A STUDY OF ENERGY CONSUMPTION OF THE HOUSEHOLD SECTOR IN MYANMAR

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A THESIS SUBMITTED AS A PART OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ENERGY TECHNOLOGY AND MANAGEMENT

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ABSTRACT

The energy consumption of the household sector in Myanmar has increased rapidly as a result of tremendous economic growth rate and structural changes in Myanmar's society. 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, industry 10%, transportation 6%, agriculture 1% and other sector 3%. Given the country's steady economic growth, cleaner energy sources are needed.

This study focuses on the analysis and the forecast for the energy demand of the 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.

Furthermore, the patterns of household energy utilization by different levels of income groups are presented and discussed using the survey results. Finally, the model forecasted the household energy consumption in business as usual (BAU) scenario and energy efficiency (EE) programs according to the government energy saving potential in this study. In this model result, the total final energy consumption projected to be 233.16 million GJ in 2013. Due to the EE program in 2020, the total final energy consumption was projected to be 257.05 million GJ and 236.15 million GJ from BAU case to EE scenario in this study. The EE program was assumed to be 8% reduction in the household sector in Myanmar from BAU, starting in 2020.

Moreover, this study includes the quantity of the CO_2 emissions of the household sector in Myanmar. Recommendations are given to future improve intervention planning and to enhance the effectiveness of interventions.

Keywords: Myanmar's household energy consumption, LEAP model

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LIST OF ABBREVIATIONS

AC	Air Conditioning
ADB	Asian Development Bank
ASEAN	Association of South East Asian Nations
BAU	Business as Usual
CO_2	Carbon dioxide
CSC	Cost of Saved Capacity
CSE	Cost of Saved Energy
DSM	Demand Side Management
EE	Energy Efficiency
GDP	Gross Domestic Product
GHG	Green House Gas
GJ	Giga Joule
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
km	kilo meter
km^2	kilo meter square
KTOE	kilo tons of oil equivalents
kW	kilo watt
kWh	kilo watt hour
LEAP	Long-range Energy Alternatives Planning
LED	Light Emitting Diode
LPG	Liquefied Petroleum Gas
LRMC	Long-run marginal cost
MCC	marginal capacity cost
MES	Myanmar Engineering Society
MJ	Mega Joules
$MMTCO_2$	million metric tons of CO_2
MTN_2O	metric tons of N_2O
MOF	Ministry of Forest
MTOE	million tons of oil equivalents

LIST OF ABBREVIATIONS (Cont')

MW	megawatts
MWe	megawatts electrical
N_2O	Nitrous Oxide
PRC	People's Republic of China
REAM	Renewable Energy Association of Myanmar
SNV	Stiching Netherlands Vrijwilligers
TED	Technology and Environment Database
TV	Television
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

CHAPTER 1
INTRODUCTION

1.1 Rationale and background

Myanmar is a large country, with a land area of 676,577 square kilometers (km^2) and approximately 49% of the total land area is covered with forest and a sustainable land area utilized for agriculture. The country is bordered by the People's Republic of China (PRC) on the northeast, Laos on the east, Thailand on the southeast, Bangladesh on the west, India on the northwest. It also has a 2,800-kilometer (km) coastline along the eastern side of the Bay of Bengal. Myanmar population is approximately 60 million, with more than 70% living in rural areas (ADB [1]). Myanmar's annual population growth rate is increasing steadily at 1.3% (2009-2011) and Myanmar GDP growth rate is 5.5% in fiscal year 2012 [3].

Figure 1.1 Country Map of Myanmar [6]

Myanmar's increasing population leads to increasing energy, food and water consumption. Modern energy services and electricity are crucial to meeting the primary development challenge of providing adequate food, shelter, clothing, water, sanitation, medical care, education, and access to information. Modern energy supports lighting, communication, transport, commerce, manufacturing and industry. Indeed, electricity makes so many things possible that some have even viewed its provision as a fundamental human right. Therefore, the energy sector remains a central component of Myanmar's economy and as such, needs to be understood prior to any assessment of challenges and approaches related to energy access and energy for all [3].

Myanmar remains a biomass-centered economy. In 2011, 76% of total 14.056 MTOE of primary energy supply 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 [4]).

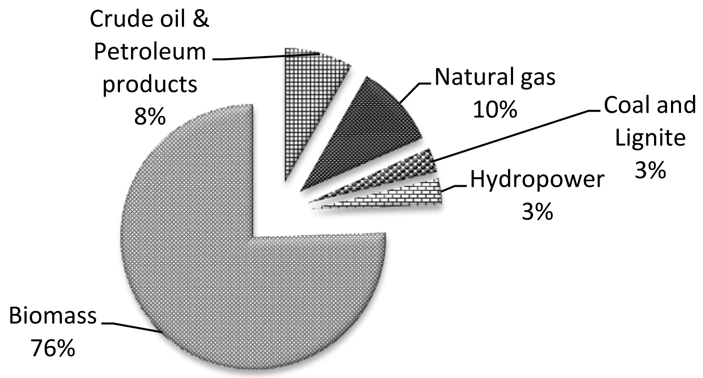


Figure 1.2 Total Primary Energy Supply in Myanmar (2011)

The country's rapid economic growth and structural changes in society lead to increasing patterns of household energy consumption. Social and economic development contributes of energy to determine the household's energy demand trend. Household sector is the largest energy consumption in Myanmar, accounting for about 80% of final energy consumption reflecting the importance of that sector in total national energy scenario in 2011 (IEA [4]).

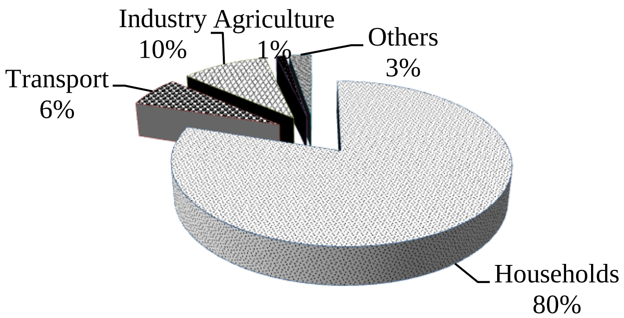


Figure 1.3 Final Energy Consumption by Sector in Myanmar (2011)

As Figure 1.3 illustrates, the total final energy consumption in the household sector was 10.464 MTOE in 2011. The largest share of household sector accounted for 97.88% of biomass, remains dominated 2.11% of hydropower and 0.01% petroleum products (IEA [4]). Use of biomass for cooking has been a noticeable feature of household energy consumption in Myanmar.

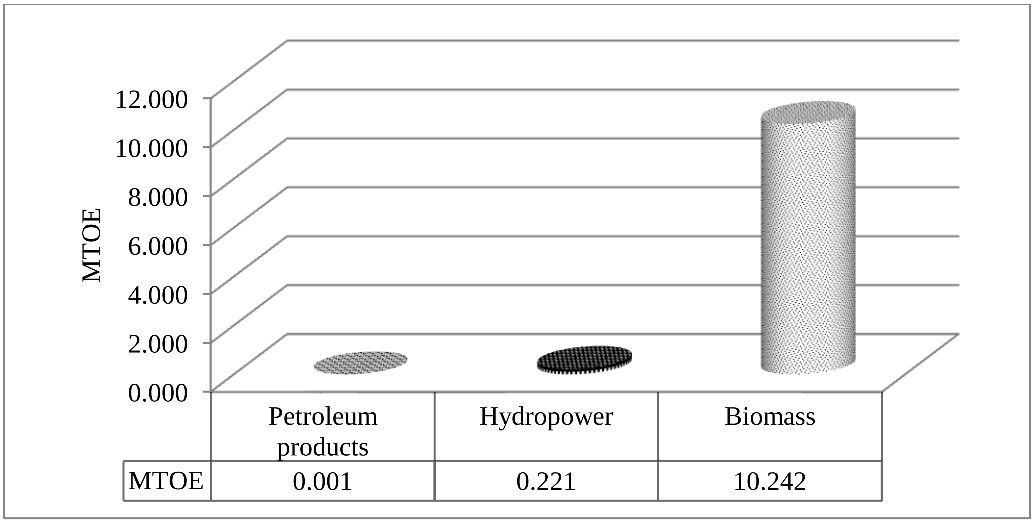


Figure 1.4 Final Energy Consumption in Household Sector of Myanmar (2011)

As the economy develops, more and cleaner energy are needed. Electricity does not directly replace biomass. The transition from traditional fuels to modern fuels is not straight. The three main determinants in the transition are availability, affordability and cultural preferences. Even if modern fuels can be afforded, people continue to use biomass if the modern fuels are much more expensive than the biomass that is readily available and perceived as free.

Lower-income households prefer to use biomass for cooking and heating. As incomes increase, more 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 (Mirjana Golusin, Sinisa Dodic, Stevan Popov [7]).

Household energy consumption is expected to increase in the future along with growth in the economy and rises in per capita incomes. The projected increases in household energy consumption are expected to result from changes in lifestyles (Pachuri, 2004[8]). Therefore, it is important to analyze household energy consumption in order to formulate policies for promotion of sustainable energy use (Reddy [10]). Energy planning needs information on the number and kind of activities involving energy use as well as information on energy requirements associate with these activities.

The fundamental premise of this study is that energy consumption at the household level is a key indicator of the standard of living in a country. There are also environmental benefits due to reduced demands on traditional fuels. This study will provide changes in patterns of household energy use in Myanmar, their impacts on household energy demand forecasting by using the long-term scenario based energy planning model.

1.2 Problem Statement

Following Myanmar's economic development, the demand for household energy has been increasing in recent years. While much of the energy demand, lack of reliable energy supply and appropriate policy, the intent of the study is to provide a key to understanding factors affecting energy use within the country adopting a household perspective.

The understanding of present and future patterns of energy use in the household sector can guide future energy development planning. Thus, this study can be guide on the following problems, what factors influence the energy demand of household sector, how does energy demand grow and what will influence the household energy demand in the future.

The encouragement of more energy efficient communities through spatial and planning policies, and offering grants to householders to install certain energy technologies and upgrading the energy performance of homes can be applied by those on low incomes.

1.3 Research Objectives

1.3.1 To analyze the household energy use patterns in different consumer categories.

1.3.2 To identify the characteristics of energy consumption of different income groups of the households in Myanmar.

1.3.3 To forecast the household energy demands to highlight the main driving forces under various economic growth scenarios.

1.3.4 To propose suitable policy recommendations for the household sector in Myanmar.

1.4 Scope of Study

1.4.1 This study targets energy consumption in the household sector of Myanmar.

1.4.2 This study uses the total GDP of the country as a proxy for households income for both theoretical and actual data available.

1.4.3 This study focuses on the next 18 years of household energy demand options from 2013 to 2030 by using the long-range energy alternatives planning system (LEAP) software tool.

1.4.4 The CO_2 emissions from household energy use are also considered in this study.

CHAPTER 2
LITERATURE REVIEW

2.1 Myanmar Energy Resources

Contrary to Myanmar's relatively low levels of energy access, the country does possess significant energy resources. This section categorizes those resources according to four types: conventional fuels, grid-connected or commercial scale renewable sources of energy, off-grid or household- and community-scale sources of energy, and energy efficiency. In Myanmar, modern forms of energy are expensive: a connection to the grid costs $595, a significant sum given that per capita GDP is less than $1,000 per year and where one-quarter of the population live below the national poverty line. However, this does, make alternative sources of energy from renewable, household-scale systems, and energy efficiency practices even more financially attractive and competitive [3].

2.1.1 Conventional Fuels

2.1.1.1 Oil and Gas

The oil and gas sector in Myanmar is composed of 105 demarcated blocks for exploration and development, 53 of them onshore and 52 offshore. Estimates suggest that Myanmar has proven gas reserves of 11.8 trillion cubic feet and gas production in 2011 was 1.2 billion cubic feet per day. Myanmar's oil production onshore reached 7,600 barrels per day in 2011, in addition to offshore gas fields that produced 11,600 barrels per day of condensates. The country was home to three refineries with a total capacity of 51,000 barrels per day of petroleum products. A vast majority of natural gas production about 95% came from two offshore fields at Yedana and Yetagun, which export their gas almost entirely to Thailand. The country has about 2,100 miles of gas pipelines onshore and 431 miles of offshore gas pipelines [3]. A third of the country's $13.6 billion in foreign direct investment is in the oil and gas sector. Myanmar is one of the five major energy exporters in the region, particularly of natural gas [1].

2.1.1.2 Coal

Myanmar has roughly 490 million tons of coal reserves, and in 2011, produced 692,000 tons of coal. Cement and steel companies use most of this coal (52%), the remainder going for power generation and other uses. Since 2010, all coal production has involved private companies with prices set by the global market [3].

2.1.2 Commercial-Scale Renewable Energy

2.1.2.1 Hydroelectricity

Myanmar's four main river basins, Ayeyarwaddy, Chindwin, Thanlwin, and Sittaung, are sources of huge hydropower potential, estimated to be more than 100,000 megawatts (MW). Myanmar has identified 92 potential large hydropower projects with a total installed capacity of 46,101 MW. Hydropower is the main source of fuel in the country electricity distribution [1].

Table 2.1 Hydropower Potential by River Basin (Including Tributaries)

No.	River Basin	No. of Promising Hydropower Projects	Installed Capacity (MW)
1	Ayeyarwaddy	34	21,821
2	Chindwin	8	3,015
3	Sittaung	11	1,128
4	Thanlwin	21	17,641
5	Mekong	4	720
6	Others	14	1,776
	Total	92	46,101

Source: Ministry of Electrical Power

2.1.2.2 Wind Energy

Myanmar has a 2,832-km coastal strip facing the Bay of Bengal and the Andaman Sea. The potential available wind energy along this coastal strip, with its southwesterly wind for 9 months and northeasterly wind for 3 months, is a significant resource with an estimated 365 terawatt-hours (TWh) of technical potential per year. This resource is especially abundant in the Chin and Shan States, more highly elevated parts of the Central Region and along the coast. The investigative results indicate that feasible areas to harness wind energy are in locations with an average wind speed of 5.6 to 7.4 meters per second, which would yield outputs ranging from 55 kW to 225 kW [1].

2.1.2.3 Biomass Energy

As Myanmar has a rice economy in which rice dominates the agricultural sector, 21.6 million tons of rice husks from milling, along with plentiful bagasse from sugarcane production and sugar processing. Each year could create 4 million metric tons of fuel, or could be converted in biomass power plants. The Myanmar Engineering Society has calculated considerable resource potential for lumber waste, bagasse, molasses, and livestock waste as well, numbers shown in table [3].

Table 2.2 Biomass Energy Resources in Myanmar

Type	Quantity per year
Rice Husks	4,392 x 10^3 ton/yr.
Lumber Waste	1.5 million ton/yr.
Bagasse	2,126 x 10^3 ton/yr.
Molasses	240 x 10^3 ton/yr.
Livestock Waste	34,421 x 10^3 ton/yr.

Source: Myanmar Engineering Society, 2012

Approximately two-thirds of primary energy in Myanmar is supplied by biomass (fuelwood, charcoal, agriculture residue, and animal waste). Fuelwood accounts for more than 90% of biomass-sourced energy, most of which is harvested from natural forests and used in both urban and rural areas. Charcoal, which accounts 4%-6% of total fuelwood consumption, is mainly used in urban areas. The annual consumption of fuelwood per household is estimated to be about 2.5 cubic tons (4.5 m^3) for rural households and 1.4 cubic tons (2.5 m^3) for urban residents [3].

In 2002, the Ministry of Forestry (MOF) announced its long-term (2030) National Forestry Master Plan, which included bio-energy. Despite an increasing population, fuelwood use is forecast to decrease, reflecting greater reliance on energy efficient stoves and alternative energy sources, such as hydropower and natural gas. By 2030, fuelwood is projected to account for less than half of total primary energy, compared to almost two-thirds currently [1].

Table 2.3 Predicted Supply of Fuelwood as Indicated in the National Forestry Master Plan

	2002		2030	
Source	(million cubic meter)	(%)	(million cubic meter)	(%)
Plantations	1.06	3.36	1.26	4.23
Non-forest land	7.89	25.01	7.44	25.00
Community forests	0.06	0.19	7.44	25.00
Natural forests	22.54	71.44	13.63	45.77
Total	31.55	100.00	29.37	100.00

Source: Ministry of Forestry

2.1.2.4 Geothermal Energy

According to government estimates, Myanmar also possesses scores of exploitable sites for geothermal power plants. The Asian Development Bank noted in December 2012 that at least 93 locations across the country had sufficient heat to produce electricity with investors, such as Japan's Electric Power Development Company and Caithness Resources in the United States, already submitting letters of interest. Geothermal energy is abundant with considerable potential for commercial development [3].

2.1.3 Household-Scale Energy Systems

2.1.3.1 Woodlots and Nurseries

As mentioned earlier, Myanmar is a biomass-centered energy economy. Therefore, one of the most effective ways to improve access to household energy is through the more sustainable or efficient harvesting of fuelwood. Community-Based Organizations have successfully managed nurseries to supply reforestation projects and encourage wood-fuel collectors to become wood-fuel producers as a key strategy to reduce illegal deforestation. In the past, the Forest Department has distributed as many as 11 million seedlings per year to be planted as part of a country-wide, re-greening programme, and the Forest Law makes provision for private entrepreneurs to establish plantations and community woodlots on government-owned land [3].

2.1.3.2 Improved Cookstoves

The government has been attempting to disseminate improved cookstoves that are 40% more efficient than traditional designs through a Ministry of Environmental Conservation and Forestry programme since the 1990s. One 2011 assessment of household willingness to pay for improved cookstoves in Myanmar noted that 100% would use them if they were available and affordable, but only 13% could afford to purchase them.

