

## การวิเคราะห์และพยากรณ์การใช้ไฟฟ้าในภาคครัวเรือน กรณีศึกษา เมืองพนมเปญ ประเทศกัมพูชา

นู โสวันตารา<sup>1</sup> อภิชาติ เทอดโยธิน<sup>2</sup>

มหาวิทยาลัยเทคโนโลยีพระจอมเกล้าธนบุรี บางมด ทุ่งครุ กรุงเทพฯ 10140

และ บัณฑิต ลีมีโชคชัย<sup>3</sup>

สถาบันเทคโนโลยีนานาชาติสิรินธร วิทยาเขตธรรมศาสตร์รังสิต จ.ปทุมธานี 12121

รับเมื่อ 22 มิถุนายน 2547 ตอบรับเมื่อ 17 ธันวาคม 2547

### บทคัดย่อ

การใช้พลังงานไฟฟ้าในภาคครัวเรือนของเมืองพนมเปญ ได้เพิ่มขึ้นอย่างรวดเร็วในช่วงไม่กี่ปีที่ผ่านมา ใน การศึกษานี้จึงมีวัตถุประสงค์ที่จะทำความเข้าใจและศึกษาถึงปัจจัยต่างๆ ที่ก่อให้เกิดการใช้ที่เพิ่มขึ้นดังกล่าว พร้อมทั้งพยากรณ์ถึงความต้องการพลังงานไฟฟ้าในช่วง 10 ปีข้างหน้า ในระหว่างปี พ.ศ. 2545-2555 โดยการพยากรณ์ ได้ใช้วิธี end-use model ซึ่งเป็นวิธีที่ใช้กันอย่างแพร่หลายเพราะสามารถสะท้อนถึงความเปลี่ยนแปลงของสังคม ออกมาในรูปของการใช้พลังงานในอนาคตได้เป็นอย่างดี ในงานวิจัยนี้ได้แบ่งกลุ่มของบ้านอยู่อาศัยออกเป็น 3 กลุ่ม ตามระดับของรายได้ของครอบครัว ส่วนการใช้พลังงานของครัวเรือนหาได้จากการนำผลคูณของจำนวนครัวเรือน ในแต่ละกลุ่ม จำนวนอุปกรณ์ไฟฟ้าเฉลี่ยที่มี กำลังไฟฟ้าเฉลี่ยของอุปกรณ์ไฟฟ้าแต่ละชนิด และชั่วโมงการใช้งาน เฉลี่ยของอุปกรณ์ไฟฟ้าแต่ละชนิด ซึ่งพบว่าปริมาณความต้องการไฟฟ้าในปี พ.ศ. 2555 จะมีค่าระหว่าง 1.9 ถึง 2.0 เท่าของพลังงานไฟฟ้าที่ใช้ไปในปี พ.ศ. 2545

**คำสำคัญ :** End-use Model / การใช้พลังงานในภาคครัวเรือน / ข้อมูลสถิติ / ข้อมูลสำรวจจริง

<sup>1</sup> นักศึกษาระดับบัณฑิตศึกษา วิทยาลัยร่วมด้านพลังงานและสิ่งแวดล้อม

<sup>2</sup> รองศาสตราจารย์ สาขาวิชาเทคโนโลยีการจัดการพลังงาน คณะพลังงานและวัสดุ

<sup>3</sup> รองศาสตราจารย์ สาขาวิชาการจัดการพลังงาน

## Household Electricity Use Analysis and Forecasting: The Case of Phnom Penh, Cambodia

Nou Sovanndara <sup>1</sup>, Apichit Therdyothin <sup>2</sup>

King Mongkut's University of Technology Thonburi, Bangmod, Toongkru, Bangkok 10140

and Budit Limmeechokchai <sup>3</sup>

Sirindhorn International Institute of Technology at Thammasart University (SIIT-TU), Pathum Thani 12121

*Received 22 June 2004 ; accepted 17 December 2004*

### Abstract

The growth of household electricity consumption in Phnom Penh has increased rapidly in recent years. To develop a better understanding of the most active component of electricity consumption, we survey its main characteristics and analyze the major factors affecting its growth. This paper examines the residential electricity demand in Phnom Penh for the next 10 years during 2002-2012. The electricity demand in the residential sector is estimated by using a detailed end-use model. To capture the difference in socio-economic characteristics and patterns of electricity demand, the residential sector is classified into three income classes, of which the electricity demand for each income class is estimated by multiplying the number of households with the average number of appliances, average capacity of appliances, and average usage hours of appliance.

