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A Study of Energy Consumption of the Household Sector in Myanmar

Win Win Kyu and Dr. Boonrod Sajjakulnukit
The Joint Graduate School of Energy and Environment, King Mongkut's University of Technology Thonburi, Bangkok, Thailand
winwinkyu.15@gmail.com

Abstract

Due to rapid economic growth, structural changes in Myanmar's society have led to a pattern of increasing household energy consumption. As an agro based country, biomass-based fuels are currently being used as a major fuel in Myanmar. They were about 76% of a total primary energy supply of 14.056 MTOE derived from biomass in 2011. In the same year, the household sector consumed 10.464 MTOE and became the largest energy consumption, accounting for 80% of the total final energy consumption, followed by the industry, transportation, agriculture and other sector with shares of 10%, 6%, 1% and 3% respectively. Given the country's steady economic growth, cleaner energy sources are needed. This study focused on analysis and forecast for energy demand of household sector in Myanmar. The household's energy demand was estimated by using an end use model, the Long-range Energy Alternative Planning (LEAP) model. The model was applied to analyze data collected from household's living in urban and rural areas at the regions of Yangon, Mandalay and Nay Pyi Taw in Myanmar. Further, the behaviors of household energy utilization at different level of income groups were presented and discussed in this study.

Keywords: Myanmar's household energy consumption, LEAP model

1. Introduction

Myanmar is a large country, with a land area of 676,577 square kilometers (km^2) and the population is approximately 60 million, with more than 67% of them living in rural areas. Myanmar's annual population growth rate is increasing steadily at 1.3 % (2009-2011) and GDP growth rate is 5.3% in fiscal year 2012(Nations & Programme, 2013). As an agro based country, biomass-based fuels are currently being used as a major fuel in Myanmar. In 2011, 76% of a total primary energy supply of 14.056 MTOE was fulfilled by biomass, followed by 8% of crude oil and petroleum products, 10% of natural gas, 3% of coal and lignite and 3% of hydroelectricity (IEA, 2012).

Due to the country's rapid economic growth and structural changes in society, the household sector is the largest energy consumption in Myanmar. The household sector consumed 10.464 MTOE of energy, about 80% of final energy consumption. This reflects the significance of the household sector in Myanmar's total national energy scenario in 2011 (IEA, 2012).

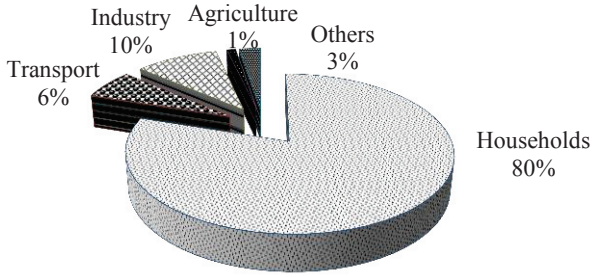

Figure 1. Final Energy Consumption by Sector in Myanmar (2011)

As the economy develops, more and cleaner energy sources are needed. Electricity does not directly replace the utilization of biomass as an energy source. Lower-income households prefer to use biomass for cooking and heating. When their income increases, it is seen that electricity and modern fuels are used for lighting, modern appliances, pumps and communication, but they do not substitute for cooking and heating. Only in higher income groups is biomass completely substituted in household consumption (Golusin, M., Dodic, S., Popov, S., 2013).

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Household energy consumption is expected to increase in the future along with growth in the economy and rise in per capita incomes. The projected increases in household energy consumption are generally affected by changes in lifestyles (Pachauri, 2004). Therefore, it is important to analyze the household energy consumption in order to formulate policies for promotion of sustainable energy use (Reddy, 2004).

The aim of this study was analysis of the household energy use patterns in different consumer categories and forecasting the energy demand of the household sector under the economic growth rates in Myanmar. The household's energy demand was estimated by using an end use model, the Long-range Energy Alternative Planning (LEAP) model. The model was applied to analyze data collected from households living in urban and rural areas at the regions of Yangon, Mandalay and Nay Pyi Taw in Myanmar. Other supporting data were also obtained from official documents, journal papers and reports from some organizations to support the model analysis. Further, the behaviors of household energy utilization at different levels of income groups were presented in this study.