However, new cookstove programmes will face barriers. Household surveys by the European Union Energy Initiative scoping mission conducted in 2012 noted that many households in Myanmar believed that they did not need an ICS, as their fuel supply situation was still favorable or cheap, and in some cases free, thus mitigating the incentive to adopt a more efficient cookstove. The surveys found that other households had negative experiences with low quality improved cookstoves that had difficulties in terms of their efficiency and durability, and that still others wanted an improve cookstove, but couldn’t find one available or couldn’t afford those that they could find.

2.1.3.3 Biogas Digesters

In June 2012, a feasibility study from the SNV Netherlands Development Organization estimated that, in sum, about 1,200 biogas units existed across the country, but that 80% of them were no longer in operation. It calculated the technical potential for at least 600,000 household-scale biogas units in addition to 5,500 community-scale units. These units would have favorable returns on investment, with a typical unit resulting in a financial rate of return of 17 to 18% (presuming that households were entirely dependent on fuelwood or diesel and that the government sponsored the system with a 40% subsidy.

Additionally, the government managed a biogas generation from an animal waste programme in Central Myanmar, distributing 867 floating type biogas plants between 1980 and 1983 across 134 townships and 14 states. From 2001 to 2005, it started promoting 50 cubic meter size biogas plants with two domes constructed from local materials made in partnership with the Yangon Technological University. According to the Ministry of Energy, 35 of these community-scale plants, which cost about $2,000 but can support 300 houses in a village, have been installed so far in the Mandalay, Sagaing and Magway Divisions [3].

2.1.3.4 Off-grid Microhydro

Myanmar has at least 17 mini-hydro facilities with about 5.23 MW of capacity, 29 microhydro facilities constituting 378.5 kW of installed capacity, and 6 picohydro facilities with 35 kW of combined capacity. However, significant microhydro potential, remains with the government estimating at least 60 sites with 170 MW in total output could be suitably developed. Rather than power the national grid, these types of sites could be utilized to generate electricity for microgrids consisting of 50 to 200 homes, or a few interconnected homes. In the rugged Shan state, for example, microhydro units ranging from 2 kW to 5 kW sell for $ 70 to $ 450 and provide enough electricity to energize light bulbs, fans, televisions and radios [3].

2.1.3.5 Solar Energy

Myanmar is well suited for solar energy, as it receives ample amounts of sunlight at its location near the equator, especially in the central dry zone. Existing uses include, among others, household electricity supply in rural areas, water pumping and irrigation and commercial supply to hospitals. One 220 kW hybrid solar-wind-diesel-battery system even provides reliable energy to 100 households in Chaungthar Village.

Many government agencies have been involved in studying the specific application of solar home systems to rural areas, but actual promotion and dissemination has been limited primarily to health centers, water supply systems, and a select few of the remote villages. The Renewable Energy Association of Myanmar (REAM) and UNDP are working to create a Revolving Fund project termed Substitution of Candle Light with Solar Lighting System with LED lights (CSSLS) in 30 other villages in 3 townships [3].

2.2 Total Primary Energy Supply in Myanmar

In 2011, the country’s total primary energy supply was about 14.056 million tons of oil equivalents (MTOE). Some two-thirds (76% or 10.617 MTOE) of Myanmar’s energy supply was from biomass, followed by 10% (1.418 MTOE) from natural gas and 8% (1.167 MTOE) from crude oil and petroleum products. Coal and hydropower accounted for only small shares (3% each) of the total energy supply.

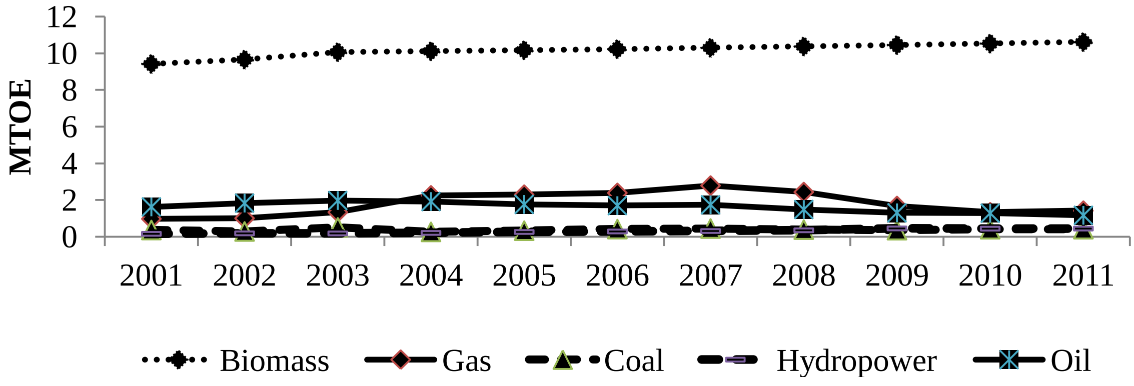


Figure 2.1 Total Primary Energy Supply in Myanmar (2001-2011)

These shares are changing, reflecting the rapid expansion of coal production (an 15.1% average annual increase from 2001 to 2011) and gas production (9.7% annually). Hydropower production increased more slowly (9.2% annually). Investment in hydropower and coal-powered plants, gas fields, and oil and gas pipelines is gaining rapidly, evidence of a highly dynamic sector. Myanmar's energy exports in 2011 were the equivalent of 8.6 MTOE, or more than half of total energy supply [1].

2.3 Total Final Energy Consumption by Type in Myanmar

Myanmar per capita electricity consumption is next to Nepal in being among the lowest in Asia, reflecting poverty-level per capita incomes. It has an electrification rate of only 26%, and much less than this in most rural areas. According to the IEA's World Energy Outlook 2012, Myanmar is an extreme example of energy poverty [5]. Lacking electricity, households rely on burning firewood and animal dung in poorly ventilated dwellings, leading to acute respiratory diseases and high mortality/morbidity rates [1].

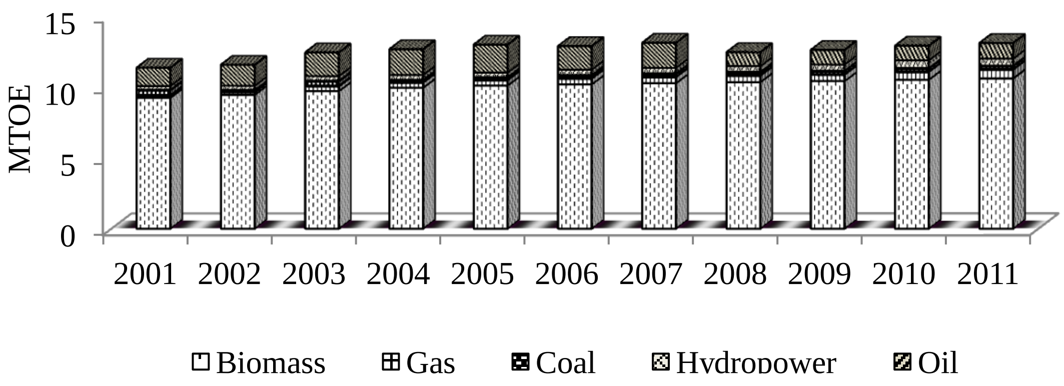


Figure 2.2 Total Final Energy Consumption in Myanmar (2001-2011)

Energy consumption by fuel type is shifting in favor of natural gas, which increased on average by an estimated 15.1% annually during 2001-2011. This was followed by coal, of which the energy consumption grew by almost 15% annually. Electricity and biomass sources increased in average annual rates of approximately 4% and 1.3%, respectively. Despite its slow increase, biomass continued to be main source for energy consumption, accounted for 80% in 2011 [1].

2.4 Total Final Energy Consumption by Sector in Myanmar

Overall final energy consumption in Myanmar increased between 2001 and 2011 by an average of 2.4 annually, from 11.346 MTOE to 13.080 MTOE. Residential consumption increased only by 1.3% annually. Nonetheless, this is the largest consumer of energy – mainly in the form of biomass (fuelwood and charcoal), followed by the industrial sector 4.8%. However, transport had a negative annual average growth of -1.9% [1].

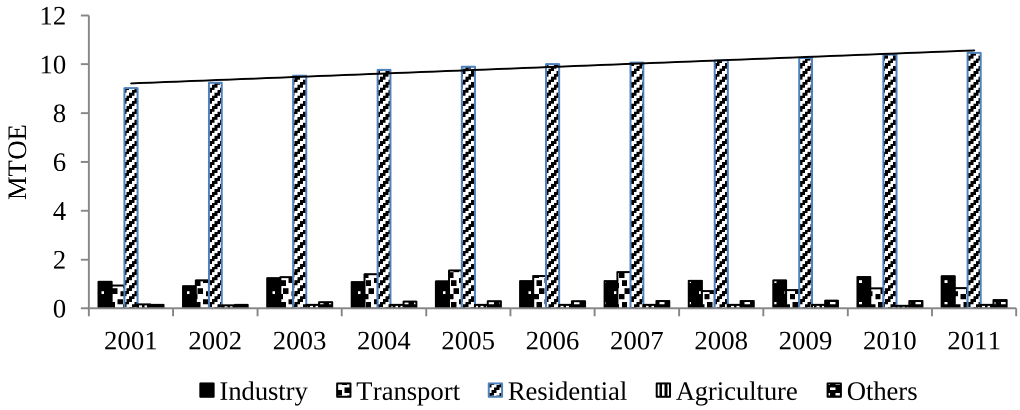


Figure 2.3 Total Final Energy Consumption by Sector in Myanmar (2001-2011)

2.5 Power Sector in Myanmar

Myanmar's per capita electricity consumption was only 100 kWh per year, which was the lowest among the ten ASEAN countries. The low national average per capita electricity consumption is due to the low electrification rate, low industrial development and lack of investment. The country's average electrification grew from about 16% in 2006 to 26% in 2011. Yangon City has the highest electrification ratio (67%), followed by Nay Pyi Taw (54%), Kayar (37%), and Mandalay (31%). The remaining rural areas are still poorly electrified averaging at about 16%.

The total system installed capacity in 2011 was 3,361 megawatts (MW), consisting of 2,520 MW (75%) hydropower capacity, 715 MW (21%) gas-fired capacity, 120 MW (4%) coal-fired capacity. Although the installed capacity exceeds the 2011 peak load of 1,533 MW, the availability capacity of the gas and the coal power plants were low due to poor maintenance.

Two distribution enterprises operate the distribution systems in the country. The Yangon City Electricity Supply Board (YESB) is responsible for the supply of electricity to consumers in Yangon City. The Electricity Supply Enterprise (ESE) covers the rest of the country comprising 13 states and regions, including off-grid generation and distribution. It was reported that technical and non-technical losses of the transmission and distribution system were as high as 30% in 2003 and reduced to 27% in 2011. These high losses and low electrification ratio will require improvement of transmission and distribution network in Myanmar [1].

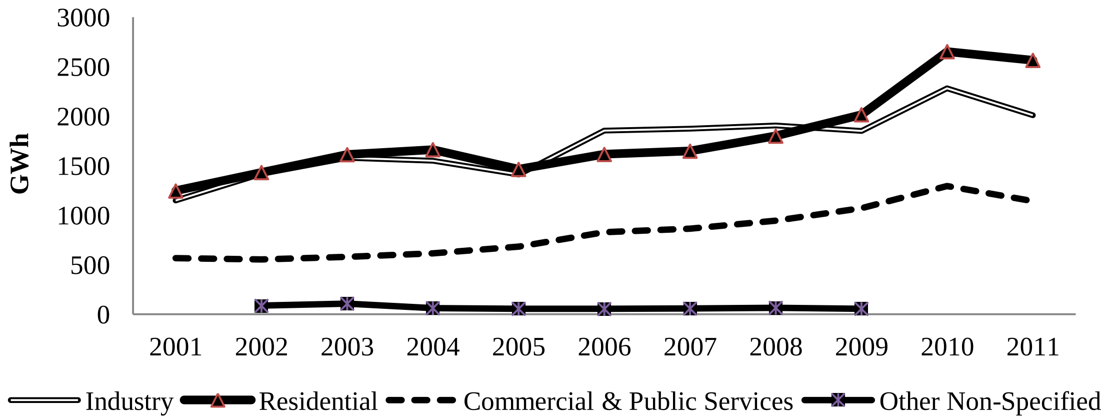


Figure 2.4 Total Electricity Consumption by Sector in Myanmar (2001-2011)

Figure 2.4 presents that the total electricity consumption by sector in Myanmar as 5716 GWh in 2011. The largest share of electricity consumption is the residential sector accounted about 2564 GWh (45%), followed by the industry sector 2010 GWh (35%), and commercial and public services 1142 GWh (20%) due to the IEA data.

2.5.1 Current Electricity Price in Myanmar

On 19 March 2014, Myanmar's parliament approved an increase in the unit price of electricity, being put into effect from 1 April 2014 as follows:

Table 2.4 Current Electricity Price in Myanmar

Electricity usage per month by:		New cost per unit	
		(Kyats)	(USD)
Household use			
(1)	From one unit to 100 units	35	0.04
(2)	101 units to 200 units	40	0.04
(3)	201 units and above	50	0.05
Business use			
(1)	From one unit to 500 units	75	0.08
(2)	501 units to 10,000 units	100	0.10
(3)	10,001 units to 50,000 units	125	0.13
(4)	50,001 units to 200,000 units	150	0.15
(5)	200.001 units to 300,000 units	125	0.13
(6)	300,001 units and above	100	0.10

Source: Ministry of Electric Power [25]

2.6 Electricity Demand Projection in Myanmar

Myanmar current electrification ratios are shown in Table 2.5

Table 2.5 Current Electrification Ratio of Myanmar

No	Description	Quantity
1.	Population	59.78 million
2.	Numbers of Household	8.92 million
3.	Electrified Household	2.575 million
4.	Percentage	28.86%

Source: Myanmar Electrical Power Enterprise

The electrification ratio was calculated by using the 6.7 persons per household according to the Myanmar Electrical Power Enterprise, so the result of the electrification rate was 28.86%. When the electrification ratio 1% increased in electrified household covers 89,200 households and is expected to be consumed 18.187 MWh/yr.

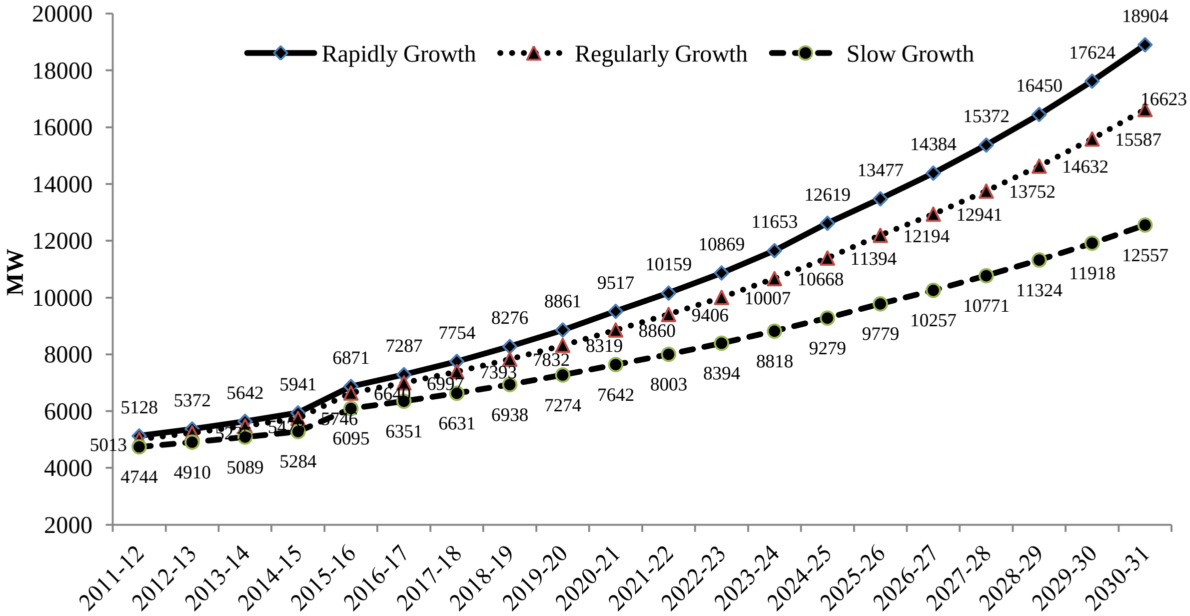


Figure 2.5 Electricity Demand Projections (2011-2030)

Figure 2.5 presents the electricity demand projection for the next 20 years from 2011 to 2030, by the Myanmar Electrical Power Enterprise, Ministry of Electrical Power [27]. The electricity demand was projected by the factors of rapidly growth, regularly growth and slow growth in the long term period. In rapidly growth, the electricity consumption was estimated 5,128 MW in 2011 to 18,904 MW in 2030, the average annual increasing of 6.5% of electricity demand. In regular growth, the electricity consumption was projected 5,013 MW to 16,623 MW from 2011 to 2030, the average annual increasing of 6% of electricity consumption factor. The electricity demand of slow growth was forecasted 4,744 MW in 2011 to 12,557 MW in 2030, the average annual increasing rate about 5% of the electricity demand.

Finally, the projections show that the electricity demand in 2030 will be higher than in 2011 by a factor of 3.68 with a rapid growth rate, 3.32 with a regular growth rate, and 2.65 with a slow growth rate.

