Air-conditioner)	Electricity (GWh)	16,963	16,668	33,630
	Amenity (water heater)	Electricity (GWh)	3,994	2,620	6,614
	Other	Electricity (GWh)	3,270	3,426	6,696
Total Liquid Petroleum Gas (kton)					**6,075**

4.6 Scenario V: Energy Efficiency Plans (EEP)

Minimum energy performance standards (MEPS) is a measure to enforce devices and appliances produced in the country and imported for sales needed to improve their efficiency to comply with the minimum requirements. This measure eliminates the low performance equipments from the market. Implemented simultaneously, higher energy performance standard (HEPS) encourages expansion of equipment with high energy efficiency in the market. Both MEPS and HEPS would benefit energy savings for the country as a whole.

To minimize the constraints to the producers, procedures stringent to the requirements of MEPS and HEPS would be carried out every five years so that would allow the producers and the responsible authorities a period of time to plan before the enforcement.

Already conducted in Thailand, MEPS and HEPS should be continued and expanded to cover more household appliance. Government should also provide additional support to enhance the ability of various testing centers to testing and certification performance standards. Including public relations people to see the benefits to be gained from use of effective equipment, encourage consumers to use efficient equipment more by reducing tax for the ones who use those equipments. This would drive manufacturers turned to producing and selling equipments with high energy performance.

4.6.1 Performance Improvement of Energy Efficient Equipment

Opportunities to improve energy efficiency in residential and small commercial buildings, details and assumption to consider the improvements by end-use device to meet savings potential of each activity are as follows.

a) Lighting

In residential and small commercial buildings, fluorescent lamps and incandescent lamps are the two most common electric lamps used that should be taken into consideration for the electricity demand.

For fluorescence lamps and ballasts, the "Energy Labeling of High Efficient Fluorescence Lamp and Electronic Ballast Campaign" in order to buyers can bring labels for reduction of electricity costs. For CFL, the "Exchange Incandescence Lamp for CFL Campaign" should implement and for nearly target we suggest that should supported by Sub District Administrative.

Energy savings potentials of lighting resulting from high energy efficient fluorescent lamp penetrates 10% (new acquisition and replacement), electronic ballast penetrates 5% and incandescence lamp is replaced by CFL with the replacement rate of 20% each year.

b) Cooking

For this activity, the use of electricity and LPG must not increase from the BAU scenario, and is expected to switch the type of energy used from fuel wood to charcoal in the future increase of 10% per year from 2011 while total useful heat demand for cooking unchanged from the BAU. The performance of LPG and charcoal stove is a great opportunity to help to reduce the waste of energy.

Promotion of LPG and charcoal stove by the "Energy Labeling of High Efficient Stove Campaign" implemented and gradually increases the concentration of the standard every five years period which focuses on saving fuel costs especially for restaurants.

Energy savings potential of cooking (both LPG and charcoal) resulting from all new stoves are high energy efficient and the existing conventional LPG stoves are replaced by the high energy efficient one at a rate of 10% each year which the energy consumption from stove calculated by the average efficiency of MEPs and HEPs. And assume that average lifetimes of LPG stove for residential building and small commercial building are 10 years and 5 years, respectively.

c) Entertainment

The use of appliances in this activity such as computer, DVD/VCD player and so on which has less potential to save electricity when compared to other activity category. Although number of some appliances is growing, the development of MEPs and HEPs existing can be helps electricity demand in this activity do not change too much. Therefore, the study not focused on the saving potential from this category. In addition, to anticipate the demand for electricity from the increasing number of devices, lack of reliable data that is used for consideration.

d) Amenity

Equipment used for this activity such as fan, air-conditioning, vacuum cleaner, washing machine, water heater, electric water pump, iron, refrigerator and freezer which are expected that electricity demand of each household to reach saturation. However, electricity demand of whole country changes due to changes in the number of households, except air conditioning and electric water heater which increased continuously. In 2030, the electricity demand due to this activity up to 61,260 GWh or 62 percent of total. Measure arising in the conservation plan is focused on the use of air conditioning and hot

water generation more efficient. In Thailand where the summer is long, hot and humid, air-conditioning and hot water generation has, in recent years, become large electricity-consuming appliance. So for energy efficiency, this activity expected the use of energy efficient air conditioning which produces hot water. In addition, the future of technology that is solar cooling and heating for air-conditioning and hot water generation can be used to produce hot water which also substitution the electricity demand from hot water generation in the future.

"MEPs and HEPs Campaign" that already exist should continue implemented and to gradually increase the concentration of the standard every five years. For hot water generation the "Promotion of Air Conditioner which produce hot water Campaign"

Energy savings potential of amenity resulting from air conditioning and hot water generation; energy consumption from new air conditioner calculated by the average efficiency of MEPs and HEPs, while conventional air conditioner (in base year 2010) is replaced by high energy efficient one with the replacement rate of 10%. Since 2021, 10% of new air conditioning is replaced by hybrid system and then after 2025, 20% of new air conditioning is replaced by solar system (5% hybrid and 15% solar system). For hot water generation, first and second period, promotion of air conditioner which produces hot water can penetrate 10% 45% and 100% of new energy demand for hot water generation for first, second and third period, respectively.