**Keywords :** End-use Model / Residential Sector / Statistical Data / Actual Data

---

<sup>1</sup> Graduate Student, The Joint Graduate School of Energy and Environment (JGSEE).

<sup>2</sup> Associate Professor, Energy Management Technology Division, School of Energy and Materials.

<sup>3</sup> Associate Professor.

## 1. Introduction

Electricity is important for all sectors of national economy. It is one of the principal production factors to satisfy basic human needs. The past, present and future growth of each activity in the economy has impact on electricity demand.

Cambodia's power sector has been severely damaged and neglected after the war; it is today at a cross road and rapidly growing. Important part of this growth is associated with industrial expansion stemming from regional trade opportunities and located mostly in Phnom Penh. Since mid-1990s garment industry has been recorded a dramatic growth rate, creating employment for thousands of workers coming from the rural areas. Industrial sector growth provides income and generates opportunities to improve human standard of living [1].

Since 1980, with reform of economic structure and opening to the outside world, urban household real income has increased rapidly in China. Therefore, electricity use has grown continuously with resident income rise [2]. The economic soaring in recent years, urbanization progresses fast and electricity service is better serving its costumers than in the previous time in Phnom Penh. This makes the urban household-electricity use the most electricity consuming appliances [1].

Presently, electricity demand in Cambodia is concentrated in Phnom Penh, accounting for 80% of the country's electricity consumption. In 2001, total electricity billed was 364.15 GWh. Energy consumption pattern in Cambodia is categorized in to residential, industrial, commercial & service, and public sector [1]. The majority of energy consumption accounts from residential sector as shown in Table 1.

**Table 1** Energy consumption on pattern in 2001

Sector	Share of Energy Used (GWh)	Percentage (%)
Residential	196.80	54.00
Commercial & Service	66.00	18.00
Public	58.00	16.00
Industrial	43.35	12.00
TOTAL	364.15	100.00

## 2. Methodology

In this study, we want to analyze and forecast the characteristics of the residential end-use energy in Phnom Penh using an end-use model [3-4]. To model the electricity consumption in the residential sector using the end-use model, the actual data from the field survey of electricity consumption in the residential sector in Phnom Penh is used.

Residential energy demand is projected by using following end-use model equation.

$$END_t = \sum_{i=1}^m \sum_{j=1}^n [TNHH_t \times PEL_t \times PIncL_{i,t} \times APN_{j,i,t} \times AUH_{j,i,t} \times ACAP_{j,i,t} \times 365days / 1,000] \quad (1)$$

$END_t$  is energy demand in kWh,  $TNHH_t$  is total number of households,  $PEL_t$  is percentage of electrified households,  $PIncL_{i,t}$  is percentage of household income level  $i$ ,  $APN_{j,i,t}$  is average number of appliances type  $j$  owned by household income level  $i$ ,  $AUH_{j,i,t}$  is average daily usage hours of appliances type  $j$  owned by household income level  $i$ ,  $ACAP_{j,i,t}$  is average capacity of appliances type  $j$  (W/Unit) owned by household income level  $i$ , and  $t$  is the year 1, 2, ...,  $n$ .

In this study,  $GDP$  is forecasted based on the three economic scenarios such as low, average and high. Average  $GDP$  growth rate considered here is 5.5% based on the 1993-2001 statistics [5], [7]. Assumed low and high  $GDP$  growth rate is 3% and 8%, respectively.

The  $GDP$  in each scenario can be projected by using the equation:

$$GDP_t = GDP_0 (1 + GR)_t \quad (2)$$

$GDP_t$  is the gross domestic products,  $GDP_0$  is the gross domestic products in base year,  $GR$  is the assumed annual growth rate of the real gross domestic products in prediction, and  $t$  is the year 1, 2, ...,  $n$ .

To estimate the number of household in Phnom Penh, the population growth projection from National Institute of Statistics (NIS) is used [5]. The number of households can be estimated by a function of population:

$$TNHH_t = A + B * PoP_t \quad (3)$$

$TNHH_t$  is total number of households,  $Pop_t$  is number of population,  $A$  is constant term for number of household,  $B$  is coefficient term for number of household, and  $t$  is the year 1, 2, ...,  $n$ .

The percentage of electrified households in Phnom Penh was 65% as per 2001 statistics. The average annual growth rate of electrified households will be increased in the order of 2% in the future as per the plan of Electricity du Cambodge [1], [8].