2.7 Energy and Environmental Policies in Myanmar

For ensuring the development of the energy and electrical sectors, the National Energy Management Committee and Energy Management Committee (NEMC) are formed in the Myanmar energy sector. The Ministry of Energy's current energy policy is as follows [26]:

2.7.1 To implement the status of sustainable energy development

2.7.2 To promote wider use of new and renewable sources of energy

2.7.3 To promote energy efficiency and conservation

2.7.4 To promote use of alternative fuels in household

2.7.5 To fulfill domestic energy requirement as a priority

2.7.6 To implement the effective utilization of discovered crude oil and natural gas resources in the interest of the entire nation, including the regions where the discoveries were made

2.7.7 To promote more private participation

Energy Efficiency and Conservation is emphasized in order to save energy through effective energy management and to reduce energy consumption so as to minimize harmful environmental impacts. Encouragement is made to utilize new and renewable energy sources, especially solar and wind, which are abundant with Myanmar's climatic conditions [22].

Myanmar still lacks a national strategy and action plan for mitigating and adapting to climate change, but several ministries have been implementing sector-specific initiatives relevant to climate change. The Government through the Ministry of Energy has initiated the Clean Fuel Program to reduce carbon dioxide emissions by increasing the use of natural gas in the industrial sector and for power generation; this includes converting gasoline, diesel, and liquefied petroleum gas (LPG) vehicles to compressed natural gas (CNG) vehicles.

The Ministry of Environmental Conservation and Forestry (MOECAF), the designated national authority for clean development mechanisms, has submitted one hydro power project to UNFCCC for consideration. The Environmental Conservation Law provides the legal basis for implementing a range of enhanced environmental management measure which embodies regulations and technical guidelines, and creating the enabling conditions for their effective implementation is being drawn up and submitted to authorize body.

2.8 Energy Saving in Myanmar

Myanmar's primary energy saving goal is to reduce energy consumption by 5 percent in 2020 and 10 percent in 2030, relative to the BAU scenario. Specifically, the goals could be achieved by the following strategies:

2.8.1 In the industrial sector, improve energy efficiency by 10 percent against BAU and reduce energy-related greenhouse gases by 2020.

2.8.2 In the transport sector, have biofuel (E85, biodiesel) substitution of at least 8 percent by 2020.

2.8.3 Increase the total installed power capacity of renewable energy to 15 percent by 2020.

2.8.4 Improve energy efficiency in the commercial/residential sector by 8 percent by 2020.

On a sectoral basis, the energy efficiency and conservation measures in Myanmar are listed below:

2.8.5 In industry, encourage the gradual replacement of low efficiency equipment with higher efficiency alternatives

2.8.6 In the transportation sector, the state will encourage fuel switching in the transport sector to bio-fuels and natural gas as alternative fuels. The state also aims to achieve energy saving through exploiting more efficient transportation networks, including road waterways, rail, air and seaways, and develop high-capacity transportation with greater volume capacity for freight and passenger traffic. Improvement in fuel efficiency in the transport sector is also considered.

2.8.7 In the residential and commercial sectors, the following are the measures that will be implemented:

2.8.7.1 Encourage the use of alternative energy and improvement in energy efficiency in existing buildings in the public and private sectors.

2.8.7.2 Promote the use of higher energy efficiency appliances and energy saving equipment in the residential and commercial sectors.

2.8.7.3 Launch the use of bio-diesel (B 100) in rural communities.

2.8.8 In the electricity sector, the following measures that will be implemented are:

2.8.8.1 Develop and expand the energy mix and supply sources through utilization of full energy potential of the country, including frontier exploration and development, and intensive research in oil, natural gas, coal, hydropower, geothermal, energy efficiency and conservation, and new and renewable sources of energy.

2.8.8.2 Replace transformers and install the capacitor banks in main sub-stations and optimize the voltage, conductor size and loading of the transformers.

2.9 The National Efficiency Policies in Myanmar

To reach a National Target for EE&C plans and programmes, the Government should implement the following actions:

2.9.1 Disseminate knowledge about EE&C to communities and encourage the use of local renewable energy resources instead of fossil fuels.

2.9.2 Conduct workshops and seminars regarding EE&C to increase public awareness.

2.9.3 Market promotion in energy efficient equipment and labeling of energy saving appliances, such as air-conditioners, motors and pumps, electric appliances, etc.

2.9.4 Encourage the private sector to implement the EE&C programs on a voluntary basis through recognition programmes.

2.9.5 Provide financial assistance on transferring advanced technology.

2.9.6 Adoption of best practices is an effective action plan for energy saving in the transport, residential and commercial sectors.

2.9.7 To consider EE&C in both demand and supply sides of electricity.

2.9.8 There should be proper policy measures and action plans to achieve energy saving targets.

2.10 Myanmar Energy Action Plan

The energy efficiency initiatives of Myanmar covered buildings, households and the industrial and transport sectors. These initiatives are listed in Table 2.6

Table 2.6 Energy Efficiency Initiatives

Sectors	EE Initiatives
Industrial	Promote introduction of equipment and facilities with high energy conservation capacity Develop energy statistics, develop goals for voluntary action plans and develop R & D, and AEMAS Programs

Transportation	Raise the fuel efficiency in terms of passenger-km, and km/litre, and Fuel substitutions with biofuels
Electricity	Develop technology transfer and renewable energy knowledge in rural areas Assist sustainable renewable energy application in electricity generation
Household	Labelling systems for buildings and appliances Develop demand side management programs Thorough management of energy and other resources

2.11 Household Income and the Energy Ladder

The income of households influences energy consumption in many ways. Firstly, the rise of income levels, energy consumption increase due to increase in prepared dishes. Secondly, with increasing incomes, the price of fuel is less of a constraint. Households prefer to use a clean and convenient form of energy, such as LPG. Due to the use of efficient devices, the total consumption of energy will not increase significantly.

High-income households have opted for cleaner and more efficient “modern” energy carriers as the end energy is increasing, such as electricity or LPG. Many household uses a mixture of modern and traditional fuels such as cooking with LPG and heating water with fuelwood. The poor households spend more time in collecting these fuels than those in higher income groups. High-income households also purchase other high-grade fuels such as electricity, which are used for a greater variety of end-uses such as air-conditioning, refrigeration, etc. The structural differences of energy carriers for cooking among different income categories present interesting result.

With increasing disposable income and changes in lifestyles, households tend to move up the energy ladder in terms of quality, convenience for use and cost, biomass to kerosene and then to LPG/Electricity. With technological advances associated with end-use devices also moving in the same direction, the efficiency of energy use tends to improve with the ladder climbing.

In general, urbanization leads to higher levels of household energy consumption, although it is difficult to separate the effects of urbanization from the increases in income levels, which generally accompany each other. There is also a shift from traditional to commercial fuels along the gradient of income levels.

Nonetheless, the use of traditional fuels in many cities of the developing world remains high in low-income groups. Another trend is a decline in the share of energy used for basic requirements, such as cooking and lighting, as incomes increase, while energy consumption grows for space heating, water heating, refrigeration, audio/video appliances, air conditioning and other modern uses.

The annual per capita energy consumption of low income households in urban areas does not differ significantly from that of the rural poor, since in both cases most energy is used for cooking and lighting. Due to the rising incomes, the energy consumption patterns of urban households change significantly. This may be due to the increase in the number of dishes prepared and the use of various appliances such as TV, microwave, AC, etc. The main factors that determine the selection of energy carriers include: prices of fuels and the corresponding utilizing devices, disposable income of households; availability of fuels and cultural preferences (Reddy and Reddy,1994 [11]).

2.12 CO_2 Emission Tool Analysis

Carbon dioxide (CO_2) is the primary greenhouse gas emitted through human activities. The main human activity that emits CO_2 is the combustion of fossil fuels, such as coal, natural gas and oil. IPCC methodology is based on the carbon content of each type of fuel, expresses in term of the amount of carbon per unit of energy contained in the fuel (the emission factor), and the quantity of fuel used in the economy. GHG estimation is divided into two categories which are CO_2 and non CO_2.

CO_2 from energy activities can be estimates from energy supply data. In contrast, CH_4, N_2O, NO_x, CO and NMVOCs requires more detailed information. Accurate estimation of their emissions depends on knowledge of several interrelated factors, including combustion conditions, technology, and emission control policies, as well as fuel characteristics. CO_2 emissions may also be calculated at the more detailed level required for other gases. Indeed, when calculating non-CO_2 emissions national experts are encouraged to calculate CO_2 emissions at the same time (IPCC, 1996).

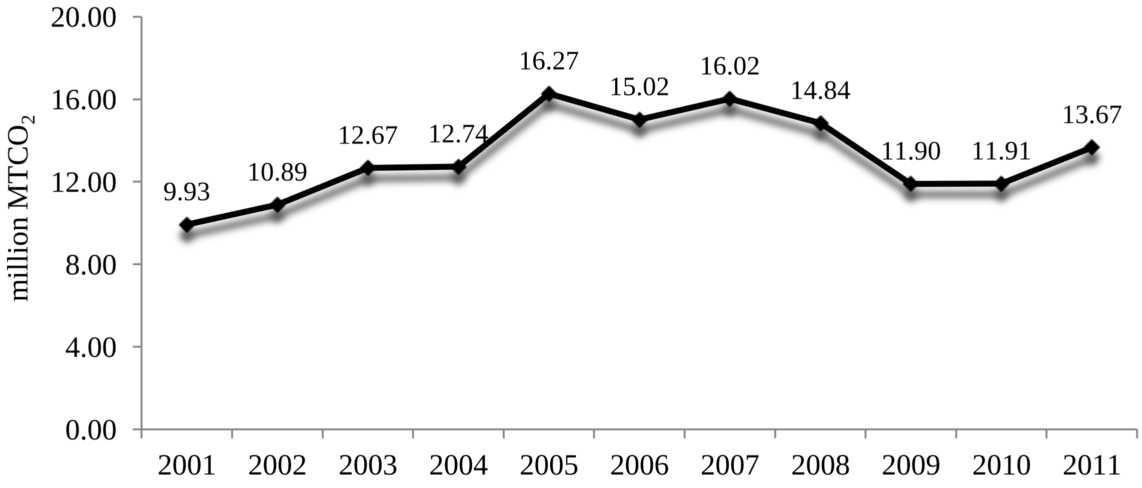


Figure 2.6 Total CO_2 Emissions from Consumption of Fossil Fuels in Myanmar

Total CO_2 emissions from the consumption of fossil fuels in Myanmar were reported at 9.93 million metric tons in 2001, according to the IEA data. In 2011, CO_2 emissions total from consumption of fossil fuels was 13.67 million metric tons, the rate of increase in emission from fuel consumption rose amount 3.74 million metric tons (37.66%) from the year 2001 to the year 2011 [23].

CHAPTER 3
THEORIES

3.1 Introduction

This chapter presents the theoretical backgrounds of three main areas of study. These are energy demand analysis, energy modeling and survey of energy consumption patterns in households.

3.2 Energy Demand Analysis

Energy is an important driver for the socio-economic development of a country. Only a sufficient amount of quality energy can promote economic development and satisfy the energy demand of the people. Therefore, one important aspect of energy planning is to devise policies that can promote a justifiable use of energy consumption. In order to be able to do so, energy planners use various kinds of mathematical models.

The analysis studies the historical growth patterns and fits the consumption patterns into various econometric models. The most significant model is then proposed for use to forecast energy consumption for a specified planning period into the future. We believe that an understanding of relationship between electricity and various socio-economic variables will help the planners to develop better generation and transmission policies (Shaligram Pokharel, Aalieh Ahmade, Fajr Al-Ansari, Hana Al Allaf, Mina Daneshvar, Ahmad Mohd AbdalQadir, [12]).

The two main approaches currently being used by most utilities and planning agencies are essentially based on econometric and end-use (engineering-oriented) models. The main difference between these two approaches is the level of aggregation of the input data. Econometric models are more aggregated and essentially base their projections on price and income factors, and the relationships of these factors to energy demand.

3.2.1 Econometric Models

Econometric models have the advantage of requiring fewer data than engineering-oriented models and have a good theoretical statistical base. Usually they are used for a whole class of customers and do not take into account the technological structure of their energy consumption. Thus, they have a more aggregate nature than the engineering-oriented end-use approach (IRP [18]).

Econometric models postulate the explicit relationship between a dependent variable and one or more exploration variables that determine the dependent variables. To forecast energy consumption using econometric model, energy consumption could be referred as dependent variables where Gross Domestic Product (GDP) and population could be selected as exploratory variable. In general, an econometric model would have the form of

$$D_i^t = a + \sum_i^n \sum_j^m b_{i,j} X_{i,j}^t \tag{3.1}$$

Where:

D_i^t : the energy consumption in sector i at time period t

a : constant

$b_{i,j}$: the coefficient to be determined for sector i and exploratory variable j

$X_{i,j}^t$: the level of activity for exploratory variable j

The econometric modeling provides the explicit relationship between a dependent variable and the exploratory variables. It help to understand why a change in energy consumption had occurred. Understanding the factors of determination the energy demand will help planning process to meet future energy needs. For example, if the econometric model revealed how responsive the energy demand to electricity price changes, this could be used to forecast the effects of electricity price to energy consumption (IRP [18]).

3.2.2 The End-Use Model

The end-use projection models or engineering models are much more detailed than the econometric models. The end-use approach is very well-suited to the purposes of energy-efficiency projections because it is possible to explicitly consider changes in technology and service levels. The product of two factors in the energy demand for each activity is the level of activity (the energy service) and the energy intensity (energy use per unit of energy service). The level of activity depends on factors such as population, income and economic output. The level of energy intensity depends on the energy efficiency, including both technological and operational aspects. A summation of the products of these two factors over all activities gives the total energy demand.

The total energy demand, E is expressed as

$$E = \sum_{i=1}^{n} Q_i I_i, \tag{3.2}$$

Where

Q_i : quantity of energy service I,

I_i : intensity of energy use of energy service i, without affecting the level

The intensity I_i can be reduced by changing technology to improve efficiency without affecting the level of energy services. Energy use can also be reduced by reducing the usage (hour/year) of a given end-use device (kW), thus reducing the annual energy use (MWh). The quantity of energy services Q_i depends on several factors, including the population, the share using the end-use service, and the extent of use of each service.

$$Q_i = N_i \cdot P_i \cdot M_i \tag{3.3}$$

Where

N_i : number of costumer eligible for end-use i

P_i : number of end-use devices i per costumer (total units/ total costumers) of end use service i (can be greater than 100%)

M_i : extent of use of end-use service i

3.2.3 End-Use Model in Household Sector

The total of energy demand in the household sector is the sum of the energy demanded by a household's end-use services, such as cooking, lighting, space cooling or heating, refrigeration, water heating, electrical devices, etc. To capture different characteristics of energy consumption in different income group, energy demand in household sector EH could be defined as follows

$$EH = \sum_{i=1}^{n} \sum_{i=1}^{m} E_{H_{i,j}}, \tag{3.4}$$

Where

i : end-use, i= 1,2,3,…,n
j : expenditure class j = 1,2,3,…,m
n : number of end-use device
m : number of income level

By substituting Equations 3.2 and 3.3 in 3.4, end-use energy consumption in households sector EH is given by

$$EH = \sum_{i=1}^{n} \sum_{i=1}^{m} N_{i,j} \cdot P_{i,j} \cdot M_{i,j} \cdot I_{i,j}, \qquad (3.5)$$

Where

$N_{i,j}$: the number of households with end-use i in income class j

$P_{i,j}$: number of appliances per household for end-use i in income class j

$M_{i,j}$: magnitude or the length of time of use of end-use i in the expenditure class j

$I_{i,j}$: the intensity end-use i in the expenditure class j

i : end-use, I = 1,2,3,…,m

j : expenditure class j= 1,2,3,…,m

In addition, to accommodate different characteristics of energy consumption in different household groups, appropriate levels of detail can be added, such as household's area (urban and rural), and access to electricity (IRP [18]).

3.3 Long-range Energy Alternatives Planning (LEAP) model

In 1987, the Long-range Energy Alternative Planning System (LEAP) was developed by the Stockholm Environmental Institute in Boston, USA. The LEAP model has been applied by "hundreds of government agencies, NGOs and academic organization worldwide for a variety of tasks including, energy forecasting, greenhouse gas mitigation analysis, integrated resource planning, production of energy master plans, and energy scenario studies." (LEAP Website 2005 [13]).

The key characteristics of LEAP are an accounting framework and a user-friendly, scenario-based integrated energy-environment model-building tool. The scope of LEAP includes energy demand, energy supply, resources, environmental loadings, cost-benefit analysis, non-energy sector emissions and most aspects optional. Basic relationships are all based on non-controversial physical accounting. Also allows for spreadsheet-like expressions, for the creation of econometric and simulation models. This model time focus medium to long-term, annual time-step and unlimited number of years. It includes technology and environmental database (TED), with technical characteristics, cost and emission factors of 1000 energy technologies. LEAP can be applied in local, national or regional system (Heap C, 2002 [14]).

Its scenarios are based on comprehensive accounting of how energy is consumed, converted and produced in a given region or economy under a range of alternative assumptions on population, economic development, technology, prices and so on.