Table 4.23 shows the high efficiency technology equipment campaign of each five year period.

Table 4.23: High efficiency technology equipment

<table>
<tr><th rowspan="2">Appliances</th><th colspan="5">High Efficiency Technology</th></tr>
<tr><th>2010</th><th>2011-2015</th><th>2016-2020</th><th>2021-2025</th><th>2026-2030</th></tr>
<tr><td>Fluorescence Lamp</td><td>36W</td><td>30 W</td><td>28 W</td><td colspan="2">25 W</td></tr>
<tr><td>Ballast</td><td>Magnetic ballast</td><td colspan="4">Electronic ballast</td></tr>
<tr><td>Incandescence Lamp</td><td>Incandescence lamp</td><td colspan="4">Compact fluorescence lamp</td></tr>
<tr><td rowspan="3">Air Conditioner</td><td rowspan="3">EER 11</td><td rowspan="3">MEPs=EER 11
HEPs=EER 12.5</td><td rowspan="3">MEPs=EER 12.5
HEPs=EER 14</td><td>MEPs=EER 14
HEPs=EER 17</td><td>MEPs=EER 17
HEPs=EER 18</td></tr>
<tr><td colspan="2">Hybrid System</td></tr>
<tr><td colspan="2">Solar Cooling System</td></tr>
<tr><td>Hot Water Generation</td><td>Electric water heater</td><td colspan="4">Air-conditioner which produce hot water (MEPs)</td></tr>
<tr><td>LPG Stove</td><td>49%</td><td>MEPs=53%
HEPs=58%</td><td>MEPs=58%
HEPs=60%</td><td>MEPs=60%
HEPs=63%</td><td>MEPs=63%
HEPs=65%</td></tr>
<tr><td>Charcoal Stove</td><td>25%</td><td>MEPs=30%</td><td>MEPs=30%</td><td>MEPs=30%</td><td>MEPs=30%</td></tr>
</table>

Note: Hybrid and solar cooling system could save 50% and 90% electricity, respectively.

4.6.2 Campaign and Potential Savings

a) Energy Labeling of High Efficient Fluorescence Lamp and Electronic Ballast

As shown in Tables 4.24 and 4.25, saving potential of electricity of high efficient fluorescence lamp campaign from both residential and small commercial sectors in year 2030 is 30%. Tables 4.26 and 4.27 show the saving potentials by replacing magnetic ballast with electronic ballast for residential and small commercial sectors in year 2030 is

91%. In 2030, the whole electricity savings of lighting equipment from this campaign is 3,023 GWh.

Table 4.24: Energy labeling campaign of high efficient fluorescence lamp for residential sector

Description	2010	2011	2012	2013	2014	2015	2020	2025	2030
BAU energy consumption by lamps (GWh)		3234	3261	3293	3322	3353	3500	3672	3845
Number of total lamps in the sector (M)	Initial no. of lamps	117	118	119	120	122	127	133	139
Number of new 30W lamps (M)		12	12	12	12	12	6		
Number of 36W lamps in the sector (M)	117.23	106	95	84	73	62	0	5	
Number of 30W lamps in the sector (M)	0	12	24	35	48	60	58	0	
Number of new 28W lamps (M)							13	0	
Number of 28W lamps in the sector (M)						0	69	68	6
Number of new 25W lamps (M)							31	13	14
Number of 25W lamps in the sector (M)							0	65	134
Energy consumption of all lamps (GWh)		3180	3153	3130	3104	3079	2812	2844	2683
Energy Savings from the program		54	108	163	218	274	688	827	1162

Table 4.25: Energy labeling campaign of high efficient fluorescence lamp for small commercial sector

Description	2010	2011	2012	2013	2014	2015	2020	2025	2030
BAU energy consumption by lamps (GWh)		972	989	1007	1024	1043	1136	1250	1376
Number of total lamps in the sector (M)	Initial no. of lamps	24	25	25	26	26	29	31	35
Number of new 30W lamps (M)		2	2	3	3	3	1		
Number of 36W lamps in the sector (M)	24	22	20	18	16	14	0		
Number of 30W lamps in the sector (M)	0	2	5	7	10	13	13	0	
Number of new 28W lamps (M)							3	0	
Number of 28W lamps in the sector (M)							15	18	3
Number of new 25W lamps (M)							7	3	3
Number of 25W lamps in the sector (M)								15	32
Energy consumption of all lamps (GWh)		956	956	957	957	959	913	918	965
Energy Savings from the program		16	33	49	67	84	223	332	411

Table 4.26: Energy labeling campaign of electronic ballast for residential sector

Description	2010	2011	2012	2013	2014	2015	2020	2025	2030
BAU energy consumption by ballasts (GWh)		988	996	1006	1015	1025	1069	1122	1175
Number of ballasts in the sector (M)		117	118	119	120	122	127	133	139
Number of new electronic ballasts	Initial no. of Ballasts	6	6	6	6	6	6	13	1
Number of electronic ballasts in the sector (M)		6	12	18	24	30	61	126	139
Number of magnetic ballasts in the year (M)	117	111	105	99	93	87	56	7	
Energy consumption of all ballasts (GWh)		943	898	852	806	759	520	154	107
Energy Savings from the program		45	99	154	209	265	549	968	1068