The percentage of households in each income level is estimated by using the statistical data from the Planning Department of Phnom Penh [7]. The percentage of households in each income level is determined by following equation:

$$PIncl_{i,t} = \alpha_i + \beta_i * GDP_t \quad (4)$$

$PIncl_{i,t}$  is percentage of household income level  $i$  (%),  $GDP_t$  is gross domestic products,  $\alpha_i$  is constant term for income level  $i$ ,  $\beta_i$  is coefficient term for income level  $i$ ,  $t$  is the year 1, 2, ...,  $n$ , and  $i$  is income level 1, 2, 3 (In Cambodia, household income level is classified into three income levels, such as low, medium, and high [6]).

### 3. Results

#### 3.1 Estimation of GDP in Cambodia

Forecasted GDP in billion riels based on the three alternative economic scenarios were estimated. The estimated forecast of GDP varies from 10,476 to 14,079 billion riels, 10,730 to 18,329 billion riels and 10,985 to 23,715 billion riels at 3%, 5.5% and 8% GDP growth rates respectively. The details of real GDP projection from 2002 to 2012 is tabulated as Table 2,

**Table 2** Real GDP projection in Cambodia from 2002 to 2012 (Billion Riels)

Year	GDP at 3%	GDP at 5.5%	GDP at 8%
2002	10,476	10,730	10,985
2003	10,790	11,321	11,863
2004	11,114	11,943	12,813
2005	11,448	12,600	13,838
2006	11,791	13,293	14,945
2007	12,145	14,024	16,140
2008	12,509	14,796	17,431
2009	12,884	15,609	18,826
2010	13,271	16,468	20,332
2011	13,669	17,374	21,958
2012	14,079	18,329	23,715

### 3.2 Estimation of number of electrified households by income level

The number of electrified households according to income level is a dominant factor of energy demand in the residential sector. Since the rates of ownership of electric devices vary by the income levels of household. It is estimated that the proportion of electrified households in the low income level will gradually decrease and shift to the medium and high levels. The number of electrified households in the low income level will slightly decrease, while the annual growth rate of GDP slightly increases. Otherwise, the number of electrified households in medium and high income levels will slightly increase (See Table 3).

**Table 3** Estimation of number of electrified households based on income level

Year	Number of Electrified Households by Income Level, (HH)								
	Low			Medium			High		
	Growth Rate of GDP			Growth Rate of GDP			Growth Rate of GDP		
	3%	5.5%	8%	3%	5.5%	8%	3%	5.5%	8%
2002	58,788	58,610	58,431	61,047	61,181	61,314	28,770	28,814	28,860
2003	62,765	62,383	61,985	65,600	65,887	66,189	30,897	30,992	31,088
2004	67,006	66,357	65,675	70,488	70,983	71,495	33,178	33,332	33,502
2005	71,362	70,395	69,355	75,577	76,306	77,073	35,525	35,763	36,036
2006	75,973	74,627	73,145	81,025	82,039	83,151	38,055	38,387	38,757
2007	80,481	78,676	76,664	86,436	87,785	89,299	40,563	41,019	41,517
2008	85,186	82,870	80,201	92,156	93,898	95,906	43,232	43,806	44,467
2009	90,052	87,125	83,658	98,156	100,357	102,957	45,998	46,724	47,591
2010	95,117	91,463	87,039	104,511	107,245	110,576	48,913	49,833	50,926
2011	100,406	95,898	90,362	111,213	114,587	118,726	51,982	53,116	54,513
2012	105,471	100,017	93,143	117,799	121,890	127,038	55,018	56,381	58,107

### 3.3 Household electricity use analysis in residential sector

The average capacity of electric appliances, the average number of electric appliances, and the average usage hours per day of each kind of electric appliance are adopted from the field survey of electricity consumption in the residential sector.

The rates of ownership of electric devices vary by the income levels of household. Therefore, these parameters are classified based on income levels.

The results of each parameter were found from the actual data. These parameters are a dominant factor of energy demand in the electrified households by income level (See Table 4). The household-electricity demand in the residential sector is estimated by using these parameters.