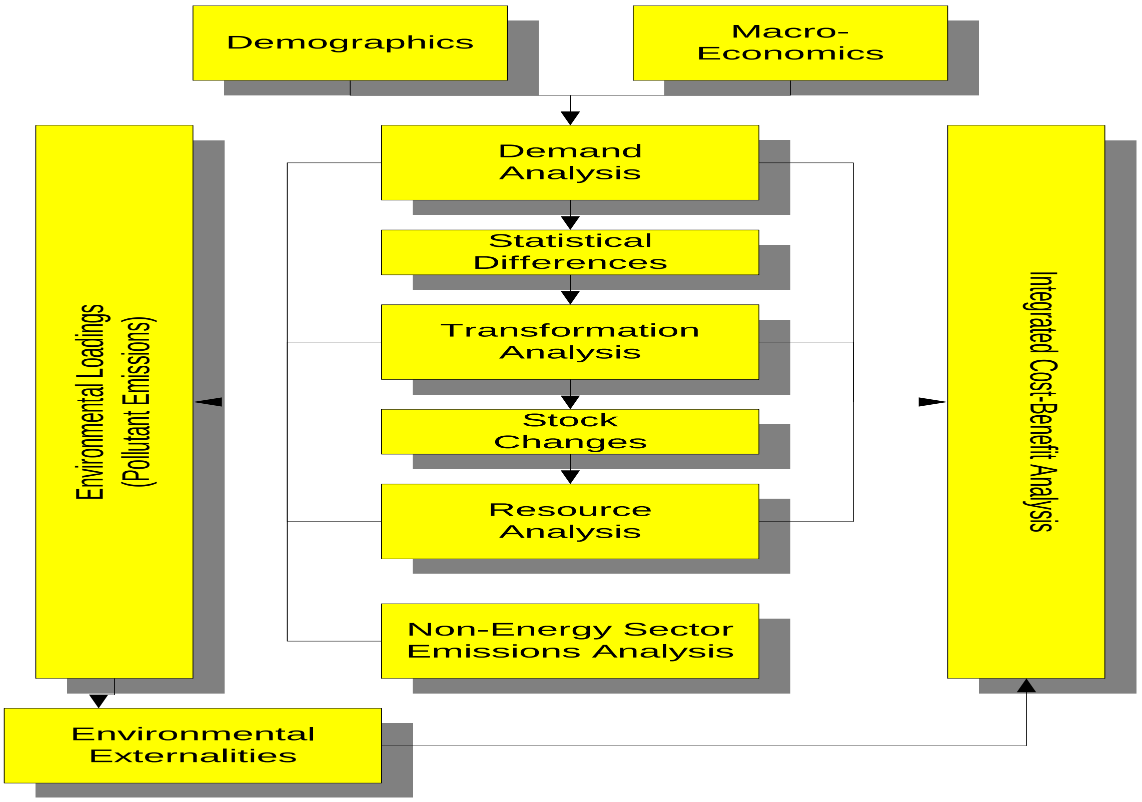


Figure 3.1 LEAP Calculation Flows [14]

3.4 Survey of Household Sector Energy Consumption in Myanmar

This section provides the theoretical background related to its survey of household sector energy consumption characteristics in Myanmar as encompass the determinants of energy consumption in households and the methods used for data collection.

3.4.1 Determinants of Energy Consumption in Household

Many factors determine energy consumption in the household sector. Those factors fall under the category ranging from demographic, economy, technical and even life style. This section will elaborate those factors along with its logical reason to point out the importance of its factor to the household energy consumption.

3.4.1.1 Household Size

The household size is essentially the number of persons for whom a person is financially responsible. Large families are an economic asset in the countryside, since child labor can be used for wood fuel collection and labor-intensive agricultural production. But large families become economically unsustainable in cities if family members cannot generate income in formal markets. The demand for traditional fuels falls, both because of the rising time opportunity costs for urban resident working in formal markets, and because of the availability and economy of alternative energy sources.

3.4.1.2 Age of Household Members

Higher proportions of household members in the productive age are expected to consume more energy.

3.4.1.3 Education of Household Members

The level of education of the head of the household may also be a factor affecting the quantity and type of energy used. This perspective helps explain why households with higher education have a greater tendency to use modern fuels more and offer significant time savings.

3.4.1.4 Income

This basically represents the economic strength of a household. In other words, it determines a household’s affordability levels with the price increases. As income increase, peoples want to live more comfortable. As income increase peoples continue to purchases of additional appliances which categorized as secondary or tertiary needs.

3.4.1.5 Investment Cost of Equipment

Normally, household members do not consider the life cycle cost of fulfilling the energy service as they only consider the investment cost of equipment. Therefore, investment cost of equipment to provide energy service is expected to the household fuel choice and consumption.

Normally, energy prices influence consumer choices and behavior. Low energy prices, particularly of modern carriers like LPG and electricity increases their penetration, high energy prices resources, foster innovation, and encourage efficiency improvements. Appliance standards have been an effective catalyst in promoting technological progress in the appliance industry to create products that serve consumer needs with fewer energy requirements. Appliances and equipment have a tremendous effect on your home energy costs. Poorly sized and inefficient heating and cooling systems can lead to high costs for home heating needs. The energy efficiency of similar appliances can vary significantly.

3.4.1.6 Modern Fuel Access

Household budgets directly influence the choice of fuel, whereas availability and price influence them indirectly. Household energy choices depend on the household income, on household needs, on the prices and availability of equipment and fuel on the status value of energy sources on other factors.

3.4.1.7 Subsidy

Policy makers have a strong direct influence on subsidies, and a strong indirect influence on the price. Subsidies shield the consumers from the effects of energy price rises through a series of pricing measures that have regulated the pass-through of global prices to domestic prices.

3.5 Data Collection of Survey Sites

The data collection for the survey of energy consumption in the household sector is very important for this study. Other supporting data were also obtained from the official document, journal papers and reports from some organizations to support the model analysis.

Myanmar is the 40th largest country in the world. It has a population of about 60 million. It is geographically the largest country in mainland Southeast Asia, with a population density of 75/km^2, one of the lowest in Southeast Asia. As of February 2011, the country constituted of 14 states and regions, 67 districts, 330 townships, 64 subtownships, 377 towns, 2914 wards, 14220 village tracts and 68290 villages [19]. In 2011, urban population is 32.7 % of total population in Myanmar (ADB [2]). There are largest cities in Myanmar, due to population, latitude and longitude.

Table 3.1 Myanmar – Largest Cities

Name			Population
1.	Yangon	Yangon Division	4,477,638
2.	Mandalay	Mandalay Division	1,208,099
3.	Nay Pyi Taw	Mandalay Division	925,000
4.	Mawlamyine	Mon State	438,861
5.	Bago	Bago Division	244,376
6.	Pathein	Ayeyarwady Division	237,089
7.	Monywa	Sagain Division	182,011
8.	Sittwe	Rakhine State	177,743
9.	Meiktila	Mandalay Division	177,442
10.	Myeik	Tanintharyi Division	173,298

Source: Biggest Cities Myanmar, [21]

This study uses some regions from these largest cities as the survey sites, and by using the survey data. We can analyze and forecast the expected successful results for this study.

3.5.1 Sampling Technique and Sample Size Determination

Sampling is a process of selecting a subset of a randomized number of the population of a study. The sampling technique divides the entire target population into different subgroups and then randomly selects the final subjects proportionally from the different strata. Simple random sampling is a sampling procedure that ensures that each demand in population will have an equal chance of being included in the sample.

The population in this study is ordinary households, which are defined as the persons or group of persons living in a building who together manage their everyday common needs, such as cooking, laundry, etc. There are parameters need to be considered to determine sample size i.e. type of variable to be measured, error estimation and estimation of variance. Types of variable included in the surveys play an important role in determining sample size n. usually ranging from smaller n for scaled continuous variable to the large n for categorical variables (Cochran, W.G [16]).

There are two factors for error estimation, level of precision and level of confidence addressed by Cochran [16]. The level of precision, or sometimes called margin of error, is the range in which the true value of population is estimated to be. This range is often expressed in percentage points (e.g. ± 5%). This study has adopted 5% of precision of the estimated value. Another factor is the confidence level. The level of confidence is based on the Central Limit Theorem, if a 95% confidence level is selected, 95 out of 100 samples will have the true population value within the range of precision specified earlier [17]. We use 95% confidence level do determine sample size in this study.

Cochran proposes the formula of a sample size n for continuous data to be presented as

$$n = \frac{Z^2 pq}{e^2} \tag{3.6}$$

A sampling size, $n_{continuous}$ to estimate a mean value of a population can be given for the continuous random variables as follows:

$$n_{continuous} = \frac{Z^2 s^2}{[(\mu + \mu.e) - (\mu - \mu.e)]^2} \tag{3.7}$$

Where Z is the value of corresponding to the selected confidence level. *Z* is found in a statistical table which contains the area under the normal curve, *p* is the estimated proportion of an attribute that is present in the population and *q* is 1-*p*, e is a specific precision of a range of the true mean's error [15]. This study adopted 0.5 as an estimate of population portion when estimating the variance of dichotomous (proportional) variables such as gender.

CHAPTER 4
METHODOLOGY

4.1 Introduction

This study focuses on the analysis and forecasting of energy demand only in the household sector in Myanmar. The final energy demand was simulated separately for each household income level on the basis of common macroeconomic and demographic projections. The energy demand in household sector can be estimated by using the end use model and energy modeling (LEAP). These models need to calculate the detailed data, such as number of electric devices, hours of usage, capacity and etc. But concerning data are not available. So, the field survey for energy consumption in household sector is very important role in this study.

The forecasted energy demand in the business as usual (BAU) case was first prepared by using the survey results of this study. Based on the analysis of the results, the energy efficiency program (EE) created by the energy consumption of household sector in Myanmar in order to reduce energy demand. In the last, the results are assessed in terms of consequence of each scenario.

4.2 Long-term Energy Demand Forecasting in Myanmar

This study projected the energy consumption during period 2012 to 2030. By using the regression model, population (Pop) and gross domestic product (GDP) were adopted as explanatory variables. Substitution of a simple linear form, the regression model used natural logarithms as explained in the following equation (4.1)

$$LN(Y) = A + B * LN(Pop) + C * LN(GDP) \qquad (4.1)$$

Where Y is energy demand (GWh), A is constant, Pop is population (millions of people), GDP is gross domestic product, B and C are constants that represent the elasticity of energy demand with respect to the population and GDP, respectively.

4.3 Field Surveys

Field surveys were conducted in order to strengthen and verify the conclusions of this study. Due to the time constraints, the field surveys focused on only three regions in Myanmar. Population of each city, its location, and available time and budget were the main consideration for determination the location of the survey. The next step was to select highly populated cities located in those areas to carry out the surveys.

4.4 Pilot Surveys

It is important to take the sample in two steps in order to estimate the variance of the population for sample size calculation. The variance of the first sampling was used to determine the appropriate sample size. Pilot survey was conducted by collecting data from the samples of Myanmar households. By examining mean and standard deviation of variables from the result of pilot survey of the households, the variable of expenditure on electricity is then as a base to calculate sample size. Since its mean and standard deviation give the largest sample size compare with other continuous variable.

4.5 Sample Size Calculation

By using the results of the pilot survey, a sample size of 95% confidence level (Z=1.96) and the level of precision 5% (e=0.05) for maximum variable can be calculated using Eq. (3.6)

$$n = \frac{Z^2 pq}{e^2} = \frac{1.96^2 \cdot 0.5 \cdot 0.5}{0.05^2} = \approx 384$$

The sample size for the maximum variable is 384, which was used as sample size in this study. Finally, we decided to survey data for the 450 households. We collected the data from each income level in urban and rural area in Myanmar.

By substituting the sample size of each income level, e.g. low income level in Eq. (3.6), the level of precision *e* is

$$e = \sqrt{\frac{Z^2 pq}{n}} = \sqrt{\frac{1.96^2 \cdot 0.5 \cdot 0.5}{140}} = 0.0035 \approx 0.04$$

4.6 Income Class Determination

The income factor is likely to be the prime driver of increasing energy requirements in the future for the country. The growth in incomes is leading to an increased demand for energy, particularly electricity end uses, and energy intensive products and services. An increase in the total per capita requirements is a consequence (Pachauri, [9]).

In order to increase income, there is a decline in the percentage of consumers who choose to consume traditional fuels [15]. Thus, income classes were chosen as a base to stratify the respondents. This study used the low, medium and high income level in both urban and rural area which the data obtained from survey then classified into the classes of income groups. Each class was categorized by one standard deviation.

4.7 Energy Consumption of Households

A household's monthly energy consumption (EH) is the summation of the monthly consumption of electricity (EL), and cooking fuel (EC). Household's electricity consumption refers the total electricity consumption for the purpose of lighting, space cooling such as air conditioning, refrigerating, and electric fan, cooking, entertainment such as television, computer and laptop, laundry, water supply, and other electricity appliances. According to the different characteristics of energy consumption in different income class, total household's electricity consumption EL is defined as follows (IRP [18]).

$$EL = \sum_{i=1}^{n}\sum_{i=1}^{m} \boldsymbol{N}_{ij} \cdot \boldsymbol{P}_{ij} \cdot \boldsymbol{M}_{ij} \cdot \boldsymbol{Ie}_{ij} \tag{4.2}$$

Where N_{ij} is the number of households with equipment i in income j, P_{ij} is the number of appliances per household for equipment i in income class j (unit/household). M_{ij} is the length of time of use for equipment i (hour) and Ie_{ij} is the electrical intensity of equipment i in the income class j (Watt). Since there is a lack of statistically detailed data on electricity consumption by the household sector in Myanmar, field surveys are very important.

For the kinds of electricity-saving functions of special household appliances, such as air conditioning and refrigerators, the rated powers of these appliances are not always equal to the average power consumed by actual use [20]. To accommodate this factor, it is important to use a coefficient R_{ij} to modify Eq, (4.3) to be

$$EL = \sum_{i=1}^{n}\sum_{i=1}^{m} N_{ij} \cdot P_{ij} \cdot M_{ij} \cdot Ie_{ij} \cdot R_{ij} \tag{4.3}$$

The ratio of average input power is R_{ij} in actual operation to the rated power of an appliance i in income class j. This study assumes the R_{ij} for refrigerators to be 0.36 [20]. In 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 wood stove, charcoal stove and LPG stove, could be write as follows;

$$EC = \sum_{i=1}^{n}\sum_{i=1}^{m} N_{ij} \cdot P_{ij} \cdot M_{ij} \cdot Ic_{ij} \tag{4.4}$$

Where EC is the monthly energy consumption for cooking (MJ), N_{ij} is the number of households with cooking equipment i in income class j, P_{ij} is the number of cooking appliances per household for equipment i in income class j (unit/household), and Ic_{ij} is the rate of energy consumption of equipment i by the income class j (MJ/ household).

4.8 Projection of Household Energy Consumption in Business as Usual Case (BAU)

According to the survey data, the total household energy consumption in the urban and rural areas in the case of business as usual (BAU) could be 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 the household size in Myanmar.

This study adopted a household population growth rate of 1.3% per annum. Household sizes in Myanmar are 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 [24]. 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 4.1. Projections of percent share of households 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

4.9 The Long-Term Planning for Energy Development in Myanmar

The improvement of energy efficiency on the demand side under this scenario was calculated by subtracting the saving potential targets.

$$Y_{EE} = Y - EESAV \quad (4.5)$$

Y_{EE} = the energy consumption with EE (MJ)

Y = the energy consumption (MJ)

EESAV = the energy savings (MJ)

4.10 Demand Side Management (DSM) Programs

The energy efficiency scenario (EE) is created by lessening the level of Ie and Ic. This could be done by introducing more efficient end-use technologies to replace the conventional less efficient traditional end-use technologies for electrical and cooking appliances.

The measures of Demand Side Management (DSM) programs will depend on the result of the survey, and will focus on the improvement of that end-use equipment that potentially have large reductions in energy consumption.

One of the measures of DSM will focus on energy efficiency improvements of lighting (EE lighting) and air conditioning equipment (EE AC). The other is energy efficiency improvement of cooking appliances (EE stove). In EE programs, the numbers of equipments per household, P, are assumed to be constant throughout the horizontal of planning period.

4.11 Technical Energy Saving Potential of DSM Program

By implementing the DSM program, the saving potential of electricity demand could be calculated as the difference of electricity consumption between the businesses as usual case (BAU) and the energy efficiency case (EE). Since the numbers of household, N, number of equipments per household, P, the length time of use, M, and the operation cycle factor, R, are assumed to be the same for the BAU and EE cases, the total electricity saving potential, ELSAV (kWh), can be expressed as:

$$ELSAV = EH_{BAU} - EH_{EE} = \sum_{i=1}^{n}\sum_{j=1}^{m} N_{ij} \cdot P_{ij} \cdot M_{ij} \cdot R_{ij} \cdot (I_{BAUij} - I_{EEij}), \quad (4.6)$$

Where I_{BAU} and I_{EE} are the electric intensity of equipment (W) for the BAU and EE cases respectively.

The energy saving potential of energy for cooking ECSAV (MJ) can be expressed as

$$ECSAV = \sum_{i=1}^{n}\sum_{j=1}^{m} N_{ij} \cdot P_{ij} \cdot (Ic_{BAUij} - Ic_{EEij}), \quad (4.7)$$

Ic_{BAU} and Ic_{EE} is the fuel consumption of cooking equipment i in the income class j (toe/household/month) for the BAU and EE cases respectively.

CHAPTER 5
RESULTS AND DISCUSSION

5.1 Introduction

According to the survey data from the characteristic of energy consumptions in urban and rural households, the case of business as usual (BAU) was calculated. Furthermore, based on the survey result, energy efficiency programs (EE) in order to reduce energy consumption were assumed to be introduced of the household sector in Myanmar.