Table 4.27: Energy labeling campaign of electronic ballast for small commercial sector

Description	2010	2011	2012	2013	2014	2015	2020	2025	2030
BAU energy consumption by ballasts (GWh)		297	302	308	313	319	347	382	421
Number of ballasts in the sector (M)		24	25	25	26	26	29	31	35
Number of new electronic ballasts	Initial no. of Ballasts	1	1	1	1	1	1	3	1
Number of electronic ballasts in the sector (M)		1	2	4	5	6	13	28	35
Number of magnetic ballasts in the year (M)	24	23	22	21	19	18	11	0	
Energy consumption of all ballasts (GWh)		284	270	256	242	227	151	31	38
Energy Savings from the program		14	32	52	71	91	196	350	382

b) Exchange of Incandescent Lamp with CFL

Electricity savings potential from CFL campaign of residential and small commercial sectors, in the year 2030, is 80% and 82%, respectively as shown in Tables 4.28 and 4.29. In 2030, whole electricity savings potential of lighting from this campaign is 257 GWh.

Table 4.28: Campaign of exchange of incandescence lamp with CFL for residential sector

Description	2010	2011	2012	2013	2014	2015	2020	2025	2030
BAU energy consumption by lamps (GWh)	226	228	230	232	234	236	247	259	271
Required No. of incandescence lamp in given year (M)		1	1	1	1	1	0	0	0
Total of incandescence lamp remaining in year (M)		5	4	2	1	0		0	0
No. of total CFL in year (M)	0	1	2	3	5	6	6	7	7
Total electricity in given year		191	156	121	85	49	48	51	54
Energy Savings from the program		37	74	111	149	187	199	208	217

Table 4.29: Campaign of exchange of incandescence lamp with CFL for small commercial sector

Description	2010	2011	2012	2013	2014	2015	2020	2025	2030
BAU energy consumption by lamps (GWh)	34	35	35	36	37	37	41	45	49
Required No. of incandescence lamp in given year (M)		0	0	0	0	0	0	0	0
Total of incandescence lamp remaining in year (M)		1	0	0	0	0	0	0	0
No. of total CFL in year (M)		0	0	0	1	1	1	1	1
Total electricity in given year		29	24	19	13	8	8	8	9
Energy Savings from the program		6	11	17	23	29	33	36	40

c) Energy Labeling of High Efficient LPG Stove

LPG savings potential from high efficient LPG stove campaign of both residential and small commercial sectors in year 2030 is 23%. Tables 4.30 to 4.33 show the LPG savings from high efficient LPG stove campaigns for each sub-sector. In 2030, whole LPG savings potential is 828,000 tons.

Table 4.30: Energy labeling campaign of high efficient LPG stove for within-municipal residential sub-sector

Description	2011	2012	2013	2014	2015	2020	2025	2030
BAU LPG Consumption (1,000 tons)	457	470	485	500	515	599	697	812
49% Stove	399	355	310	266	222	-	-	-
Lot (2011-2015)	51	103	154	207	259	244	-	-
Lot (2016-2020)	-	-	-	-	-	254	243	-
Lot (2021-2025)	-	-	-	-	-	-	312	300
Lot (2025-2030)	-	-	-	-	-	-	-	322
LPG Consumption by program	450	457	465	473	481	497	555	622
Savings of LPG (1,000 tons)	7	13	20	27	34	101	141	190

Table 4.31: Energy labeling campaign of high efficient LPG stove for outside-municipal residential sub-sector

Description	2011	2012	2013	2014	2015	2020	2025	2030
BAU LPG Consumption (1,000 tons)	1,444	1,436	1,427	1,417	1,406	1,339	1,246	1,123
49% Stove	1,307	1,162	1,016	871	726	-	-	-
Lot (2011-2015)	122	243	363	483	602	565	-	-
Lot (2016-2020)	-	-	-	-	-	547	525	-
Lot (2021-2025)	-	-	-	-	-	-	468	450
Lot (2025-2030)	-	-	-	-	-	-	-	410
LPG Consumption by program	1,428	1,404	1,379	1,354	1,328	1,112	994	860
Savings of LPG (1,000 tons)	16	32	47	63	78	227	253	263

Table 4.32: Energy labeling campaign of high efficient LPG stove for within-municipal small commercial sub-sector

Description	2011	2012	2013	2014	2015	2020	2025	2030
BAU LPG Consumption (1,000 tons)	178	193	211	230	251	384	585	903
49% Stove	131	98	65	33	-	-	-	-
Lot (2011-2015)	41	84	129	175	222	-	-	-
Lot (2016-2020)	-	-	-	-	-	319	-	-
Lot (2021-2025)	-	-	-	-	-	-	467	-
Lot (2025-2030)	-	-	-	-	-	-	-	691
LPG Consumption by program	172	182	194	207	222	319	467	691
Savings of LPG (1,000 tons)	5	11	17	23	29	65	119	211