**Table 4** Average capacity of appliance, number of appliances, and average usage hours of appliance per household of each income level (W), (Unit), and (Hour)

Appliances	Income Levels								
	High			Medium			Low		
	(W)	(Unit)	(Hour)	(W)	(Unit)	(Hour)	(W)	(Unit)	(Hour)
Fluorescent (10 W)	16.000	0.424	4.261	16.000	0.561	4.713	16.000	0.840	3.833
Fluorescent (20 W)	28.000	11.376	2.518	28.000	7.494	2.790	28.000	3.211	3.108
Fluorescent (32 W)	39.000	1.729	2.014	39.000	0.244	1.273	-	-	-
Fluorescent (40 W)	47.000	2.847	2.079	47.000	1.472	3.435	47.000	0.411	2.143
Incandescent (5 W)	5.000	0.459	8.205	5.000	1.350	8.319	5.000	1.149	7.925
Incandescent (25 W)	25.000	3.824	1.000	25.000	0.522	1.000	-	-	-
C Fluorescent (9 W)	9.000	3.000	8.035	9.000	1.178	7.991	9.000	0.234	7.624
Radio/Tape/VCD/CD	26.942	1.424	5.583	21.169	1.117	5.315	11.835	0.954	5.496
Television	56.048	1.459	5.608	53.871	1.033	5.738	51.026	0.891	5.644
Electric Fan	50.933	4.035	5.755	50.780	3.133	5.195	45.930	1.124	5.272
Air-conditioner	553.314	2.152	5.693	508.000	0.130	4.000	-	-	-
Refrigerator	70.790	1.181	12.000	69.400	0.585	12.000	68.700	0.090	12.000
Iron	1,000.000	1.000	0.287	1,000.000	1.000	0.282	1,000.000	0.731	0.251
Rice Cooker	600.000	0.459	0.703	600.000	0.428	0.720	600.000	0.063	0.603
Electric Stove	1,000.000	0.341	0.989	1,000.000	0.278	0.901	-	-	-
Electric Pot	600.000	0.741	0.495	600.000	0.606	0.527	600.000	0.166	0.402
Microwave	700.000	0.082	0.322	-	-	-	-	-	-
Vacuum	1,000.000	0.259	0.281	-	-	-	-	-	-
Aspirator	45.000	1.024	0.960	45.000	0.100	1.000	-	-	-
Electric Pump	368.000	0.188	0.250	368.000	0.083	0.250	368.000	0.063	0.255
Water Heater	1,200.000	0.812	0.527	-	-	-	-	-	-
Washing Machine	275.000	0.715	0.277	270.000	0.540	0.285	300.000	0.052	0.250
Computer	300.000	0.482	2.122	300.000	0.178	1.906	300.000	0.029	1.600
Other	170.624	0.813	0.642	161.672	0.622	0.500	142.656	0.531	0.430

The above results also shows that lighting load is essential an use for all income levels, while the Radio/Tape/CD-player, TV, electric fan, iron, refrigerator, air-conditioner, etc, are second uses for entertainment and comfort of living. The characteristic of the dwelling were related to the household-electricity demand such as villas and some beautiful wooden houses are large houses and belong to the households with high income level. Moreover, the number of population in the household high income level is also high, so the need for electricity is high too. Therefore, the electricity consumption in household high income level is higher than the other two income levels, even though the number of households in the high income level is small. It means that the households in high income level use many kind of electric appliances to serve their needs and comfort of living, while the households in the low income level uses the only important electric appliances for their living because of the electricity price and electric appliance price are barrier to their electricity use.

Table 5 presents the estimation of household electricity consumption of each type of end-use appliance used by each household income level in the residential sector in Phnom Penh.

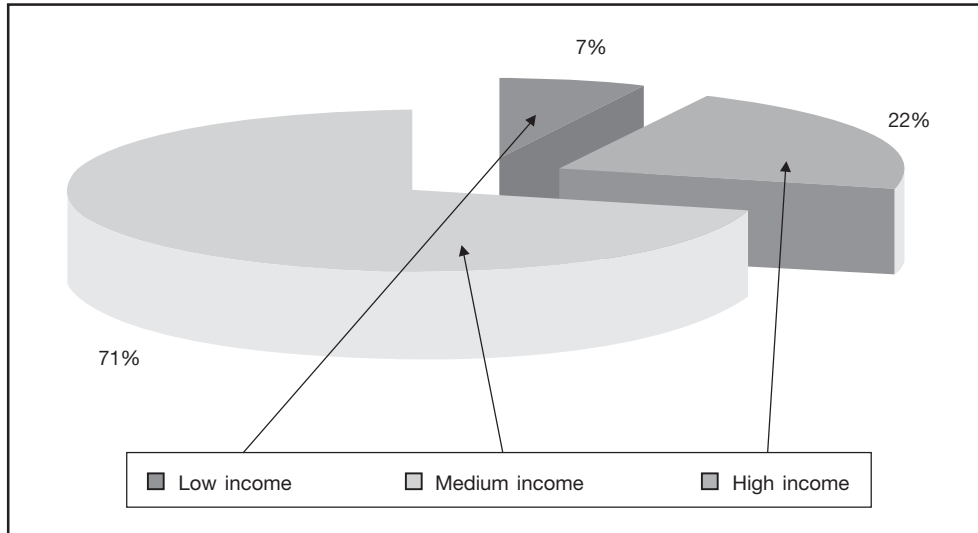
**Table 5** Electricity consumption by type of appliances per household income level in the residential sector in 2002 (Wh/HH-Day) and (%).