5.2 Energy Demand Projections of Residential Sector in Myanmar

The predicted annual energy demand projections of the residential sector in Myanmar were estimated by using Equation (4.1). It can be assumed by using IEA data of the energy consumption in Myanmar, and historical values of GDP and populations. Figure 5.1 presented the results of the energy consumption in the residential sector for the next decade from the year 2012 to 2030 under 7%, 10% and 12% regarding to the low, medium and high economic growth rate scenario as used in this study.,

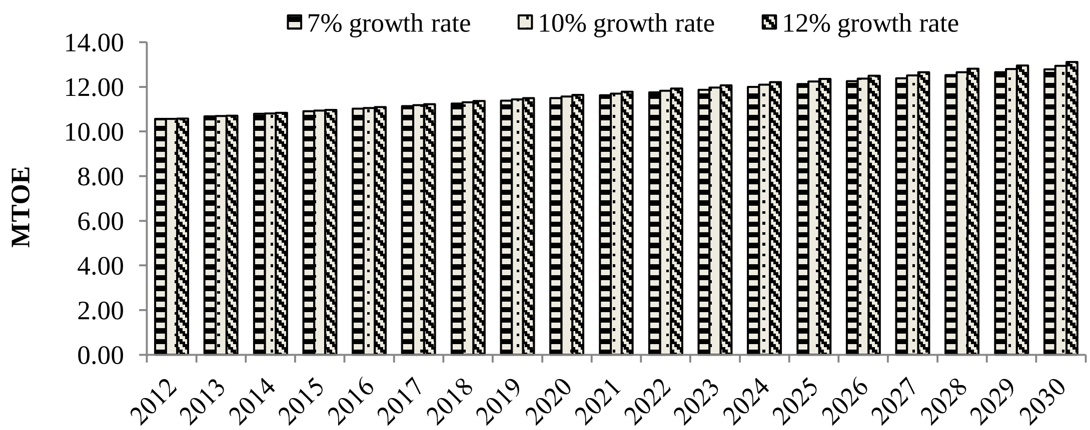


Figure 5.1 Predicted Annual Energy Consumption in Residential Sector under the low, medium and high economic growth rate (2012-2030)

According to the results, the projected energy demand in 2012 will increase from 10.56 MTOE to 12.79 MTOE in 2030 under the 7% low economic growth rate. Under the medium economic growth rates of 10%, the projected energy demand in 2012 will increase from 10.57 MTOE to 12.94 MTOE in 2030. Under the high economic growth rate of 12%, the energy demand projected to be 10.58 MTOE in the year 2012 to 13.12 MTOE in the year 2030. The increasing rate of the energy demand was about 21% of the base year 2012 energy demand to the end year 2030 demand as the low economic growth rate and 22% of the year 2012 energy demand to the year 2030 as the medium economic growth rate. For the high economic growth rate, the energy demand promoted about 24% of the year 2012 to the end year 2030 in this study.

5.3 Energy Saving Projections of Residential Sector in Myanmar

According to the Myanmar's energy saving goal, the energy efficiency program was assumed to be 8% of the residential sector in 2020. This target focused the reduction of final energy demand of residential sector in Myanmar. This study projected the 8% energy saving target for low economic growth rate, 10% for medium economic growth and 12% for high economic growth rate by starting the year 2020.

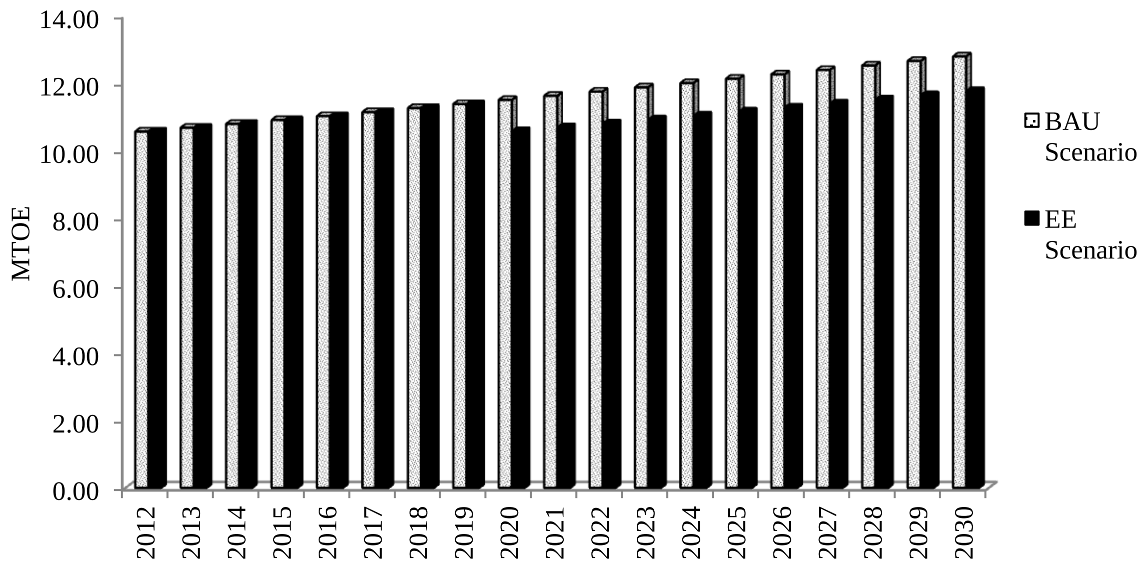


Figure 5.2 Predicted Annual Energy Consumption in Residential Sector under the low economic growth rate by EE scenario (2012-2030)

Figure 5.2 shows that the energy saving target was assumed by using an 8% low economic growth rate in 2020. In this result, the final energy consumption was projected about 11.50 MTOE in BAU scenario and 10.58 MTOE in EE scenario in 2020. The energy saving amount was about 0.92 MTOE or 8% of BAU scenario in this year. In 2030, the reduction amount was projected to be 1.02 MTOE or 8% from 12.79 MTOE in the BAU scenario to 11.77 MTEO in the EE scenario.

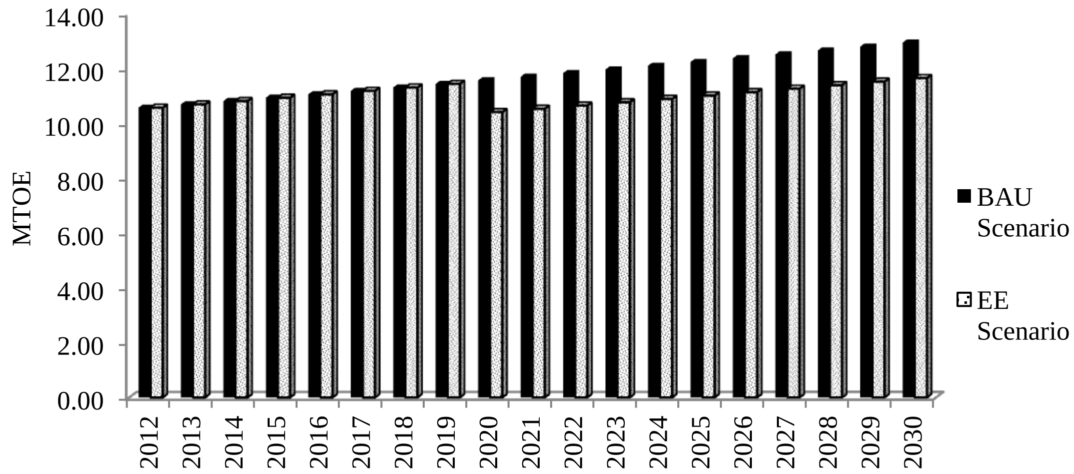


Figure 5.3 Predicted Annual Energy Consumption in Residential Sector under the medium economic growth rate by EE scenario (2012-2030)

Figure 5.3 shows that the energy saving amount was projected to be 1.15 MTOE or 10% from 11.83 MTOE under the BAU case to 10.41 MTOE under the EE program in 2020 by using the medium economic growth rate. In 2030, the reduction of energy consumption amount was projected to be 1.29 MTOE or 10% from 12.94 MTOE in BAU scenario to 11.65 MTEO in EE scenario in this study.

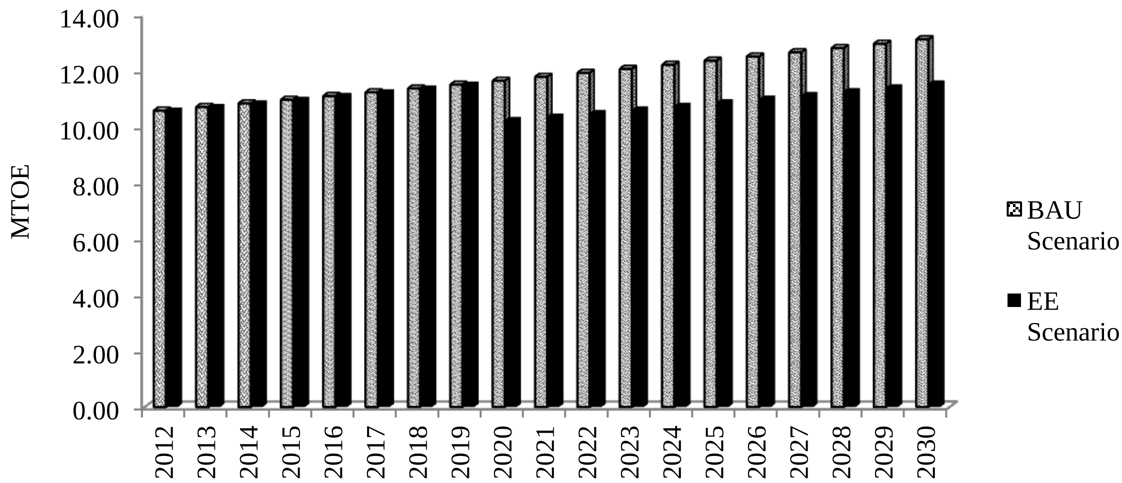


Figure 5.4 Predicted Annual Energy Consumption in Residential Sector under the high economic growth rate by EE scenario (2012-2030)

As shown in Figure 5.4, a 12% energy saving target was assumed by the high economic growth rate in 2020. In this result, the annual final energy consumption was projected to be 11.64 MTOE in BAU scenario and 10.24 MTOE in EE scenario in the year 2020. Meanwhile, the reduction amount was 1.40 MTOE or 12% in BAU case to EE case. In the end year 2030, the energy saving amount 1.58 MTOE (12%) under the high economic growth rate was projected from 13.21 MTOE to 11.54 MTOE under BAU case and EE program in this study.

5.4 Energy Consumption Characteristics of Household Sector in Myanmar

This study provides the results of the survey data for energy consumption by the household sector of the urban and the rural areas of the 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 5.1

Table 5.1 Number of respondents of urban and rural areas in Myanmar

Region	Number 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

Yangon city is the most populated region with about 4.48 million people [21]. The main sea port and Industry Zones and the biggest load center of Myanmar. Mandalay and Nay Pyi Taw also have the high population density and the power demand is increasing rapidly. Yangon city has the highest electrification ratio (67%) followed by the Nay Pyi Taw (54%), Mandalay (31%) and rural areas electrification rate (16%). The survey sites of rural areas in Yangon region also have access electrified areas.

Table 5.2 Average monthly income per capita and corresponding standard deviation

Region	Number of respondents (household)	Monthly average of income per capita(μ) (Kyat)	Standard deviation(σ) (Kyat)
Yangon	350	275,714	174,055
Mandalay	50	219,286	99,893
Nay Pyi Taw	50	209143	85,538
Total	450		
Average		234,714	119,829

Table 5.3 Classification of Income Class

Income Class	Monthly income per capita (Kyat)
Low-income	114,885 - 234,713
Medium-income	234,714 - 354,543
High-income	354,543<

By using the monthly average of income per capita (μ) and standard deviation (σ) as shown in Table 5.2, the income classes were classified as shown in Table 5.3.

5.5 Urban Household Energy Consumption in Myanmar

By using the survey results, the urban household energy consumption in Myanmar was calculated by Equations (4.2) (4.3) and (4.4), Figure 5.5 presents the accumulated annual total energy consumption of the urban household sector in Myanmar in 2013.

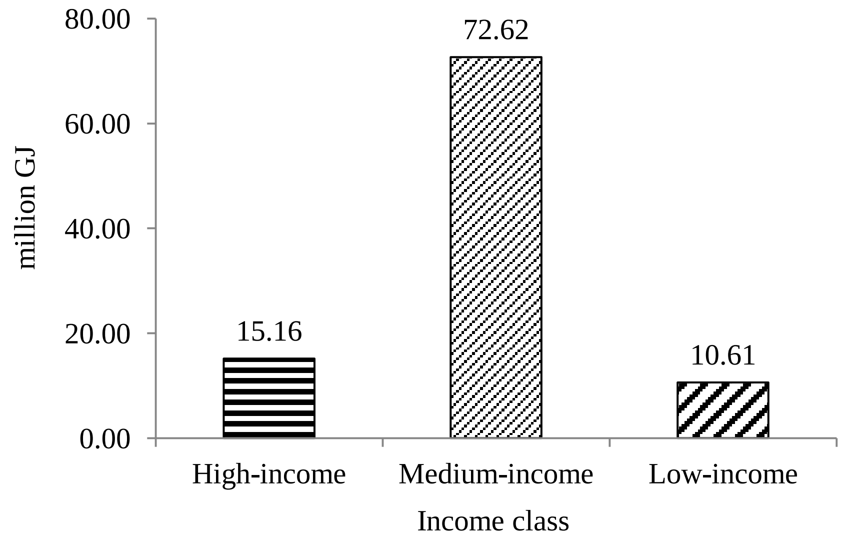


Figure 5.5 Accumulated annual total energy consumption of the urban household sector in Myanmar by income classes

Due to these results, the annual total final energy consumption in urban households accounts for about 98.39 million GJ and the high-income class consumed about 15.16 million GJ or (15.41%), the medium-income class consumed 72.62 million GJ (73.81%) and the low-income class energy consumption was 10.61 million GJ (10.78%) of this year's final energy consumption.

Meanwhile, detailed urban household energy consumption by type of energy carrier is presented in Tables 5.4 and 5.5

Table 5.4 Annual average electricity consumption in income classes and percentage shares of each type of appliance in urban households

Appliances	Income Class					
	High-Income		Medium-Income		Low-Income	
	(KWh)	(%)	(KWh)	(%)	(KWh)	(%)
Lighting	1121.21	(15.59%)	935.18	(19.41%)	845.90	(29.65%)
Cooking	1025.00	(14.26%)	865.00	(17.95%)	574.70	(20.14%)
Entertainment	571.75	(7.95%)	288.84	(6.00%)	240.30	(8.42%)
Television (TV)	446.00	(6.20%)	214.00	(4.45%)	208.40	(7.30%)
Computer	125.75	(1.75%)	74.84	(1.55%)	31.90	(1.12%)
Space Cooling	3876.54	(53.92%)	2284.15	(47.40%)	832.60	(29.18%)
Air Conditioning (AC)	2725.00	(37.90%)	1157.00	(24.01%)	227.20	(7.96%)
Refrigerator	935.81	(13.02%)	828.83	(17.20%)	285.00	(9.99%)
Electric Fan	215.73	(3.00%)	298.32	(6.19%)	320.40	(11.23%)
Other Appliances (Water Pump, Electric Iron, Washing Machine Hand Phone, Hair dryer, Water Cooler and Heater)	595.43	(8.28%)	445.00	(9.24%)	359.90	(12.61%)
	7189.93	(100.00%)	4818.17	(100.00%)	2853.40	(100.00%)

1 kWh = 3.6 MJ (Electricity)

Table 5.5 Annual average energy consumption for cooking appliances by income classes of urban households

Appliances	Income Class		
	High-Income (MJ)	Medium-Income (MJ)	Low-Income (MJ)
LPG Cooking Stove	8885.76	5553.60	3887.52
Charcoal Cooking Stove	2851.20	4003.20	4550.40
Fuelwood Cooking Stove	-	-	-

1 Kg = 46.28 MJ (LPG), 1 Kg = 28.8 MJ (Charcoal)

As Table 5.4 shows space cooling and lighting had the largest consumption among the high and medium-income classes. The other shares were cooking, electrical appliances and entertainment respectively. In the low-income level, lighting was the most shares and followed by the space cooling, cooking, other appliances and entertainment. The energy consumption rate of the high-income and low-income households diverse significantly, Annual average energy consumption ranges from 7189.93 KWh in the high-income level to 2853.40 KWh in the low-income level per household in the urban area. The result shown that energy consumption in the high-income is higher than the low-income by 2.5 times.

In Table 5.5, LPG cooking energy consumption was used the most by the high-income level, followed by the medium-income and low-income. On the other hand, charcoal cooking stove was consumed by the largest share in the low-income household in urban area.

5.6 Rural Household Energy Consumption in Myanmar

The rural household energy consumption in Myanmar was calculated by Equations (4.2) (4.3) and (4.4), and the accumulated annual total energy consumption of the rural household sector in 2013 accounted for about 134.77 million GJ. In these results, high-income class consumed about 8.64 million GJ or (6.41%), medium-income class consumed 92.75 million GJ (68.82%) and low-income class energy consumption was 33.38 million GJ (24.77%) of this year final energy consumption, as shown in Figure 5.6.

The detail energy consumption patterns of rural households by type of energy carrier are presented in Tables 5.6 and 5.7.