2. Methods

2.1 Household Energy Consumption

For this study, the households' energy consumption data was collected using a questionnaire for households of the urban and rural areas in Myanmar. The questionnaire included the total energy consumption in a household for lighting, cooking (electricity), space cooling (air conditioning, refrigerating, and electric fan), entertainment (TV and computer), other electrical appliances and cooking (LPG, charcoal and firewood). The electricity consumption was calculated based on data on input power usage period by evaluating the following equation:

$$EL = N_{i,j} \cdot P_{i,j} \cdot M_{i,j} \cdot Ie_{i,j} \quad (1)$$

Where EL is the electricity consumption unit by device of type j, $N_{i,j}$ is the number of households with the equipments i for income class j, $P_{i,j}$ is the number of appliance per household for end-use i in income class j (unit/household), $M_{i,j}$ is the usage period of equipment i (hour) and $Ie_{i,j}$ is the energy power consumption i in the income class j (watt) (Swisher, J.N., Jannuzzi, G.M., and Redlinger, R.Y. 1997). In other kinds of electricity-saving functions, the power rating power of some appliances is not always equal to their average power consumed in actual use. To accommodate for this, it is important to use a coefficient $R_{i,j}$ to modify as follows:

$$EL = N_{i,j} \cdot P_{i,j} \cdot M_{i,j} \cdot Ie_{i,j} \cdot R_{i,j} \quad (2)$$

Where $R_{i,j}$ is the ratio of average input power in actual operation to the power rating of an appliance i in income class j. This study used the value of coefficient $R_{i,j}$ for refrigerator to be 0.36 (Murata, Kondou, Hailin, & Weisheng, 2008). In the air conditioning system, it is difficult to determine the accurate electricity consumption, since its electricity consumption is affected by temperature setting, humidity room configuration, number of occupants, etc.

For cooking appliances such as LPG stove, charcoal stove and wood stove, the equation is as follows:

$$EC = N_{i.j} \cdot P_{i,j} \cdot M_{i,j} \cdot Ic_{i,j} \quad (3)$$

Where EC is the energy consumption for cooking (TOE), $N_{i,j}$ is the number of households with cooking equipments i in income class j, $P_{i,j}$ is the number of cooking appliance per household for equipment i in income class j (unit/household), and $I_{i,j}$ is the intensity of equipment i in the income class j (TOE/household).

2.2 Long-range Energy Alternatives Planning (LEAP) model

The key characteristics of the LEAP model include accounting framework, a user-friendly interface and scenario-based integrated energy-environment model-building tools (Heap, 2002). By using this model, the result show the analysis and forecast the household sector energy consumption in Myanmar under a range of alternative assumption depending on population, economic development and technology.

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3. Key assumptions

This section provides the result of survey data for energy consumption from the household sector of urban and rural areas of Yangon, Mandalay and Nay Pyi Taw regions in Myanmar. There were 450 households in total collected as valid respondents in these areas as shown in Table 1.

Table 1. Numbers of respondents of urban and rural areas in Myanmar

	Numbers of respondents					
	Urban Area (Income Class)			Rural Area (Income Class)		
	High	Medium	Low	High	Medium	Low
Yangon	80	40	80	50	50	50
Mandalay	-	20	30	-	-	-
Nay Pyi Taw	-	20	30	-	-	-
Total	80	80	140	50	50	50

According to the survery data, the total household energy consumption in the urban and rural areas for the case of business as usual (BAU) was calculated. The projected numbers of households can be calculated by using the historical data, such as the percentage of populations in urban and rural areas and household size in Myanmar. This study adopted the household population growth rate of 1.3% per annum and household size in Myanmar is assumed to be 5 persons per household from the official data. The percent share of household growth rate is 0.05% per annum in urban area. Further, the percent shares of household income growth rate were 1.16% for urban areas and 1.32% for rural areas in this study (worldbank.org/indicator). Table 2 presents the projection of percent share of households and percent share of income classes of urban and rural areas household in Myanmar from 2013 to 2030.