Appliances	Income Levels					
	High		Medium		Low	
	(Wh)	(%)	(Wh)	(%)	(Wh)	(%)
Air-conditioner	6,779.00	50.71	264.00	6.33	0.00	0.00
Lighting	1,576.00	11.79	1,031.00	24.73	433.00	30.91
Electric Fan	1,183.00	8.85	826.00	19.81	272.00	19.41
Refrigerator	1,003.00	7.50	487.00	11.68	74.00	5.28
Television	459.00	3.43	319.00	7.65	257.00	18.34
Electric Iron	287.00	2.15	282.00	6.76	183.00	13.06
Electric Stove	337.00	2.52	250.00	6.00	0.00	0.00
Water Heater	514.00	3.85	0.00	0.00	0.00	0.00
Electric Pot	220.00	1.65	192.00	4.61	40.00	2.86
Computer	307.00	2.30	102.00	2.45	14.00	1.00
Radio/tape/VCD/CD-player	214.00	1.60	126.00	3.02	62.00	4.43
Rice Cooker	194.00	1.45	185.00	4.44	23.00	1.64
Other Appliances	89.00	0.67	50.00	1.20	33.00	2.36
Clothing Washing Machine	54.00	0.40	42.00	1.01	4.00	0.29
Vacuum	73.00	0.55	0.00	0.00	0.00	0.00
Aspirator	44.00	0.33	5.00	0.12	0.00	0.00
Electric Pump	17.00	0.13	8.00	0.19	6.00	0.43
Microwave	18.00	0.13	0.00	0.00	0.00	0.00
Total electricity consumption	13,368.00	100.00	4,169.00	100.00	1,401.00	100.00

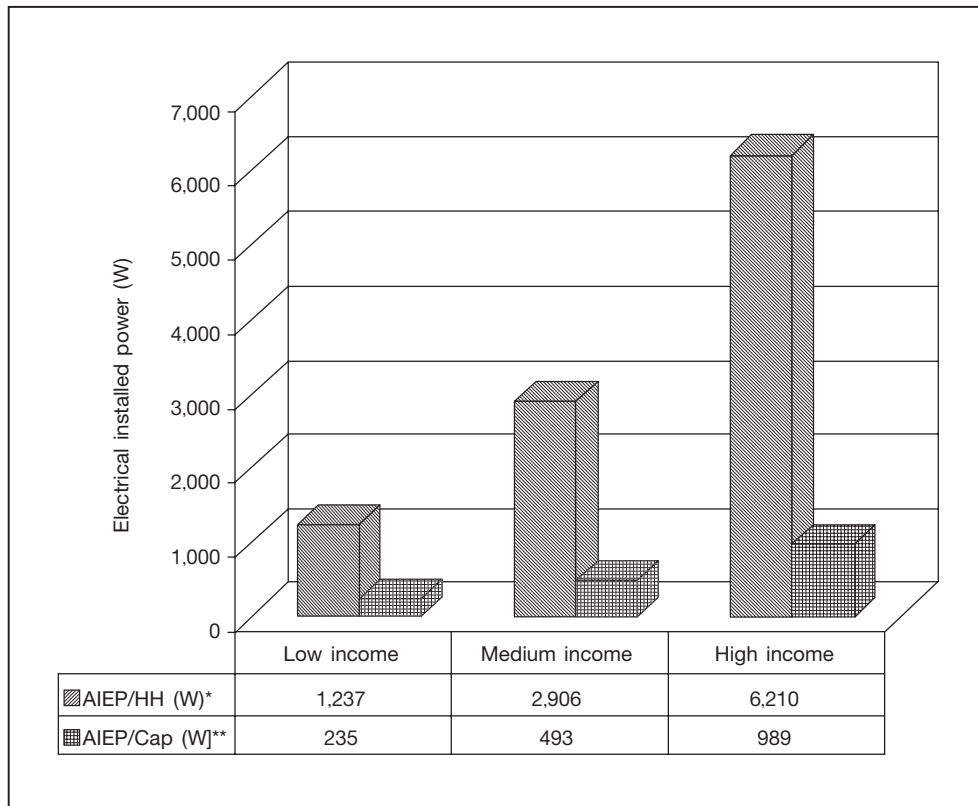
From the above results, it can be concluded that the households in high income level consumes more electricity than the medium and low income levels. In the residential sector, the air-conditioner and lighting are the major consumers of electricity, followed by electric fan, refrigerator, television, electric iron, electric stove, water heater, electric pot, computer, radio/tape/VCD/CD-player, rice cooker, other appliances, washing machine, vacuum, aspirator, electric pump, and microwave.