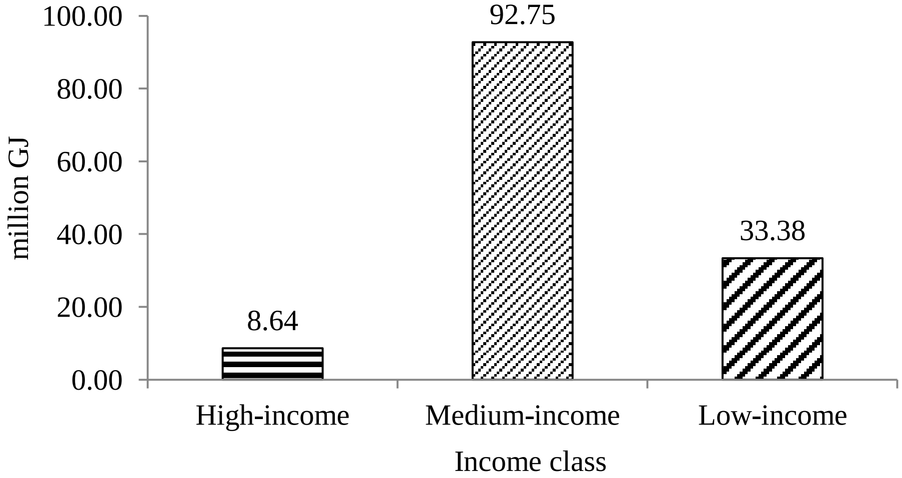


Figure 5.6 Accumulated annual total energy consumption of the rural household sector in Myanmar by income classes

Table 5.6 Annual average electricity consumption in income classes and percentage shares of each type of appliance in rural areas

Appliances	Income Class					
	High-Income		Medium-Income		Low-Income	
	(KWh)	(%)	(KWh)	(%)	(KWh)	(%)
Lighting	710.00	(30.21%)	524.00	(31.37%)	320.00	(33.26%)
Cooking	415.00	(17.66%)	295.00	(17.66%)	225.00	(23.39%)
Entertainment	180.44	(7.68%)	122.21	(7.32%)	85.00	(8.84%)
Television (TV)	145.44	(6.19%)	101.21	(6.06%)	85.00	(8.84%)
Computer	35.00	(1.49%)	21.00	(1.26%)	-	-
Space Cooling	650.00	(27.65%)	434.00	(25.99%)	112.00	(11.64%)
Air Conditioning (AC)	250.00	(10.64%)	142.00	(8.50%)	-	-
Refrigerator	245.00	(10.42%)	170.00	(10.18%)	-	-
Electric Fan	155.00	(6.59%)	122.00	(7.31%)	112.00	(11.64%)

Other Appliances (Water Pump, Electric Iron, Washing Machine, Hand Phone, Hair dryer, Water Cooler and Heater)	395.00	(16.80%)	295.00	(17.66%)	220.00	(22.87%)
	2350.44	(100.00%)	1670.21	(100.00%)	962.00	(100.00%)

1 kWh = 3.6 MJ (Electricity)

Table 5.7 Annual average energy consumption for cooking appliances of income classes in rural areas

Appliances	Income Class		
	High-Income (MJ)	Medium-Income (MJ)	Low-Income (MJ)
LPG Cooking Stove	-	-	-
Charcoal Cooking Stove	3456.00	2764.80	1872.00
Fuelwood Cooking Stove	10454.00	9416.00	8659.00

1 Kg = 46.28 MJ (LPG), 1 Kg = 28.8 MJ (Charcoal), 1 Kg = 17.6 (Fuelwood)

Table 5.6 shows that the number of lighting as the largest share of electricity consumption in all income classes of rural household energy consumption in 2013. In the high-income and medium-income class, space cooling is the second shares and cooking, other appliances and entertainments respectively. On the other hand, low-income consumed lighting in the first, followed by the cooking, other appliances, cooling and entertainment. These low-income level households cannot buy luxury things and they emphasized for only lighting appliances in their living standard. Finally, the results present the annual final electricity consumption of high income level accounted to 2350.44 KWh was the 2.4 times of low-income level energy consumption by 962.00 KWh per household in rural area.

In Table 5.7, the energy consumption of cooking appliances in the rural household mostly depended on fuelwood cooking and charcoal cooking stoves. Due to the survey data, high-income is the largest energy consumption in all cooking stoves. And medium-income and low-income consumed as the second and third shares in these stoves according their income range.

5.7 Comparison of Electrical Appliances and Energy Cooking Stoves Used by Household Sector in Myanmar

Table 5.8 Comparison of Electrical Appliances and Energy Cooking Stoves Used in Urban Households

Appliances	High-Income (%)		Medium-Income (%)		Low-Income (%)	
	Use	Non-Use	Use	Non-Use	Use	Non-Use
Lighting Lamps	100	-	100	-	100	-
Rice Cooking	100	-	100	-	100	-
Television & entertainment	100	-	100	-	100	-
Computer	100	-	62	38	33	67
Air Conditioning	100	-	77	23	19	81
Refrigerator	100	-	97	3	57	43
Electric Fan	100	-	100	-	100	-
LPG Cooking Stove	75	25	50	50	35	65
Charcoal Cooking Stove	30	70	65	35	85	15
Fuelwood Cooking Stove	-	100	-	100	-	100

Table 5.9 Comparison of Electrical Appliances and Energy Cooking Stoves Used in Rural Households

Appliances	High-Income (%)		Medium-Income (%)		Low-Income (%)	
	Use	Non-Use	Use	Non-Use	Use	Non-Use
Lighting Lamps	100	-	100	-	100	-
Rice Cooking	80	20	68	32	46	54
Television & entertainment	100	-	100	-	88	12
Computer	28	72	22	78	-	100
Air Conditioning	14	86	10	90	-	100
Refrigerator	28	72	22	78	-	100
Electric Fan	88	12	84	16	82	18
LPG Cooking Stove	-	100	-	100	-	100
Charcoal Cooking Stove	75	25	60	40	45	55
Fuelwood Cooking Stove	100	-	100	-	100	-

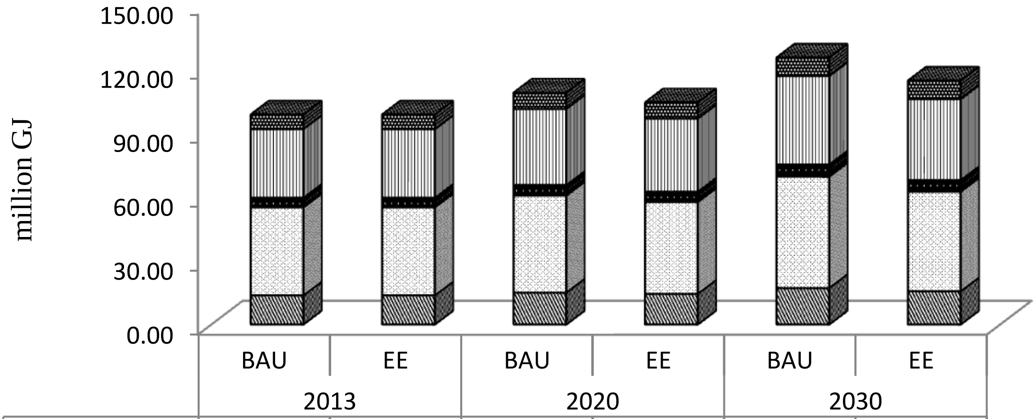
Table 5.8 presents the comparison of electrical appliances and energy cooking stoves used by the urban household sector in Myanmar. In these results, all urban households are using 100% of lighting lamps, electric rice cooking and television and entertainment appliances. Computer using is 100% in high-income class, 62% in medium-income class and 33% in low-income class of urban households. Air conditioning using is 100% in high-income class, 77% in medium-income class and 19% in low-income class. Refrigerator using is 100% in high-income class, 97 % in medium-income class and 57% in low-income class. Electric fan using is 100% in all income classes of households.

In energy cooking stoves, the use of LPG cooking stoves is 75% by the high-income class, 50% by the medium-income class and 35% by the low-income class. Charcoal cooking stove using is 30% by high-income class, 65% by medium-income class and 85% by low-income class of urban households.

As shown in Table 5.9, all rural households uselighting lamps. The use of electric rice cooking is 80% by high-income households, 68% by medium-income and 46% by low-income households. Television appliances are 100% by high-income and medium-income households and 88% by low-income households. Computer use is 28% by high-income households and 22% by medium-income households. Air conditioning use is 14% by high-income households and 10% by medium-income households. Refrigerator use is 28% and 22% by high-income and medium-income households. The low-income households cannot use computers, air conditioners and refrigerators. The using of electric fan is 88%, 84% and 82% by high-income, medium-income and low-income households of rural area.

For energy cooking stoves in rural areas, the use of charcoal cooking stove is 75%, 60% and 45% in the high-income, medium-income and low income households, respectively. The fuelwood cooking stove using are 100% in all income households of this area.

5.8 Annual Total Final Energy Consumption of the Urban Household Sector



	BAU	EE	BAU	EE	BAU	EE
	2013		2020		2030	
Other	6.86	6.86	7.56	7.56	8.66	8.66
Cooling	32.14	32.14	35.67	34.24	41.40	37.93
Entertainment	4.49	4.49	4.96	4.85	5.73	5.42
Cooking	41.26	41.26	45.45	43.03	52.18	46.70
Lighting	13.64	13.64	14.96	14.37	17.11	15.56

Figure 5.7 Annual total final energy consumption of the urban household sector in Myanmar under each scenario

By using the model, the annual total final energy consumption of the urban household sector in Myanmar under the BAU and EE scenarios were projected in this study. In 2013, the total final energy consumption was 98.39 million GJ in the urban household sector. Due to the energy efficiency program in 2020, total final energy consumption is projected to be 108.60 million GJ under BAU case and 104.05 million GJ in EE program. The energy savings are projected to be about 4.55 million GJ (4.19%) of BAU case in this year. Moreover, the total final energy consumption was projected to be 125.08 million GJ in BAU case and 114.27 million GJ in EE program in the year 2030.

Figure 5.7 shows that cooking is the largest energy consumption in all income classes, followed by cooling, lighting, other appliances and entertainment, respectively. In 2020, lighting energy consumption is projected to be saved amount 0.59 million GJ, or (0.54%), cooking energy consumption is projected to be reduced about 2.42 million GJ, or (2.23%), entertainment to be saved 0.11 million GJ (0.10%) and cooling energy consumption can be saved 1.43 million GJ (1.32%) of the total final energy consumption 108.60 million GJ in the BAU scenario in the same year.

5.9 Annual Total Final Energy Consumption of Income Classes of the Urban Household Sector

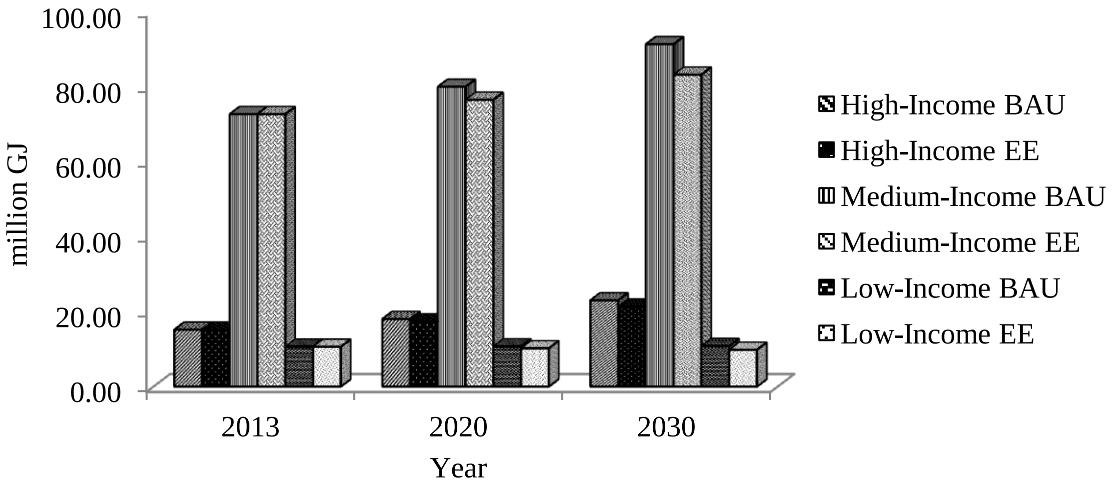
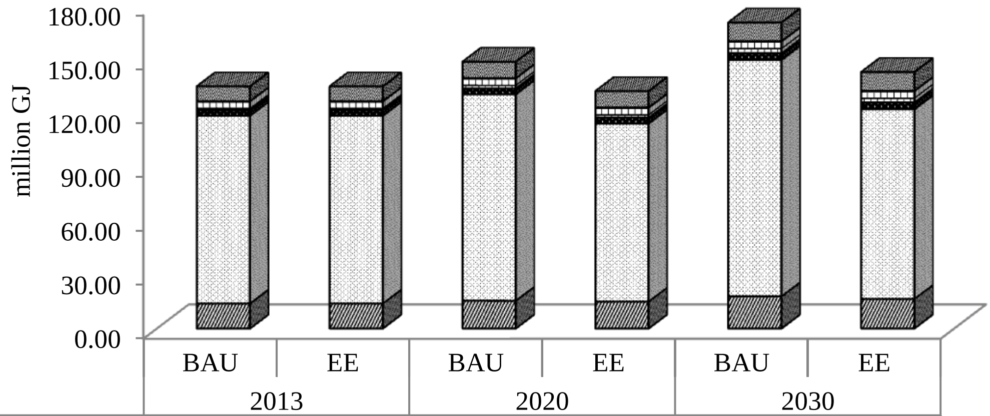


Figure 5.8 Annual total final energy consumption of income classes of the urban household sector in Myanmar under each scenario

As shown in Figure 5.8, the total final energy consumption in 2013 was projected to be 15.16 million GJ in high-income, 72.62 million GJ in medium-income and 10.61 million GJ in low-income households. By starting the EE program in 2020, the total final energy consumption was projected to be 17.99 million GJ under BAU and 17.37 million GJ for EE in the high-income class, 79.91 million GJ for BAU and 76.48 million GJ for EE in the medium-income class, and 10.70 million GJ under BAU and 10.20 million GJ for EE in the low-income class. Furthermore, in 2030, energy consumption was projected to be 22.98 million GJ in the BAU case and 21.32 million GJ for EE in high-income, 91.26 million GJ in BAU and 83.16 million GJ for EE program in medium-income, and 10.84 million GJ in BAU scenario and 9.79 million GJ for EE in low-income household sectors in urban areas.

According to these results, medium-income households in urban areas were projected to be the highest total final energy consumers, second were the low-income and last were the high-income level. The percent share of medium households was 74.3% of the total urban number, so this income level was the largest energy consumption among the income levels. In 2020, the reduction amount was projected to be about 0.62 million GJ (0.57%) in high-income, 3.43 million GJ (3.16%) in medium-income and 0.50 million GJ (0.46%) in low-income, between the BAU scenario and EE scenario of the total final energy consumption in urban area households.

5.10 Annual Total Final Energy Consumption of the Rural Household Sector



	2013 BAU	2013 EE	2020 BAU	2020 EE	2030 BAU	2030 EE
Other	8.18	8.18	9.03	9.03	10.40	10.40
Cooling	5.17	5.17	5.75	5.69	6.68	6.50
Entertainment	2.95	2.95	3.26	3.26	3.74	3.74
Cooking	104.53	104.53	114.97	99.13	131.64	105.62
Lighting	13.94	13.94	15.44	14.99	17.88	16.45

Figure 5.9 Annual total final energy consumption of the rural household sector in Myanmar under each scenario

Figure 5.9 shows that rural household energy consumption can be calculated by using the survey data and projecting the annual total final energy consumptions for the BAU case and the EE programs. In 2013, the total final energy consumption was projected 134.77 million GJ. The energy efficiency program should start in 2020, so total final energy consumption was forecasted to be 148.45 million GJ in the BAU case and 132.10 million GJ for EE program, with a reducing of 16.35 million GJ (11.01%) of total final energy consumption of the BAU case to EE program in this year. In 2030, the total final energy consumption of rural household was projected to be 170.34 million GJ in BAU case and 142.71 million GJ in EE program.

In rural areas, cooking is the largest energy consumption in all income levels followed by lighting, other electric appliances, cooling and entertainment. These results show that the rural areas used fuelwood and charcoal, so the cooking energy consumption was higher than that of other appliances. By introducing the energy efficiency program in 2020, lighting energy consumption is projected to be reduced about 0.45 million GJ or (0.30%) of total final energy consumption from the BAU scenario, cooking energy consumption is projected to be reduced about 15.84 million GJ or (10.67%) and space cooling energy consumption can be reduced 0.06 million GJ or (0.04%) of total final energy consumption 148.45 million GJ from the BAU scenario in the same year.