Table 4.33: Energy labeling campaign of high efficient LPG stove for outside-municipal small commercial sub-sector

Description	2011	2012	2013	2014	2015	2020	2025	2030
BAU LPG Consumption (1,000 tons)	315	331	349	366	385	482	588	701
49% Stove	241	181	120	60	-	-	-	-
Lot (2011-2015)	66	133	202	271	341	-	-	-
Lot (2016-2020)	-	-	-	-	-	401	-	-
Lot (2021-2025)	-	-	-	-	-	-	469	-
Lot (2025-2030)	-	-	-	-	-	-	-	537
LPG Consumption by program	307	314	322	331	341	401	469	537
Savings of LPG (1,000 tons)	9	17	26	35	44	82	119	164

d) Energy Labeling of High Efficient Charcoal Stove

Savings potential of charcoal from high efficient charcoal stove campaign of both residential and small commercial sectors in the year 2030 is 13% as shown in Tables 4.34 to 4.37. In 2030, whole LPG savings potential is 1,061,000 tons.

Table 4.34: Energy labeling campaign of high efficient charcoal stove for within-municipal residential sub-sector

Description	2011	2012	2013	2014	2015	2020	2024	2025	2029	2030
BAU charcoal consumption (1,000 tons)	242	255	269	283	298	384	433	447	505	521
Useful heat from 25% stove Ref. (MMJ)	1,368	1,443	1,520	1,601	1,686	2,169	2,449	2,525	2,854	2,943
Useful heat from 30% Stove Ref. (MMJ)	456	481	507	534	562	723	816	842	951	981
Useful heat from 25% Stove Remaining (MMJ)	1,095	866	608	320	-	-	-	-	-	-
Useful heat from 30% stove Remaining (MMJ)	730	1,058	1,419	1,815	2,248	2,892	3,266	3,367	3,805	3,924
Charcoal from 25% Stove (1,000 tons)	152	120	84	44	-	-	-	-	-	-
Charcoal from 30% Stove (1,000 tons)	84	122	164	209	259	334	377	389	439	453
Savings of Charcoal (1,000 tons)	6	13	21	30	39	50	57	58	66	68

Table 4.35: Energy labeling campaign of high efficient charcoal stove for outside-municipal residential sub-sector

	2011	2012	2013	2014	2015	2020	2024	2025	2029	2030
Reference Charcoal (1,000 tons)	5374	5486	5594	5697	5795	6190	5859	5763	5318	5191
Useful Heat from 25% Stove Ref. (MMJ)	30,365	31,001	31,611	32,193	32,745	34,978	33,105	32,562	30,051	29,332
Useful Heat from 30% Stove Ref. (MMJ)	10,122	10,334	10,537	10,731	10,915	11,659	11,035	10,854	10,017	9,777
Useful Heat from 25% Stove Remaining (MMJ)	24,292	18,601	12,644	6,439	-	-	-	-	-	-
Useful Heat from 30% stove Remaining (MMJ)	16,195	22,734	29,504	36,486	43,660	46,638	44,140	43,415	40,068	39,109
Charcoal from 25% Stove (1,000 tons)	3,365	2,576	1,751	892	-	-	-	-	-	-
Charcoal from 30% Stove (1,000 tons)	1,869	2,624	3,405	4,211	5,039	5,383	5,095	5,011	4,625	4,514
Saving of Charcoal (1,000 tons)	140	286	438	595	756	807	764	752	694	677

Table 4.36: Energy labeling campaign of high efficient charcoal stove for within-municipal small commercial sub-sector

	2011	2012	2013	2014	2015	2020	2024	2025	2029	2030
Reference Charcoal (1,000 tons)	270	294	322	351	384	591	827	901	1273	1389
Useful Heat from 25% Stove Ref. (MMJ)	1,526	1,663	1,817	1,985	2,170	3,337	4,671	5,088	7,191	7,847
Useful Heat from 30% Stove Ref. (MMJ)	509	554	606	662	723	1,112	1,557	1,696	2,397	2,616
Useful Heat from 25% Stove Remaining (MMJ)	1,221	998	727	397	-	-	-	-	-	-
Useful Heat from 30% stove Remaining (MMJ)	814	1,219	1,696	2,249	2,893	4,449	6,228	6,784	9,588	10,463
Charcoal from 25% Stove (1,000 tons)	169	138	101	55	-	-	-	-	-	-
Charcoal from 30% Stove (1,000 tons)	94	141	196	260	334	513	719	783	1,107	1,208
Saving of Charcoal (1,000 tons)	7	15	25	37	50	77	108	117	166	181

Table 4.37: Energy labeling campaign of high efficient charcoal stove for outside-municipal small commercial sub-sector