Table 2. Projection of percent share of household and income classes in urban and rural areas in Myanmar

	Household		Urban Household			Rural Household		
	Urban	Rural	High	Medium	Low	High	Medium	Low
Year	(%) Share		(%) Share			(%) Share		
2013	33.00	67.00	10.00	74.30	15.70	5.00	65.80	29.20
2014	33.34	66.67	10.12	74.37	15.52	5.07	66.12	28.81
2015	33.67	66.33	10.23	74.43	15.34	5.13	66.43	28.43
2016	34.00	66.00	10.35	74.49	15.16	5.20	66.74	28.06
2017	34.33	65.67	10.47	74.54	14.98	5.27	67.04	27.69
2018	34.66	65.34	10.59	74.60	14.81	5.34	67.34	27.32
2019	34.99	65.01	10.72	74.65	14.64	5.41	67.63	26.96
2020	35.31	64.69	10.84	74.69	14.47	5.48	67.91	26.61
2021	35.63	64.37	10.97	74.73	14.30	5.55	68.19	26.26
2022	35.96	64.04	11.09	74.77	14.13	5.63	68.46	25.91
2023	36.28	63.72	11.22	74.81	13.97	5.70	68.73	25.57
2024	36.59	63.41	11.35	74.84	13.81	5.78	68.99	25.23
2025	36.91	63.09	11.48	74.87	13.65	5.85	69.25	24.90
2026	37.23	62.77	11.62	74.89	13.49	5.93	69.50	24.57
2027	37.54	62.46	11.75	74.91	13.33	6.01	69.75	24.24
2028	37.85	62.15	11.89	74.93	13.18	6.09	69.99	23.92
2029	38.16	61.84	12.03	74.95	13.03	6.17	70.23	23.61
2030	38.47	61.53	12.17	74.96	12.88	6.25	70.46	23.30

4. Results and Discussion

The energy efficiency scenario was created by using the energy consumption of the household sector in the urban and rural areas in Myanmar. In the results of the survey data, air conditioning was the largest shares of electricity consumption in high-income class in urban areas and cooking appliances such as charcoal and firewood were the largest shares of energy consumption in the rural area households. So, in this study the energy efficiency program (EE) was assumed to be 8% reduction in the household energy consumption from BAU, starting in 2020 due to the target of government energy saving goal.

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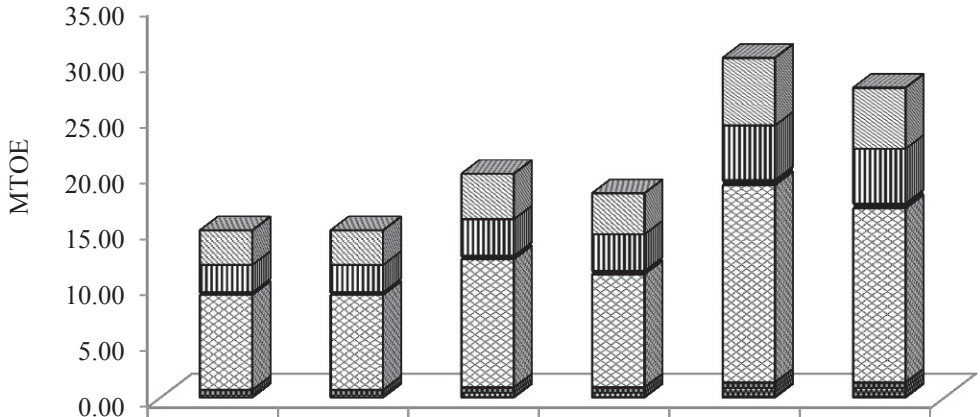

	BAU	EE	BAU	EE	BAU	EE
	2013		2020		2030	
Lighting	3.08	3.08	4.06	3.66	6.03	5.44
Cooking	2.47	2.47	3.28	3.28	4.89	4.89
Entertainment	0.22	0.22	0.30	0.30	0.46	0.46
Cooling	8.47	8.47	11.43	10.09	17.60	15.52
Other	0.70	0.70	0.92	0.92	1.37	1.37

Figure 3. Annual total final energy consumption of the urban household sector in Myanmar under each scenario