5.11 Annual Total Final Energy Consumption of Income Classes of the Rural Household Sector

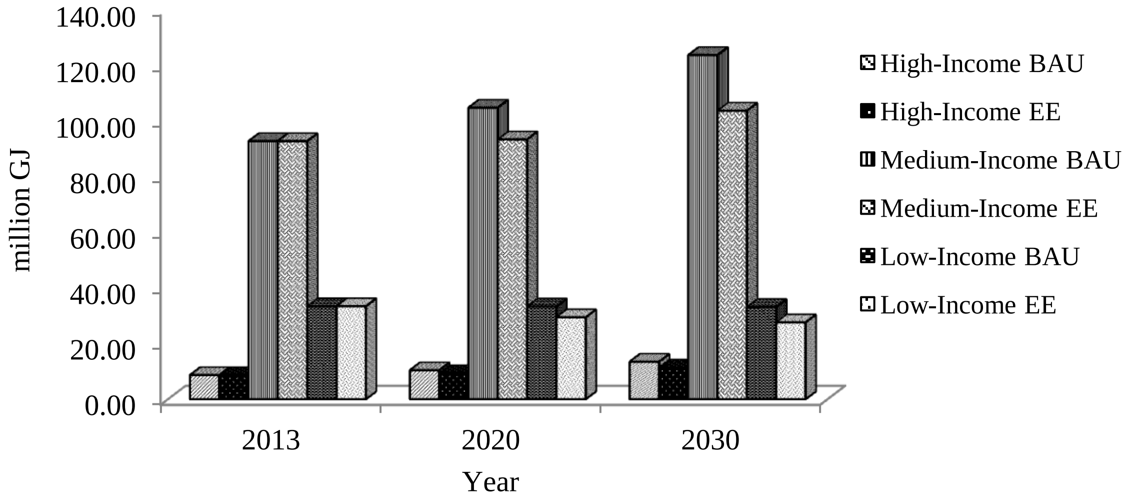


Figure 5.10 Annual total final energy consumption of income classes of the rural household sector in Myanmar under each scenario

Figure 5.10 presents the annual total final energy consumption of the income classes of the rural household sector in Myanmar under each scenario. In 2013, the total final energy consumption was projected to be 8.64 million GJ in high-income, 92.75 million GJ in medium-income and 33.38 million GJ in low-income. Due to the EE program in 2020, the total final energy consumption was projected to be 10.37 million GJ in BAU scenario reduced to 9.31 million GJ for EE program in high-income, 104.78 million GJ and 93.37 million GJ for EE in medium-income, and 33.30 million GJ in BAU and 29.42 million GJ for EE program in low-income. In 2030, energy consumption was projected to be 13.46 million GJ for BAU and 11.38 million GJ for EE program in high-income, 123.70 million GJ to 103.72 million GJ between BAU case and EE in medium-income and 33.18 million GJ for BAU and 27.61 million GJ for EE program in low-income households.

The results of these data show that the highest total final energy consumer is projected to be the medium-income level, 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 1.06 million GJ (0.71%) for high-income, 11.41 million GJ (7.69%) for medium-income, and 3.88 million GJ (2.61%) for low-income households, between the total final energy consumption of the BAU case and the EE program in rural area households.

5.12 Estimation of Potential Energy Savings from Energy Efficiency Improvements (EE) Program

With the increase of the energy consumption of the household sector in Myanmar, the need to implement energy efficiency practices is extremely important for the development and renewal of policy instruments in the household sector. Energy policy for households ought to make better use of measures related to each other and support accumulated energy efficient behaviours in a policy chain.

Table 5.10 Estimation of Potential Energy Savings from Energy Efficiency Improvements (EE) in Urban Households

	High-Income		High-Income		High-Income	
	2020	2030	2020	2030	2020	2030
	Potential Energy Savings (million GJ)	Potential Energy Savings (million GJ)	Potential Energy Savings (million GJ)	Potential Energy Savings (million GJ)	Potential Energy Savings (million GJ)	Potential Energy Savings (million GJ)
Lighting Lamps	0.08 (4.15%)	0.22 (8.91%)	0.44 (3.97%)	1.15 (9.08%)	0.07 (3.61%)	0.18 (9.14%)
Rice Cooking Stove	0.08 (4.55%)	0.22 (9.78%)	0.51 (4.97%)	1.17 (9.98%)	0.07 (5.30%)	0.14 (10.45%)
Charcoal Cooking Stove	0.13 (9.56%)	0.35 (20.11%)	1.32 (10.01%)	3.01 (19.99%)	0.30 (10.31%)	0.59 (20.07%)
TV	0.03 (3.9%)	0.08 (8.16%)	0.08 (3.15%)	0.20 (6.90%)	0.01 (2.08%)	0.03 (6.25%)
Air Conditioning	0.24 (5.12%)	0.60 (10.02%)	0.69 (5.03%)	1.56 (9.96%)	0.03 (5.77%)	0.05 (9.43%)
Refrigerator	0.06 (3.73%)	0.19 (9.22%)	0.39 (3.97%)	1.01 (8.99%)	0.02 (3.08%)	0.06 (9.09%)
	0.62 (3.45%)	1.66 (7.22%)	3.43 (4.29%)	8.10 (8.88%)	0.50 (4.67%)	1.05 (9.69%)

In the urban households, modern electrical appliances are used more than in rural households, so their electricity consumption is very high in this area. As shown in Table 5.10, the potential energy saving in lighting lamps is projected to be amount 0.59 million GJ in 2020 and 1.55 million GJ in 2030 in these households. By substituting the more efficient lamps and LED lamps, the energy consumption could be reduced in this sector. The percent share of energy consumption of the electric rice cooking stoves, TVs, air conditioning and refrigerators appliances are increasing due to their income levels. So, the projected energy saving targets need to promote by using the energy efficiency goods and labeling appliances in the EE programs. More information about saving potentials would be warranted in order to further strengthen the motivations of such respondents.

Table 5.11 Estimation of Potential Energy Savings from Energy Efficiency Improvements (EE) in Rural Households

	High-Income		Medium-Income		Low-Income	
	2020	2030	2020	2030	2020	2030
	Potential Energy Savings	Potential Energy Savings	Potential Energy Savings	Potential Energy Savings	Potential Energy Savings	Potential Energy Savings
	(million GJ)	(million GJ)	(million GJ)	(million GJ)	(million GJ)	(million GJ)
Lighting Lamps	0.03	0.13	0.35	1.08	0.08	0.22
	(2.40%)	(7.98%)	(3.05%)	(7.99%)	(2.92%)	(8.06%)
Rice Cooking Stove	0.02	0.08	0.19	0.62	0.06	0.15
	(2.74%)	(8.42%)	(2.95%)	(8.14%)	(3.11%)	(7.81%)
Charcoal Cooking Stove	0.18	0.44	1.68	3.96	0.44	0.89
	(10.59%)	(20.00%)	(10.01%)	(19.98%)	(9.89%)	(20.05%)
Fuelwood Cooking Stove	0.81	1.40	9.14	14.17	3.30	4.31
	(15.82%)	(21.05%)	(15.98%)	(20.99%)	(16.01%)	(20.99%)
Air Conditioning	0.01	0.01	0.03	0.08	-	-
	(9.09%)	(7.14%)	(3.85%)	(8.70%)		
Refrigerator	0.01	0.02	0.02	0.07	-	-
	(4.55%)	(7.14%)	(2.75%)	(7.95%)		
	1.06	2.08	11.41	19.98	3.88	5.57
	(10.22%)	(15.45%)	(10.89%)	(16.15%)	(11.65%)	(16.79%)

Myanmar is essentially an agrarian economy with two-thirds of the total population engaged in subsistence agriculture. The majority of the sample rural households depend on the agriculture activities for their livelihoods in these areas. The rural poor households have suffered from low access to various services (education, health and water supply, etc) and lack of assets such as land and livestock, which are strongly related to the rural poverty status. Non-commercial energy needs of rural households are much higher than the use urban households.

According to Table 5.11, potential energy saving targets could be promoted in these rural households. The percent share of electric appliances using is less in the rural area. They are mostly emphasized on the lighting and traditional cooking stoves for their daily life. So, in the lighting energy consumption, the energy efficient light bulbs and LED lamps should be used by supporting the information and production development rebates. In the traditional cooking stoves, it should to be promoted the clean and efficient cooking stoves in the EE program development.

To promote energy efficiency, energy labeling has been developed for household technology to promote information to consumers. It is also very important to promote behaviours in line with recent trends in lifestyles, e.g. time saving behaviours, latest fashion for energy efficient technology or a cosy indoor environment.

Some respondents do not turn off their television sets, but instead put them into stand-by mode. This is the example of behaviour in the area of entertainment and information that were not very energy efficient. New attitudes and lifestyles in combination with information about energy efficient behaviour have coincided to make a new behaviour a habit in everyday life.

Government should implement the EE programs in the household sector, such as use of energy efficient light bulbs and lamps, turning lights off when leaving a room, and lowering indoor temperatures at night by supporting information and production development rebates. The energy saving function appliances and energy labeling appliances should be used in the households by giving the entertainment and information.

On the other hand, the role of intermediate agencies is important in terms of financial, technical, social and organizational aspects in the achievement of the objective of providing increased comfort levels. For example energy service companies or entrepreneurs should be encouraged to provide quality energy service to the households. It is important to involve equipment manufacturers, financial institutions/development banks. Focus should be placed on bridging the gap between entrepreneurs and financiers, the need for capital at the local level and affordable financing.

5.13 Total Final Energy Consumption of the Household Sector in Myanmar under the BAU and EE scenarios

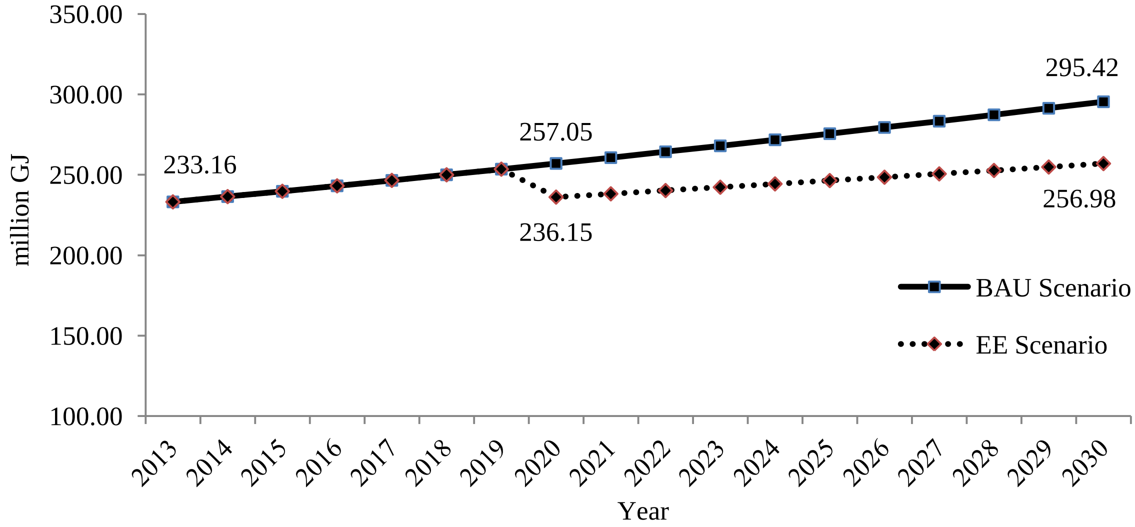
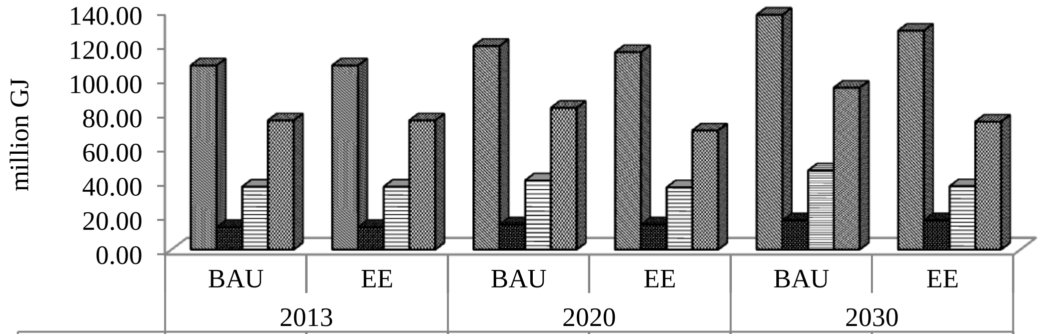


Figure 5.11 Annual total final energy consumption of the household sector in Myanmar under each scenario (2013-2030)

Figure 5.11 shows that the projection of annual total final energy consumption of the household sector in Myanmar was presented during the long term period 2013-2030 using the model. In 2013, the total final energy consumption was projected to be 233.16 million GJ. The energy savings were projected to be 20.90 million GJ or (8.13%) from 257.05 million GJ in the BAU scenario to 236.15 million GJ in the energy efficiency (EE) scenario in 2020. The total final energy consumption was projected to be 295.42 million GJ in BAU case to 256.98 million GJ in EE program in the year 2030. Finally, the results show that about 13.01% of the total final energy consumption can be saved from the BAU scenario to EE scenario. The growth rate of the total energy consumption of the household sector in Myanmar was calculated as about 15% from the year 2020 to 2030 in this study.

5.14 Total Final Energy Consumption by Fuel Type in the Household Sector in Myanmar under the BAU and EE scenarios



	2013 BAU	2013 EE	2020 BAU	2020 EE	2030 BAU	2030 EE
Electricity	107.73	107.73	119.10	115.50	137.39	128.07
LPG	13.13	13.13	14.64	14.64	17.13	17.13
Charcoal	36.75	36.75	40.40	36.36	46.21	36.97
FuelWood	75.55	75.55	82.91	69.65	94.69	74.81

Figure 5.12 Annual total final energy consumption by Fuel type in the household sector in Myanmar under each scenario

As shown in Figure 5.12, the annual total final energy consumption by fuel type in household sector in Myanmar was projected in this study. In 2020, the electricity consumption can be saved about 3.60 million GJ from BAU scenario to EE scenario. Charcoal consumption can be saved 4.04 million GJ and Fuelwood consumption can be saved 13.26 million GJ from BAU scenario to EE scenario in this year. In 2030, the electricity energy consumption was projected to be reduced 9.32 million GJ, Charcoal energy consumption can be saved 9.24 million GJ and Fuelwood consumption energy saving projected to be 19.88 million GJ from BAU case to EE programs in this study.

5.15 Comparison of Carbon dioxide emissions in the BAU and EE scenarios

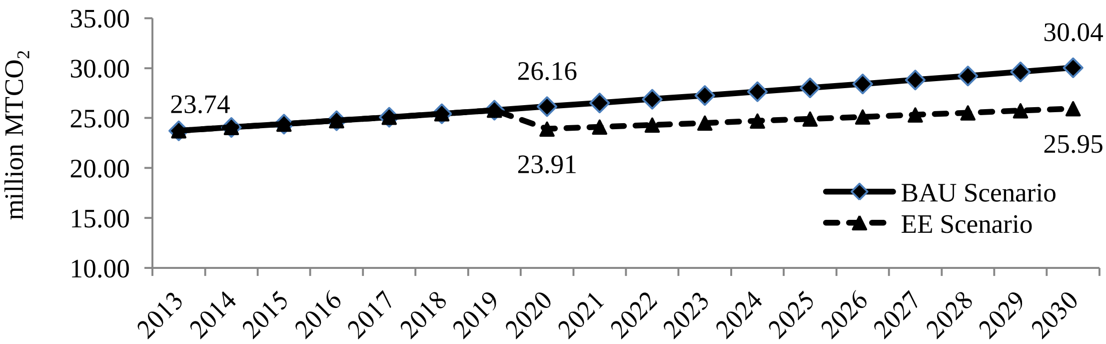


Figure 5.13 CO_2 emissions comparison of household sector energy consumption under each scenario

Figure 5.13 shows that the CO_2 emissions comparison of household sector energy consumption in Myanmar was projected to be about 23.74 million $MTCO_2$ to 30.04 million $MTCO_2$ under the BAU scenario from 2013 to 2030. This study started the EE program in 2020, so CO_2 emission was projected about 26.16 million $MTCO_2$ to 23.91 million $MTCO_2$ in BAU case to EE program in this year. The reduction of CO_2 emission was forecasted 2.25 million $MTCO_2$ or 8.60% of BAU case to EE program in 2020. In the end year 2030, the CO_2 emission projection amount was 30.04 million $MTCO_2$ to 25.95 million $MTCO_2$ in BAU scenario to EE scenario in this study. The decreasing amount was projected to be 4.09 million $MTCO_2$ or 13.61% of BAU case of CO_2 emission in 2030.

5.16 Comparison of Nitrous oxide emissions in the BAU and EE scenarios

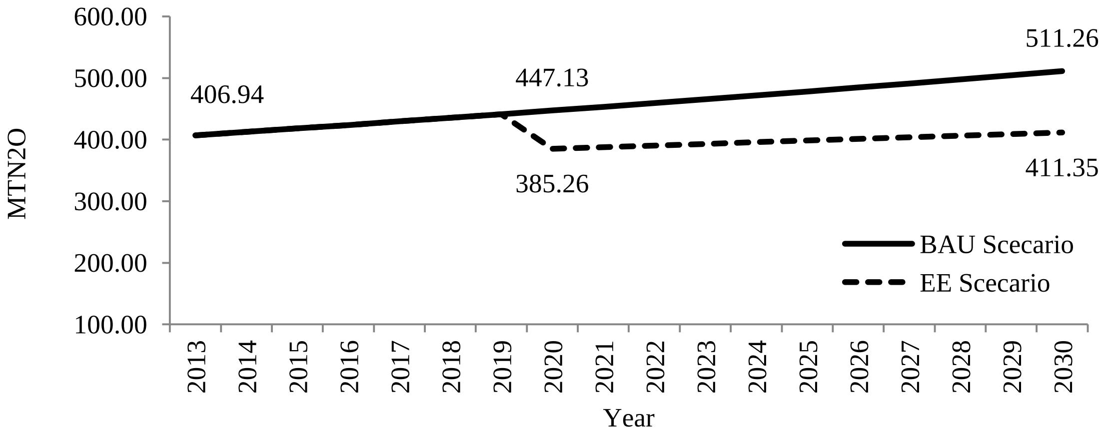


Figure 5.14 N_2O emissions comparison of household sector energy consumption under each scenario

Figure 5.14 presents the N_2O emissions comparison of household sector energy consumption in Myanmar under each scenario. In this result, the N_2O emissions of household sector energy consumption were projected to be about 406.94 MTN_2O to 511.26 MTN_2O emissions in the BAU scenario from 2013 to 2030. In the 2020, according to the EE program, the reduction of N_2O emission was projected about 61.87 MTN_2O or (13.84%) from 447.13 MTN_2O in BAU case to 385.26 MTN_2O in EE scenario. In 2030, the emission of N_2O of household energy consumption was projected to be 511.26 MTN_2O to 411.35 MTN_2O from BAU case to EE case in this study. The reduction amount was forecasted about 99.91 MTN_2O or 19.54% of BAU case in this year.