	2011	2012	2013	2014	2015	2020	2024	2025	2029	2030
Reference Charcoal (1,000 tons)	395	423	454	486	520	710	833	866	999	1032
Useful Heat from 25% Stove Ref. (MMJ)	2,232	2,390	2,563	2,745	2,940	4,012	4,708	4,893	5,646	5,833
Useful Heat from 30% Stove Ref. (MMJ)	744	797	854	915	980	1,337	1,569	1,631	1,882	1,944
Useful Heat from 25% Stove Remaining (MMJ)	1,786	1,434	1,025	549	-	-	-	-	-	-
Useful Heat from 30% stove Remaining (MMJ)	1,191	1,752	2,392	3,111	3,920	5,349	6,277	6,523	7,529	7,777
Charcoal from 25% Stove (1,000 tons)	247	199	142	76	-	-	-	-	-	-
Charcoal from 30% Stove (1,000 tons)	137	202	276	359	452	617	724	753	869	898
Saving of Charcoal (1,000 tons)	10	22	35	51	68	93	109	113	130	135

e) MEPS and HEPS of Air Conditioner Campaign

Electricity savings potential from air conditioner campaign, for new air conditioner of both residential and small commercial sectors is 30% as shown in Tables 4.38 and 4.39, for existing air conditioner is 17% (see Tables 4.40 and 4.41), and for solar cooling system is 6% and 3% of residential and small commercial sectors, respectively (see Tables 4.42 and 4.43). In 2030, whole electricity savings potential of air conditioner is 10,768 GWh.

New Air Conditioner

Table 4.38: MEPS and HEPS of new air-conditioner for residential sector

Description	2010	2011	2012	2013	2014	2015	2020	2025	2030
A/C consumption (BAU II) (GWh)	8,123	8,769	9,415	10,061	10,707	11,354	14,585	17,815	21,046
Consumption by new A/C (GWh)		646	646	646	646	646	646	646	646
BAU A/C consumption (GWh)		646	1,292	1,939	2,585	3,231	6,462	9,693	12,924
MEPS consumption (GWh)		587	587	587	587	587	517	462	380
HEPS consumption (GWh)		517	517	517	517	517	462	380	349
Program new A/C (GWh)		552	552	552	552	552	489	205	94
Program A/C consumption (GWh)		552	1,104	1,657	2,209	2,761	5,207	6,234	6,705
Energy savings (GWh)		94	188	282	376	470	1,255	3,459	6,219

Table 4.39: MEPS and HEPS of new air-conditioner for small commercial sector

Description	2010	2011	2012	2013	2014	2015	2020	2025	2030
A/C consumption (BAU II) (GWh)	1,873	2,023	2,172	2,321	2,470	2,619	3,364	4,109	4,854
Consumption by new A/C (GWh)		149	149	149	149	149	149	149	149
BAU A/C consumption (GWh)		149	298	447	596	745	1,490	2,236	2,981
MEPS consumption (GWh)		135	135	135	135	135	119	106	88
HEPS consumption (GWh)		119	119	119	119	119	106	88	81
Program new A/C (GWh)		127	127	127	127	127	113	47	22
Program A/C consumption (GWh)		127	255	382	509	637	1,201	1,438	1,547
Energy savings (GWh)		22	43	65	87	108	289	798	1,434

Existing Air Conditioner

Table 4.40: MEPS and HEPS of existing air-conditioner for residential sector

Description	2010	2011	2012	2013	2014	2015	2020	2025	2030
A/C consumption (BAU II) (GWh)	8,123	8,769	9,415	10,061	10,707	11,354	14,585	17,815	21,046
Consumption by new A/C (GWh)		812	812	812	812	812	812	812	812
BAU A/C consumption (GWh)		7,310	6,498	5,686	4,874	4,061	0	0	0
MEPS consumption (GWh)		738	738	738	738	738	650	580	478
HEPS consumption (GWh)		650	650	650	650	650	580	478	439
Program new A/C (GWh)		694	694	694	694	694	615	529	302
Program A/C consumption (GWh)		8,005	7,886	7,768	7,650	7,532	6,546	5,720	4,624
Energy savings (GWh)		118	236	354	473	591	1,577	2,403	3,499

Table 4.41: MEPS and HEPS of existing air-conditioner for small commercial sector

Description	2010	2011	2012	2013	2014	2015	2020	2025	2030
A/C consumption (BAU II) (GWh)	1,873	2,023	2,172	2,321	2,470	2,619	3,364	4,109	4,854
Consumption by new A/C (GWh)		187	187	187	187	187	187	187	187
BAU A/C consumption (GWh)		1,686	1,499	1,311	1,124	937	0	0	187
MEPS consumption (GWh)		170	170	170	170	170	150	134	110
HEPS consumption (GWh)		150	150	150	150	150	134	110	101
Program new A/C (GWh)		160	160	160	160	160	142	122	70
Program A/C consumption (GWh)		1,846	1,819	1,792	1,764	1,737	1,510	1,319	1,067
Energy savings (GWh)		27	55	82	109	136	364	554	807

Solar Cooling System

In 2030, electricity savings potential from solar cooling system campaign of residential and small commercial sectors is 967 GWh and 133 GWh, respectively. Whole electricity savings potential of air conditioner from this campaign is 1,100 GWh.