Figure 3 presents the annual total final energy consumption of the urban household sector in Myanmar under BAU scenario and EE scenario projected by using the model. In 2013, the total final energy consumption was 14.94 MTOE in the urban household sector. Due to the energy efficiency program in 2020, total final energy consumption is projected to be 19.99 MTOE under BAU case and 18.25 MTOE in EE program, and the energy savings are projected to be about 1.74 MTOE (8.70%) of BAU case in this year. Moreover, the total final energy consumption was projected to be 30.35 MTOE in BAU case and 27.68 MTOE in EE program in 2030.
Figure 3 shows that cooling is the largest energy consumption in all income classes followed by the lighting, cooking, other appliances and entertainment, respectively. In 2020, lighting energy consumption is projected to be 0.40 MTOE, or (2%) of the total final energy consumption 19.99 MTOE in the BAU scenario. Cooling energy consumption is projected to be reduced about 1.34 MTOE, or (6.70%) of total final energy consumption of 19.99 MTOE in the BAU scenario in the same year.

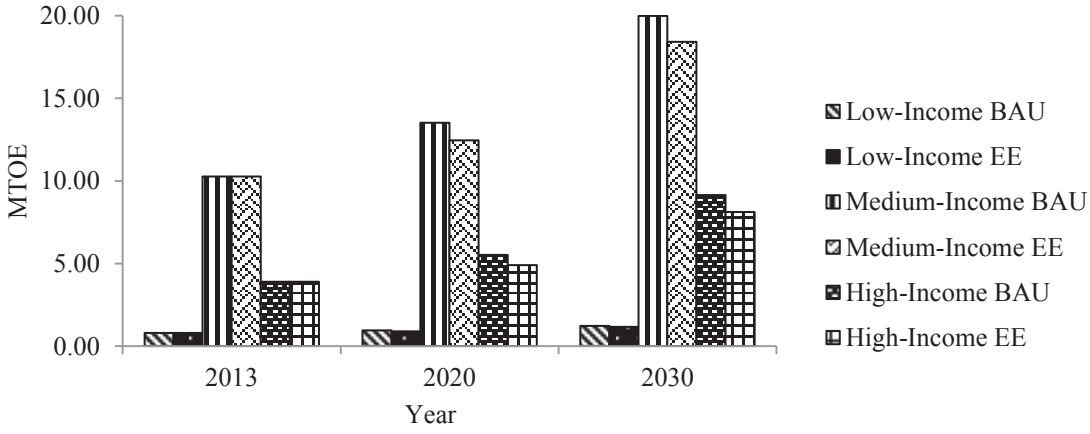

Figure 4. Annual total final energy consumption of income classes of the urban household sector in Myanmar under each scenario

Figure 4 presents that the total final energy consumption in 2013 was projected to be 0.79 MTOE in low-income, 10.26 MTOE in medium-income and 3.89 MTOE in high-income households. By starting the EE program in

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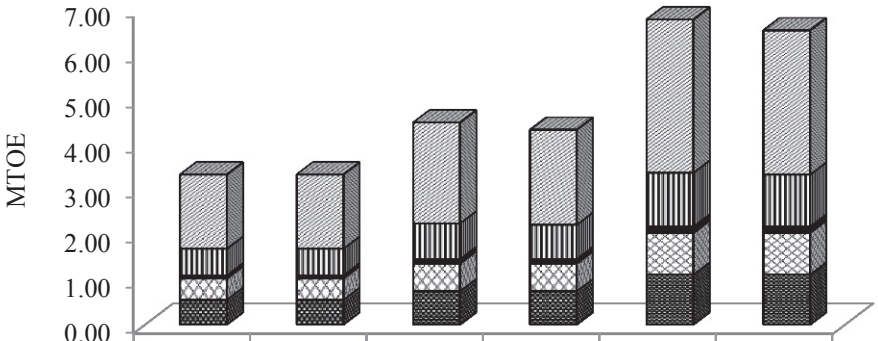
2020, the total final energy consumption was projected to be 0.95 MTOE under BAU and 0.90 MTOE for EE in the low-income class, 13.52 MTOE for BAU and 12.45 MTOE for EE in the medium-income class, and 5.52 MTOE under BAU and 4.90 MTOE for EE in the high-income class. Further, in 2030, energy consumption was projected to be 1.22 MTOE in BAU case and 1.16 MTOE for EE in low-income, 19.99 MTOE in BAU and 18.41 MTOE for EE program in medium-income, and 9.14 MTOE in BAU scenario and 8.11 MTOE for EE in high-income household sectors in urban areas.