Share of energy demand and electrical installed power per household of each income level are shown in Fig. 1 and Fig. 2, respectively.





**Fig. 1** Share of energy demand in each income level (%)



**Fig. 2** Electrical installed power per household of each income level, and per capita.

Note: \* is Average electrical installed power per household in watt.

\*\* is Average electrical installed power per capita in watt.

### 3.4 Household electricity demand projection

This study forecasts the household electricity demand in three scenarios in the period 2002-2012, the patterns of household electricity use resulting from the field-survey data of this research will be used as an important parameter [6]. The results of the projection of the household electricity demand are presented in Table 6.

**Table 6** Household electricity demand projection by each income level in the three scenarios [GWh]

Year	3% GDP Growth			5.5% GDP Growth			8% GDP Growth		
	Income Level			Income Level			Income Level		
	Low	Medium	High	Low	Medium	High	Low	Medium	High
2002	30.07	92.89	140.38	29.98	93.10	140.60	29.89	93.30	140.82
2003	32.11	99.82	150.76	31.91	100.26	151.23	31.71	100.72	151.69
2004	34.28	107.26	161.89	33.95	108.01	162.64	33.60	108.79	163.47
2005	36.51	115.00	173.34	36.01	116.11	174.51	35.48	117.28	175.84
2006	38.86	123.29	185.69	38.18	124.84	187.31	37.42	126.53	189.12
2007	41.17	131.53	197.93	40.25	133.58	200.15	39.22	135.88	202.58
2008	43.58	140.23	210.95	42.39	142.88	213.75	41.03	145.94	216.98
2009	46.07	149.36	224.45	44.57	152.71	227.99	42.80	156.67	232.22
2010	48.66	159.03	238.67	46.79	163.19	243.16	44.53	168.26	248.49
2011	51.36	169.23	253.65	49.06	174.36	259.18	46.23	180.66	266.00
2012	53.95	179.25	268.46	51.16	185.48	275.11	47.65	193.31	283.53

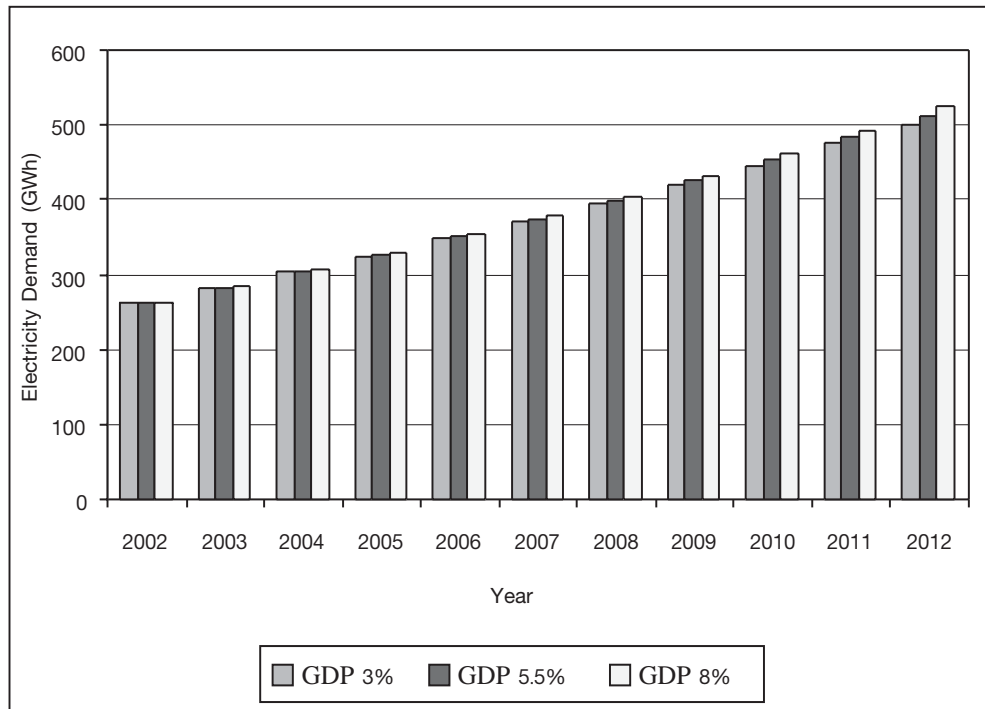
The above results show that the electricity consumption for the households in the low income level will slightly decrease, while the annual growth rate of GDP increases. Conversely, the electricity consumption for the households in the medium income and high income levels will slightly increase. In terms of economic changes, the household income levels would be changed. They would be gradually changed or rapidly changed according to the economic growth. Therefore, the electricity demand for the residential sector could be changed by the change of household income level.