Table 4.42: Solar cooling system for residential sector

Description	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
A/C consumption (BAU II) (GWh)	14,585	15,231	15,877	16,523	17,169	17,815	18,462	19,108	19,754	20,400	21,046
Fraction of new BAU A/C (EER 10) (GWh)		65	65	65	65	65	129	129	129	129	646
Fraction of BAU A/C consumption (GWh)		65	129	194	258	323	452	582	711	840	1,486
Hybrid Cooling System (GWh)		32	32	32	32	32	16	16	16	16	81
Solar Cooling System (GWh)							10	10	10	10	48
Program new A/C (GWh)		32	32	32	32	32	26	26	26	26	11
Program A/C consumption (GWh)		32	65	97	129	162	187	213	239	265	276
Energy savings (GWh)		32	65	97	129	162	265	368	472	575	1,210

Table 4.43: Solar cooling system for small commercial sector

Description	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
A/C consumption (BAU II) (GWh)	3,364	3,513	3,662	3,811	3,960	4,109	4,258	4,407	4,556	4,705	4,854
Fraction of new BAU A/C (EER 10) (GWh)		15	15	15	15	15	30	30	30	30	30
Fraction of BAU A/C consumption (GWh)		15	30	45	60	75	104	134	164	194	224
Hybrid Cooling System (GWh)		7	7	7	7	7	4	4	4	4	4
Solar Cooling System (GWh)							2	2	2	2	2
Program new A/C (GWh)		7	7	7	7	7	6	6	6	6	6
Program A/C consumption (GWh)		7	15	22	30	37	43	49	55	61	67
Energy savings (GWh)		7	15	22	30	37	61	85	109	133	156

f) Promotion of "Air Conditioner which produces hot water" Campaign

If energy demand for hot water generation is decreasing continuously, there is no electricity demand for hot water generation in 2030 (see Figure 4.2).

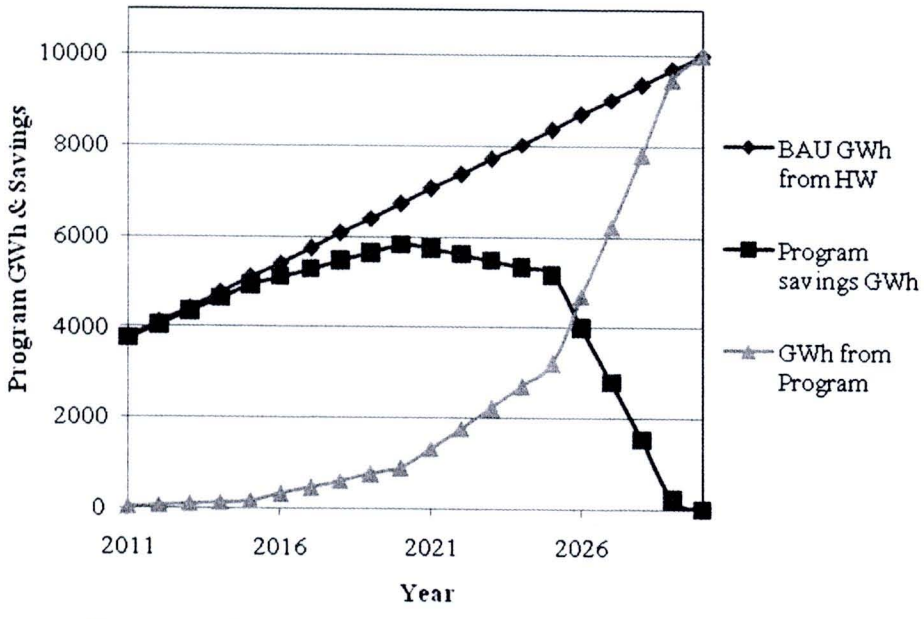


Figure 4.2: Promotion for "Air Conditioner which produces hot water" Campaign

Savings Potential

The details of the promoting project of high efficient equipment and potential of energy conservation activities are broken down by category. The savings resulting from the implementation of the plan for 20 years by facilitating the replacement of conventional equipment with high-performance equipment such as fluorescent lamp with electronic ballasts, compact fluorescent lamp, water heater, solar cooling and heating for air-conditioning and hot water generation, LPG and charcoal stove. Table 4.44 is shown the energy saving potential according to the plan.

Table 4.44: The energy saving potential

Appliance	Energy Saving Potential							
	2011	2012	2013	2014	2015	2020	2025	2030
Fluorescence Lamp (GWh)	70	141	213	285	358	911	1,155	1,573
Magnetic Ballast (GWh)	58	131	206	280	357	745	1,319	1,450
Incandescence Lamp (GWh)	43	85	128	172	216	232	244	257
Air-Conditioning (GWh)	261	522	783	1,044	1,305	3,485	7,412	13,325
Water Heater (GWh)	22	43	65	87	108	596	2,125	6,614
Total Electricity (GWh)	454	923	1,395	1,868	2,345	5,969	12,256	23,219
LPG Stove (1,000 tons of LPG)	36	73	111	148	186	474	632	829
Charcoal Stove (1,000 tons of charcoal)	164	337	520	711	913	1,027	1,040	1,061

Energy efficiency plans (EEP)

The EEP, which the electricity and LPG consumption for cooking is identical with BAU II but the useful heat demand of fuel wood was substituted by charcoal (increased 10% each year until 100% in the tenth year) and energy conservation plans are implemented.