In these results, medium-income households in urban areas were projected to be the highest total final energy consumption, second was the low-income and last was the high-income level. The percent share of medium household was 74.3% of the total urban household number, so this income level was the largest energy consumption among the income levels. In 2020, the reduction amount was projected to be about 0.05 MTOE (0.25%) in low- income, 1.07 MTOE (5.35%) in medium-income, and 0.67 MTOE (3.10%) in high-income, between BAU scenario and EE scenario of the total final energy consumption in urban area households.



	BAU	EE	BAU	EE	BAU	EE
	2013		2020		2030	
Lighting	1.64	1.64	2.23	2.10	3.39	3.19
Cooking	0.59	0.59	0.79	0.76	1.19	1.15
Entertainment	0.07	0.07	0.10	0.10	0.14	0.14
Cooling	0.47	0.47	0.61	0.61	0.92	0.92
Other	0.55	0.55	0.74	0.74	1.11	1.11

Figure 5. Annual total final energy consumption of the rural household sector in Myanmar under each scenario

In figure 5, the results of total final energy consumption of rural areas in Myanmar are presented based on analysis and forecasting using the model. In 2013, the total final energy consumption was projected 3.32 MTOE. The energy efficiency program should start in 2020, so total final energy consumption was forecasted to be 4.47 MTOE in the BAU case and 4.31 MTOE for EE program, with a reducing of 0.16 MTOE (3.58%) of total final energy consumption of BAU case to EE program in this year. In 2030, the total final energy consumption of rural household was projected to be 6.75 MTOE in BAU case and 6.51 MTOE in EE program.

In rural areas, lighting is the largest energy consumption in all income levels followed by cooking, other electric appliances, cooling and entertainment. These results show that the rural areas emphasized the lighting energy consumption and they cannot buy luxury appliances due to their lifestyle. According to the energy efficiency program, in 2020, lighting energy consumption is projected to be reduced about 0.13 MTOE or (2.91%) of total final energy consumption from the BAU scenario and cooking energy consumption is projected to be reduced about 0.03 MTOE or (0.67%) of total final energy consumption 4.47 MTOE from the BAU scenario in the same year.

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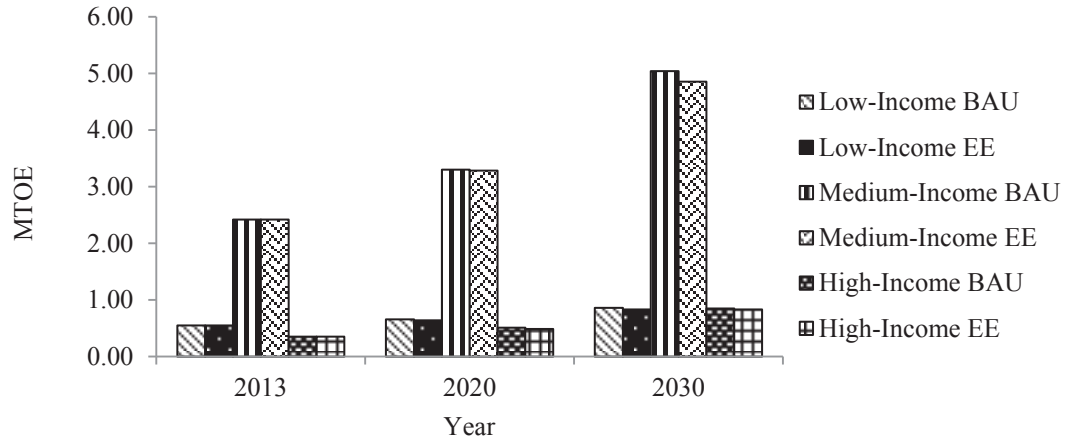

Figure 6. Annual total final energy consumption of income classes of the rural household sector in Myanmar under each scenario

Figure 6 provides the annual total final energy consumption of income classes of the rural household sector in Myanmar under each scecario. In 2013, the total final energy consumption was projected to be 0.55 MTOE in low-income, 2.42 MTOE in medium-income and 0.35 MTOE in high-income. Due to the energy efficiency (EE) programs in 2020, the total final energy consumption was projected to be 0.66 MTOE in BAU scenario reduced to 0.64 MTOE for EE program in low-income, 3.30 MTOE in BAU and 3.18 MTOE for EE in medium-income, and 0.51 MTOE in BAU and 0.49 MTOE for EE program in high-income. In 2030, energy consumption projected 0.86 MTOE for BAU and 0.83 MTOE for EE program in low-income, 5.04 MTOE to 4.85 MTOE between BAU case and EE in medium-income and 0.85 MTOE for BAU and 0.83 MTOE for EE program in high-income households.