Table 7 presents the results of the electricity demand projection for the residential sector in the three scenarios. These results show that the electricity demand will increase in all economic growth scenarios. These results are also shown that the electricity demand will be slightly different among these three scenarios.

**Table 7** Electricity demand projection in the residential sector in each scenario.

Year	Electricity demand (GWh)		
	GDP growth rate of 3%	GDP growth rate of 5.5%	GDP growth rate of 8%
2002	263.35	263.68	264.01
2003	282.69	283.40	284.12
2004	303.43	304.60	305.86
2005	324.85	326.63	328.60
2006	347.85	350.32	353.06
2007	370.63	373.98	377.69
2008	394.76	399.03	403.94
2009	419.88	425.27	431.68
2010	446.36	453.14	461.28
2011	474.24	482.60	492.89
2012	501.67	511.75	524.49

The household demand for electricity in residential sector in the next 10 years (2002-2012) is presented in Fig. 3.



**Fig. 3** Electricity demand projection in the three scenarios of each GDP growth.

#### 4. Discussion and Conclusion

From the Fig.1, high income level household consumes about 71% of electrical energy compared to medium and low income level households, which accounts for 21% and 7%, respectively. Therefore, the number of electrified households is a factor influenced in the household electricity demand for the residential sector. And also installed electrical appliances vary by the income levels of households. In other words, the use of end-use appliances in each income level affected the electricity consumption in the residential sector.

From Fig. 3, the high scenario of GDP growth at 8%, the electricity demand projection would be different by 22.82 GWh and 12.74 GWh in 2012 or accounted 4.55% and 2.49% of the total demand in the low scenario of GDP growth at 3% and in the base scenario of GDP growth at 5.5%, respectively. These results have shown that the influence of GDP on the household electricity demand is minimal. However, if the past historical data on end-use appliances is made available, more satisfactory results could have been achieved. Apart from this, the assumed data, which is made fixed throughout the period of forecasting, has also led to these inaccuracies. In reality, as in the case for Cambodia, the numbers of electric appliances in use by households in all income levels have not reached their saturation level yet.

End-use model have flexibility that can support the change in both macro economic parameters such as GDP, energy intensity, as well as end-use technical parameters such as the devices' efficiency. It is hoped that, the further study would be conducted in order to obtain good accuracies on the future projection for the forecasts of the energy demand in the residential sector in Phnom Penh. To achieve this, an adequate amount of quality historical data combined with new up-to-date one from time to time is required. It is hoped that, the method used in this study is the first exploration and would be taken as a role model to develop energy demand forecast in the future for all sectors not just for the Phnom Penh city, but also throughout the whole of Cambodia. However, it should be tested with a large number of survey data at varied conditions to standardize the end-use model.

#### 5. References

1. Electricite du Cambodge (EDC) and Ministry of Industry, Mines and Energy (MIME), 1991-2001 and 2002, *Annual Reports*, Cambodia.
2. Falong Yan, (1995), "Urban Household-Electricity Use in China", *The Energy Journal*, Vol. 20, No. 8, pp. 711-713.

3. Jerasorn Santisirisomboon, 2001, *Environmental Emission Abatement Strategies in the Energy Sector: The Integrated Economic, Environment and Energy Approach*, Thesis Report of Doctor of Philosophy (ISBN 974-572-885-3), Mechanical Engineering, Sirindhorn International Institute of Technology, Bangkok, Thailand.

4. Joel N. Swisher, et. al., 1997, *Tools and Methods for Integrated Resource Planning*, Working Paper No. 7, United Nations Environment Programme (UNEP).

5. Ministry of Planning (MOP), National Institute of Statistics (NIS), 2000, *Population Projections 2001-2021, and Analysis of Census Results Report 6, and Cambodia Statistical Yearbook 2001*, Phnom Penh, Cambodia.