Table 4.45 shows the energy consumption of residential sector in various activities of EEP. In 2030, total electricity consumption decreased about 23% and reduced LPG consumption about 23%. Energy consumption of air conditioning and hot water was reduced more than half.

Table 4.45: Energy consumption of residential sector in various activities of EEP

Energy	Activities		2010	2011	2012	2013	2014	2015	2020	2025	2030
Electricity (GWh)	**Total electricity**		**35,307**	**35,924**	**36,531**	**37,134**	**37,733**	**38,329**	**40,221**	**39,717**	**34,564**
	Lighting		4,582	4,468	4,344	4,217	4,090	3,959	3,341	2,849	2,460
	Cooking		4,000	4,020	4,039	4,059	4,077	4,096	4,181	4,254	4,310
	Entertainment		5,265	5,299	5,332	5,365	5,398	5,431	5,592	5,747	5,892
	Amenity	Air-conditioning	8,123	8,557	8,991	9,425	9,859	10,293	11,753	11,792	10,119
		Electric hot water	2,277	2,472	2,667	2,862	3,057	3,253	3,849	3,404	0
		Other	9,759	9,803	9,845	9,887	9,928	9,968	10,147	10,290	10,384
	Other		1,300	1,306	1,312	1,318	1,324	1,330	1,358	1,381	1,398
LPG (10^3 tons)	Cooking		1,895	1,878	1,861	1,844	1,826	1,809	1,610	1,549	1,482
Fuel wood (10^3 tons)	Cooking		4,745	4,253	3,763	3,277	2,793	2,314	0	0	0
Charcoal (10^3 tons)	Cooking		5,453	5,470	5,442	5,405	5,357	5,299	5,717	5,400	4,967

Table 4.46: Energy consumption of small commercial sector in various activities of EEP

Energy	Activities		2010	2011	2012	2013	2014	2015	2020	2025	2030
Electricity (GWh)	**Total electricity**		**13,304**	**14,079**	**14,934**	**15,878**	**16,876**	**17,950**	**23,932**	**31,687**	**42,692**
	Lighting		1,293	1,343	1,397	1,462	1,533	1,612	2,093	2,845	4,209
	Cooking		905	963	1,027	1,099	1,175	1,258	1,740	2,403	3,354
	Entertainment		1,764	1,887	2,025	2,179	2,344	2,524	3,602	5,143	7,441
	Amenity	Air-conditioning	1,873	1,974	2,074	2,174	2,274	2,374	2,711	2,720	2,457
		Other	5,835	6,185	6,577	7,013	7,474	7,972	10,822	14,626	19,933
	Other		1,633	1,728	1,834	1,952	2,076	2,209	2,964	3,951	5,298
LPG (10^3 tons)	Cooking		465	479	496	516	538	563	719	935	1,228
Fuel wood (10^3 tons)	Cooking		242	4,253	3,763	3,277	2,793	2,314	0	0	0
Charcoal (10^3 tons)	Cooking		615	648	680	715	750	786	1,131	1,536	2,105

Energy performance of new houses

Energy labeling program for new houses demonstrates the success of using high performance equipment in new housing estates. In high end housing estates with prices of around 15 million and install high performance of air conditioning system or Solar Cooling that consume electricity only 10% of conventional system. The use of renewable energy in housing, especially solar cells will increase the potential of energy consumption close to Net Zero Energy Buildings that will attract the consumer.

Due to the absorber in Solar Cooling System must be high vacuum system and development of production is not support enough therefore in the third period (2020-2025) will be used the Hybrid Cooling System (the combination of electric and solar energy) and the last period (2025-2030) will use only Solar Cooling systems.

Assumptions

a) The number of new housing estates in each year is expected to equal 25% of the increase of within-municipal households in each year as shown in Table 4.47.

Table 4.47: Number of new housing estate

Year	Unit	Year	Unit	Year	Unit	Year	Unit
2011	53,289	**2016**	62,323	**2021**	72,995	**2026**	85,628
2012	54,978	**2017**	64,317	**2022**	75,353	**2027**	88,423
2013	56,724	**2018**	66,379	**2023**	77,792	**2028**	91,315
2014	58,529	**2019**	68,510	**2024**	80,316	**2029**	94,309
2015	60,394	**2020**	70,715	**2025**	82,927	**2030**	97,408

b) Equipment used in BAU houses
- 6 circular fluorescent lamps
- a set of two LPG stoves
- 3 air-conditioning
- an electric water heater

c) The electricity consumption of an appliance depends on the time of use which will be the same as above scenarios. Table 4.48 shows the average energy consumption of equipment in a year.