The results of these data present that the highest total final energy consumption is projected to be medium-income, according to the household percentage. The percent share of medium-income households was 65.80% of the total rural household number. In 2020, the savings in energy consumption were projected to be about 0.02 MTOE (0.45%) in low-income, 0.12 MTOE (2.68%) in medium-income, and 0.02 MTOE (0.45%) in high-income households, between total final energy consumption of BAU case and EE program in rural area households.

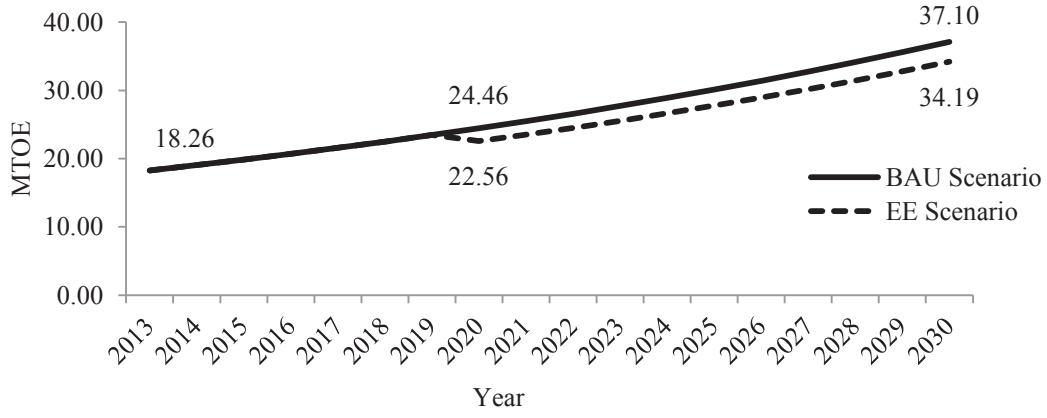

Figure 7. Annual total final energy consumption of the household sector in Myanmar under each scenario (2013-2030)

Figure 7 presents the projection of annual total final energy consumption of the household sector in Myanmar during the long term period 2013-2030 using the model. In 2013, the total final energy consumption was projected to be 18.26 MTOE. The energy savings were projected to be about 1.90 MTOE or (7.77%) from 24.46

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MTOE in BAU scenario to 22.56 MTOE in energy efficiency (EE) scenario in 2020. The total final energy consumption was projected to be 37.10 MTOE in BAU case to 34.19 MTOE in EE program in the year 2030. Finally, the results show that about 8% of the total final energy consumption can be saved form the BAU scenario to EE scenario. The growth rate of the total final energy consumption of the household sector in Myanmar was calculated as about 50% from the year 2020 to 2030 in this study.

5. Conclusion and recommendations

In this study, we focused on energy consumption in the household sector for both urban and rural areas in Myanmar. The survey sites in urban areas were Yangon, Mandalay and Nay Pyi Taw. These major cities are electrified; therefore, they have access to modern electrical appliances. Moreover, the electricity consumption has risen according to income classes. In rural areas, some areas are non-electrified and most of consumers are dependent on the traditional biomass and low-efficiency electric appliances. The results show that energy consumption in the urban areas is higher than rural areas by a factor of 4.5.

It was found that Myanmar's government lacks energy information management, especially the household energy survey. This causes poor energy efficiency policy in Myanmar. The government of Myanmar should start to implement energy efficiency programs in the household, such as a voluntary efficiency program in the residential sector in Myanmar and micro-incentive for low-income households. Moreover, the majority of official data for the household sector energy consumption should be improved by cooperation of government, the private sector and international organizations. It is really important to emphasize the rural area development and improve modern energy sources because it would develop energy consumption behaviors in the future. Energy efficiency policy in the household sector is highly required in order to provide information regarding household energy saving methods and to improve public awareness through effective education.

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