6. Nimol Por, 1996, *Assessment of Electric Power Systems and Power Demand Forecasting: The Case of Siam Reap City, Kingdom of Cambodia*, AIT Thesis Report, Thailand.

7. Planning Department of Phnom Penh Municipality, *Data of Socio-Economic of Phnom Penh Year 2001, and Draft Report, 2002*, Cambodia.

8. World Bank, 1999, *Cambodia Power Sector Strategy*, Report No. 19382-KH, Phnom Penh, Cambodia.

## 6. Appendix

**Table A** Household electricity consumption in Phnom Penh, 1991-2001

Year	Energy Sales (GWh)	Growth Rate (%)	No. of Customers (HH)	Growth Rate (%)	Energy per HH (kWh/M)	Growth Rate (%)	No. of Household (HH)	Electrified Household (%)
1991	14.81	-	39,600	-	31.16	-	111,889	35
1992	28.50	92	53,740	36	44.19	42	119,864	45
1993	32.59	14	55,400	3	49.02	11	121,134	46
1994	42.16	29	59,860	8	58.69	20	136,800	44
1995	55.00	30	65,626	10	69.84	19	139,735	47
1996	99.01	80	89,200	36	92.50	32	150,280	59
1997	132.50	34	93,766	5	117.76	27	168,200	56
1998	152.70	15	98,857	5	128.72	9	173,678	57
1999	165.30	8	104,257	5	132.13	3	174,000	60
2000	184.00	11	109,538	5	139.98	6	174,859	63
2001	196.80	7	114,203	4	143.60	3	175,400	65

**Source** : Compiled from other Sources, MIME and EDC' s Report (1991-2001)

**Table B** Statistical data of RGDP, percentage of income level, number of population, number of household, and average household size, (1991-2001)

Year	Real GDP in 1993		Income Levels (%)			No of Pop (Person)	No of HH (HH)	Avg. HH Size (Person/HH)
	(Bl. Riels)	(%)	High	Medium	Low			
1991	280.00	-	-	-	-	632,142.00	111,889.00	5.65
1992	302.00	7.9	-	-	-	668,593.00	119,864.00	5.57
1993	6,545.00	2067.2	18.89	39.68	41.43	717,261.00	121,134.00	5.92
1994	7,047.00	7.7	18.95	39.85	41.20	793,400.00	136,800.00	5.80
1995	7,464.00	5.9	19.02	40.00	40.98	795,600.00	139,735.00	5.60
1996	7,808.00	4.6	19.07	40.16	40.77	796,936.00	150,280.00	5.30
1997	8,143.00	4.3	19.12	40.31	40.57	925,289.00	168,200.00	5.50
1998	8,318.00	2.1	19.16	40.46	40.38	999,804.00	173,678.00	5.75
1999	8,889.00	6.9	19.21	40.61	40.18	958,578.00	174,000.00	5.50
2000	9,570.00	7.7	19.26	40.76	39.98	961,578.00	174,859.00	5.50
2001	10,171.00	6.3	19.29	40.87	39.84	986,750.00	175,400.00	5.62

**Source :** Compiled from NIS and MOP, (Year Book 2001), and Planning Department of Phnom Penh, (2002).

**Table C** Population projections (2001-2021); and estimation of number of household, and household size (2001-2012).

Year	Number of Population (Person)	Annual Growth Rate (%)	Number of Households (HH)	Household Size (Per/HH)
2001	1,185,000	-	175,400	5.62
2002	1,234,000	4.13	221,799	5.56
2003	1,283,000	3.97	230,815	5.56
2004	1,335,000	4.05	240,383	5.55
2005	1,387,000	3.89	249,951	5.55
2006	1,442,000	3.96	260,071	5.54
2007	1,493,000	3.53	269,455	5.54
2008	1,546,000	3.55	279,207	5.54
2009	1,600,000	3.50	289,143	5.53
2010	1,656,000	3.50	299,447	5.53
2011	1,714,000	3.50	310,119	5.53
2012	1,767,000	3.09	319,871	5.52
2013	1,821,000	3.05	-	-
2014	1,876,000	3.02	-	-
2015	1,932,000	2.98	-	-
2016	1,990,000	3.00	-	-
2017	2,042,000	2.61	-	-
2018	2,094,000	2.54	-	-
2019	2,147,000	2.53	-	-
2020	2,200,000	2.46	-	-
2021	2,254,000	2.45	-	-

**Source :** NIS and MOP, (July, 2000), and Compiled from NIS and MOP, (Year Book 2001)