Table 4.48: The average annual electricity consumption of equipment

Equipment	Average Annual Electricity Consumption (kWh/year)
Circular Fluorescent Lamp	157
Compact Fluorescent Lamp	55
Electric Water Heater	1,640
Air Conditioner (EER=10)	1,854
Air Conditioner (EER=11)	1,685
Air Conditioner (EER=12.5)	1,483
Air Conditioner (EER=14)	1,324
Solar Cooling	185

Note:

- A circular fluorescent lamp consumed 43 watts for 10 hours a day.
- A compact fluorescent lamp consumed 15 watts for 10 hours a day.
- Electric water heater consumed 1,084 kWh per year.
- Air conditioner (EER = 10) consumed 1,854 kWh per year.
- Air conditioners which produce hot water consume electricity the same as minimum energy performance air conditioning of each period.

d) The average amount of fuel used in LPG stove:
In BAU housing, the LPG consumption for the 49% efficiency stove will not change from 2010 of within-municipal residential building (117 kg/year) and the average amount of LPG used in each efficient is stove shown in Table 4.49.

Table 4.49: The average amount of LPG used in LPG stove

Efficiency (%)	49	58	60	63	65
LPG (kg/year)	117	99	96	91	88

e) The end-use devices and design of energy labeling houses that changes the type or range of device performance in each year period are shown in Table 4.50.

Table 4.50: End-use devices and design of an energy labeling house

New House Condition	Descriptions
Lamp	2 of 15W CFL instead of a circular fluorescent lamp
Air Conditioning	In 2011-2020 must be used air conditioner more than the level five of energy labeling and at least one air conditioner which produce hot water.
Hybrid Cooling System	In 2021-2025 must be use at least one air conditioner which produce hot water and 2 solar cooling air conditioning systems.
Solar Cooling System	In 2026-2030 all air conditioning are Solar Cooling System.
Hot Water Generation	hot water from air conditioning system
Envelope	Design for reduce 20% of electricity consumption in air conditioning system.
LPG Stove	high energy performance of LPG stove in each period

In 2030, electricity and LPG savings of BAU houses from energy labeling of new housing estates is 70% and 20%, respectively. Figure 4.3 and 4.4 show the potential of electricity and LPG conservation of energy labeling for new house programs, respectively.

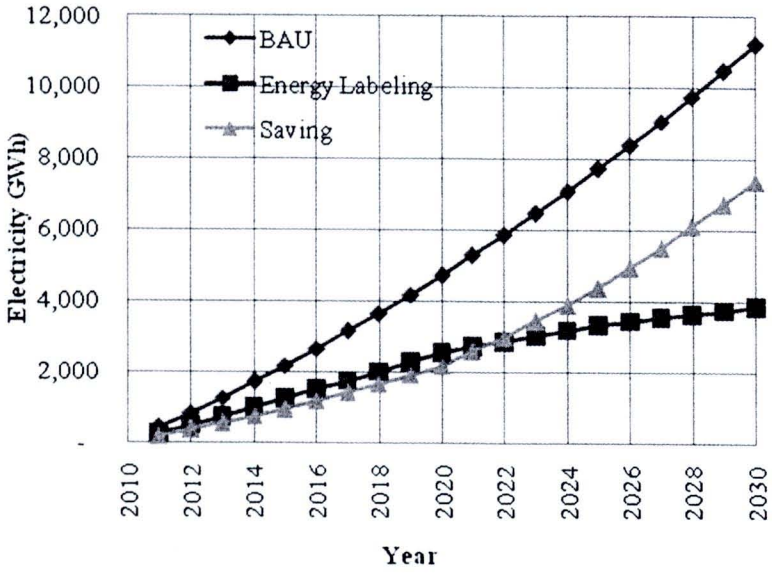


Figure 4.3: Potential of electricity conservation of energy labeling for new house programs

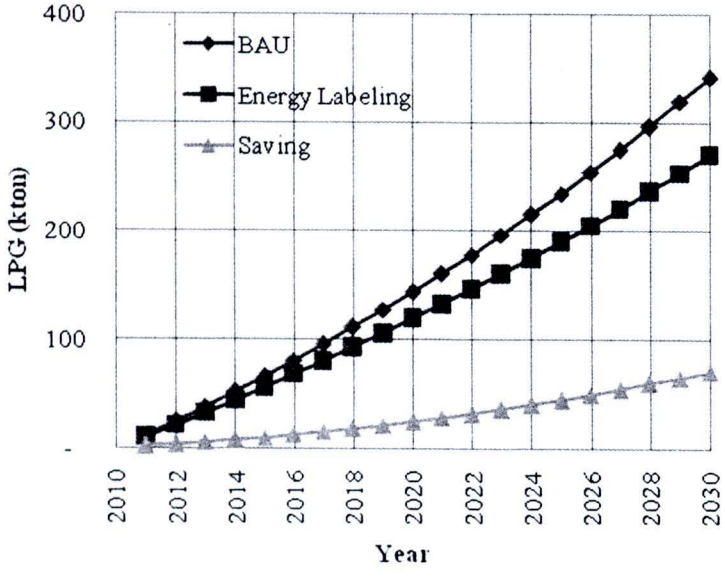


Figure 4.4: Potential of LPG conservation of energy labeling for new house programs