CHAPTER 6
CONCLUSION AND RECOMMENDATIONS

In this study, we focused on the energy consumption of the household sector for both urban and rural areas in Myanmar. The survey sites in urban areas were selected in Yangon, Mandalay and Nay Pyi Taw regions in Myanmar. On the other hand, we also selected the survey sites for the rural area in Yangon region. These major cities are electrified; therefore, they have access to modern electrical appliances. Moreover, the electricity consumption has risen according to income classes in urban areas. In rural areas, some areas are non-electrified and most of consumers are dependent on the traditional biomass and low-efficiency electric appliances.

Table 6.1 Annual total final energy consumption of household sector in Myanmar

	2013		2020		2030	
	BAU	EE	BAU	EE	BAU	EE
Urban Energy Consumption (million GJ)	98.39	98.39	108.60	104.05	125.08	114.27
Rural Energy Consumption (million GJ)	134.77	134.77	148.45	132.10	170.34	142.71
Total Energy Consumption (million GJ)	233.16	233.16	257.05	236.15	295.42	256.98

The energy consumption of the residential or household sector in Myanmar is mainly for lighting, space cooling and cooking. The sector uses both commercial fuels, such as electricity, and LPG in the urban areas, and non-commercial sources of charcoal and fuelwood in the rural areas. Meanwhile, the use of charcoal for cooking is widespread, even in urban areas.

As shown in Table 6.1, the projection of the final energy consumption has nearly increased 27% from 233.16 million GJ in 2013 to 295.42 million GJ in 2030 under the BAU scenario, with an average annual growth rate of 1.4% of energy consumption in the household sector. The results show that the rural area energy consumption is higher than urban areas by a factor of 1.4 in this study. According to these results, urban area households can be used modern electric appliances, on the other hand rural area mostly emphasized on traditional cooking stoves, such as charcoal and fuelwood, due to their living standards, so that their energy consumption is increasing in the household sector. In this study, EE program was assumed by 8% energy saving according to the government energy saving potential in household sector in 2020.

Table 6.2 Annual energy savings of household sector in Myanmar

	2020		2030	
Urban Energy Saving (million GJ)	4.55	4.19%	10.81	8.64%
Rural Energy Saving (million GJ)	16.35	11.01%	27.63	22.09%
Total Energy Saving (million GJ)	20.90	8.13%	38.44	13.01%

The government has significant responsibilities, including overall authority for energy efficiency and leadership on climate change through a dedicated department. Table 6.3 presents the CO_2 emissions of the final energy consumption of the household sector in Myanmar.

Table 6.3 CO_2 emissions of household sector energy consumption in Myanmar

	2030		2020		2030	
	BAU	EE	BAU	EE	BAU	EE
CO_2 emissions (million $MTCO_2$)	23.74	23.74	26.26	23.91	30.04	25.95

Estimated CO_2 emissions in the household sector in Myanmar were increased from 23.74 million $MTCO_2$ to 30.04 million $MTCO_2$ in the BAU case. It was found that Myanmar's government lacks energy information management, especially the household energy survey. So, Myanmar government should start to implement energy Efficiency and Conservation regarding to save energy through effective energy management and to reduce energy consumption particularly in the residential sector and micro-incentive for low-income households as to minimize harmful environmental impacts.

The utilization of new and renewable energy sources, especially solar and wind, which are abundant under Myanmar's climate condition, should be encouraged for the rural energy consumption. This result also accepts the fact that consumption of the traditional energy sources such as fuel-wood and charcoal still needs to be practiced. Regulatory and anticipatory actions are necessary for the sustained harvesting of this primary energy source.

On the other hand, fuel switching in the end-use sectors plays an important role in reducing CO_2 emissions. A program to promote the residential use of LPG stoves should be initiated on an experiment basis by the using of electricity and charcoal as the cooking fuel in the urban household areas. The energy promotion for rural village should emphasize in the energy consumption in household sector. Improved cook stoves more efficient than traditional one should be used by substituting the efficient fuel sticks and briquettes made from rice husks, sawdust and charcoal dust in the controlling fuel wood consumption in rural area.

There is a need for a detailed policy mechanism for the renewable energy sector to implement the potential programs and projects. Coordination mechanisms, institutional arrangements and legal frameworks need to be adopted and to enhance private participation to ensure reliable electricity supply in remote areas.

In conclusion, the energy efficiency policies have been successful in restricting the growth in energy consumption, particularly in the residential sector in Myanmar. The majority of official data for the household sector energy consumption should be improved by the cooperation of the government, the private sector and international organizations. In parallel with the creation of a comprehensive energy accounting scheme there is a substantial need to begin a series of carefully targeted energy surveys. The surveys of the household sector are thought to be useful, especially as a means of increasing the database from which energy projections could be confidently made to evaluate energy demand.

It is really important to emphasize rural area development and to improve modern energy sources, because this would develop energy consumption behaviors in the future. Better energy statistics and energy efficiency policy is highly required in order to provide information regarding household energy saving methods and to improve public awareness through effective education system and energy efficiency labelling program for energy service companies and appliances in household sector in Myanmar.

6.1 Further Recommendations for Future Studies

In this study, we were only concerned with the energy consumption of the household sector in Myanmar. Myanmar has started off on a strong footing, with emphasis on environmental and social aspects of investment. Pragmatic approach required when implementing environmental and social policies. Balance will need to be struck to ensure Myanmar's continued economic growth. Continued advocacy of such policies and appropriate regulatory action are required to ensure such emphasis is maintained.

The rural areas of Myanmar are facing big problems of access to electricity. The electrification program must be anchored by the technical least-cost expansion plan that includes grid and off-grid. The program needs a credible manager, with ability to allocate resources institutional reforms will be essential to the success of the electrification program. Thus, the implementation of DSM programs is the effective problem solving of the electric power sector improvement in these areas. This study is very interesting study in the next step. According to the implementation of the energy saving program in the household sector in Myanmar, the results presented more benefits for the future household energy consumption.

Future studies could look at (i) sector specific studies to access CO_2 emission reduction possibilities, and how they affect our consumption patterns, (ii) studies on household electricity consumption patterns in detail to find out whether the usage is optimal or indiscriminate (guided by the activity effect), (iii) use of non-conventional energy by households, and (iv) calculation of domestic emissions subject to the availability of competitive import transitions.

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APPENDICES

The Questionnaire for the Survey of Energy Consumption by the Household Sector in Myanmar

My name is Ms. Win Win Kyu, Master of Science Student in Energy Technology and Management, The Joint Graduate School of Energy and Management, King Mongkut's University. This questionnaire is part of the research that aims to understand the characteristics of energy consumption of the household sector in Myanmar.

Please be assured that all information you provide will be kept strictly confidential. The information is only for my M.Sc thesis. You and your household will not be identifiable in any outputs from this study. Do not hesitate to contact me if you have any questions or concerns about the questionnaire or any aspect of this study. Thank you very much for your participation.

Section (1) Information about the household

1.	Name	Region
2.	Age	□ 18-39 □ 40-59 □ 60 +
3.	How much salary per month earned in your household?	Kyat 114,885 - 234,713 234,714 - 354,543 354,543 <
4.	How many wage earners are in your household?	
5.	How many members are in your household?	
6.	How many are under 16 years of age?	
7.	Do you own or rent your property?	Own Rent No answer
8.	Do you use any commercial activities from your property?	□ Residential □ Commercial □ Other □ No answer
9.	Do you live in a house or an apartment?	□ House □ Apartment □ Other No answer
10.	How many rooms are there in your household?	

Section (2) Energy Baseline data

1.	Does your household have access to electricity?	□ Yes □ No
2.	How much did your household spend on grid electricity in the last month?	
3.	On average, how many hours a day is electricity available to you?	< 1 hour per day □ 1-6 □ 6-12 > 12 No answer

4. Lighting Consumption

Lighting technology	Capacity (Watt/Horse Power)	Number	Extent of use (hours/day)
Incandescent light bulbs	5		
	10		
	20		
	40		
	60		
	100		
Fluorescent lamps	20		
	40		
Compact fluorescent lamps	10		
	15		
	25		
	40		
Candles			
Batteries/ torches			
Lighting emitting diode lamps			
Others			

5. Air Conditioning

AC Brand, Model	Capacity (Watt/Horse Power)	Number	Extent of use (hours/day)

6. Appliances for Cooking

Cooking technology	Number	Consumption of fuel in a day	Extend of use (per month)
Charcoal Stove			
Wood Stove			
Kerosene Stove			
LPG Stove			

7. Entertainment and Education			
Electrical Appliances (Brand, Model)	Capacity (Watt/Horse Power)	Number	Extent of use (hours/day)
Refrigerator			
Box TV			
Flat TV			
Hand Phone			
Radio			
Video/DVD player			
Computer			
Laptop			
Electric Fan			
Rice Cooker			
Electric Pot			
Iron			
Electric Stove			
Heater			
Cooler			
Washing Machine			
Water Pump			
Hair Dryer			
Other Electric Appliances			

Results of urban household's electricity consumption survey in Myanmar (High-Income Class)

Respondent	Lighting Lamps	Cooking	Entertainment EL(kWh)		Space Cooling EL(kWh)			Other appliances	TOTAL
	EL(kWh)	EL(kWh)	TV	Computer	AC	Refrigerator	Electric Fan	EL(kWh)	EL(kWh)
1	141.00	60.75	45.50	12.00	268.00	302.40	30.00	82.50	942.15
2	81.60	66.75	36.60	3.00	223.50	151.20	15.00	47.40	625.05
3	78.84	66.75	45.00	3.60	167.60	302.40	15.00	47.40	726.59
4	59.40	59.25	55.00	0.00	210.00	151.20	18.00	39.41	592.26
5	85.80	59.25	35.00	2.55	120.00	151.20	12.00	47.40	513.20
6	117.00	21.90	19.80	7.65	201.00	453.60	9.00	33.21	863.16
7	118.50	62.25	36.30	10.20	223.50	126.00	6.00	58.88	641.63
8	78.96	76.65	23.40	10.20	335.25	151.20	3.00	69.98	748.64
9	73.92	28.35	47.70	15.60	223.50	86.40	3.00	36.23	514.70
10	67.20	45.75	37.50	5.10	268.20	75.60	3.00	22.93	525.28
11	78.00	54.00	42.60	5.10	167.63	72.00	0.00	55.93	475.26
12	118.56	60.75	35.10	10.20	67.05	151.20	4.50	69.90	517.26
13	138.00	68.25	30.75	15.60	402.85	302.40	15.00	82.50	1040.35
14	51.84	60.75	35.10	10.20	120.00	72.00	3.00	64.46	417.35
15	81.36	53.25	37.10	7.65	223.50	804.60	3.00	70.78	1281.24
16	83.40	74.25	24.90	5.10	223.50	151.20	15.00	69.90	669.75
17	77.10	72.00	38.10	12.50	111.75	151.20	3.00	78.60	544.25
18	108.00	64.50	35.20	15.00	210.00	536.40	4.50	33.49	1007.09
19	58.80	112.50	45.00	4.80	167.63	378.00	3.00	42.41	812.14
20	96.00	74.25	82.05	11.00	335.25	1166.40	6.00	100.73	1871.68
21	77.10	55.50	28.80	12.00	210.00	288.00	2.70	80.40	754.50
22	88.80	72.00	27.60	12.50	335.25	151.20	3.00	68.40	758.75
23	103.00	48.00	35.00	11.70	402.84	108.00	3.00	43.50	755.04
24	103.20	94.50	16.80	2.40	210.00	720.00	7.20	60.15	1214.25
25	139.20	90.75	18.00	10.20	223.50	302.40	21.00	100.50	905.55
26	73.20	67.50	45.00	5.10	335.25	151.20	6.00	68.40	751.65
27	84.60	54.75	55.00	7.20	210.00	54.00	9.00	51.00	525.55
28	85.20	75.00	10.50	5.10	167.63	151.20	6.00	57.23	557.86

29	94.20	54.75	45.00	7.20	111.75	576.00	9.00	94.20	992.10
30	192.60	90.00	25.00	5.10	312.90	151.20	84.00	50.52	911.32
31	132.60	95.00	10.20	4.50	193.50	72.00	45.00	45.41	598.21
32	73.20	75.00	45.00	0.00	210.00	360.00	60.00	88.58	911.78
33	110.10	95.00	36.00	9.60	486.00	151.20	54.00	40.91	982.81
34	116.10	96.95	45.50	3.90	388.00	60.00	57.60	57.23	825.28
35	22.50	50.25	37.00	4.50	134.00	50.40	36.00	38.96	373.61
36	66.60	146.00	63.00	14.00	111.75	151.20	19.20	47.33	619.08
37	70.80	106.50	35.00	15.00	335.70	30.00	7.20	52.91	653.11
38	62.40	54.75	16.50	12.50	201.42	72.00	22.50	41.06	483.13
39	88.80	87.00	35.00	4.50	402.84	151.20	45.00	22.03	836.37
40	84.60	100.50	45.00	15.60	111.75	60.00	30.00	54.43	501.88
41	236.25	93.00	36.60	4.50	537.00	360.00	30.00	22.03	1319.38
42	84.60	100.50	45.50	15.60	111.75	60.00	30.00	54.43	502.38
43	62.40	63.00	37.20	3.90	504.00	45.00	21.60	38.79	775.89
44	72.60	120.00	22.20	7.80	67.05	108.00	7.20	54.43	459.28
45	70.80	87.00	36.70	11.50	268.56	151.20	9.00	22.03	656.79
46	77.40	170.70	45.00	3.90	223.50	126.00	7.50	33.43	679.93
47	79.20	65.00	26.00	5.85	201.00	72.00	30.00	23.53	502.58
48	84.60	100.50	30.00	11.70	201.00	37.80	30.00	27.73	523.33
49	56.00	122.00	23.40	11.50	335.70	72.00	15.00	22.03	657.63
50	88.20	97.50	40.50	15.60	111.75	240.00	4.50	54.43	652.48
51	93.60	87.00	36.60	4.50	201.42	151.20	30.00	23.53	627.85
52	117.60	75.00	45.00	15.60	241.20	240.00	18.00	54.43	806.83
53	105.60	125.00	33.60	13.50	201.42	100.80	15.00	23.53	618.45
54	98.00	118.50	55.00	15.60	241.20	72.00	18.00	54.43	672.73
55	105.00	87.00	36.60	4.50	201.42	75.60	15.00	23.53	548.65
56	57.44	100.50	65.00	15.60	241.20	165.00	9.00	54.43	708.17
57	98.00	95.00	45.00	18.00	241.20	210.00	18.00	55.03	780.23
58	79.00	150.00	36.60	11.50	201.00	108.00	15.00	23.53	624.63
59	111.60	112.00	35.00	19.20	241.20	60.00	15.00	62.81	656.81
60	105.00	133.50	25.50	15.60	241.20	302.40	18.00	64.91	906.11

61	105.60	120.00	36.60	25.00	201.20	347.76	15.00	31.91	883.07
62	110.40	100.50	24.60	15.60	241.20	165.00	9.00	54.43	720.73
63	98.40	125.00	26.00	11.20	201.00	347.76	30.00	23.53	862.89
64	115.00	95.00	27.00	15.60	241.00	180.00	18.00	55.03	746.63
65	120.00	100.50	36.60	13.50	111.70	216.00	15.00	23.53	636.83
66	117.60	95.00	37.50	15.60	240.00	180.00	18.00	54.43	758.13
67	75.00	93.30	55.00	15.00	201.00	216.00	30.00	23.53	708.83
68	75.00	95.00	27.00	15.60	240.00	120.00	18.00	55.03	645.63
69	90.00	120.00	24.60	13.50	201.00	216.00	15.00	23.53	703.63
70	121.00	95.00	37.50	15.60	240.00	540.00	18.00	54.43	1121.53
71	102.00	75.00	40.00	15.60	120.00	216.00	18.00	55.03	641.63
72	80.00	75.00	45.00	12.00	201.00	216.00	27.00	23.53	679.53
73	79.00	95.00	36.80	15.60	241.00	120.00	18.00	54.43	659.83
74	90.00	90.00	42.00	15.00	201.00	252.00	30.00	23.53	743.53
75	78.00	85.00	35.00	12.00	201.00	252.00	18.00	55.03	736.03
76	110.73	97.00	55.00	10.00	210.00	216.00	15.00	23.53	737.26
77	97.00	77.00	45.00	11.00	201.00	348.50	18.00	54.43	851.93
78	110.00	95.00	40.00	12.50	120.00	120.00	18.00	54.43	569.93
79	75.00	75.50	37.50	12.00	201.00	216.00	18.00	58.73	772.73
80	80.00	75.00	45.00	11.30	175.00	540.00	18.00	57.25	1081.55
Total Electricity Consumption per Month	7474.70	6833.35	2973.30	838.30	18166.66	17329.82	1438.20	3969.51	59182.84
Electricity Consumption per Household	93.43	85.42	37.17	10.48	227.08	216.62	17.98	49.62	739.79
Annual Electricity Consumption per Household	1121.21	1025.00	446.00	125.75	2725.00	935.81	215.73	595.43	7189.93
% of Electricity Consumption	15.59	14.26	6.20	1.75	37.90	13.02	3.00	8.28	100.00

Remark: *0.36 (Rated power for Refrigerator)

Results of urban household's electricity consumption survey in Myanmar (Medium-Income Class)

Respondent	Lighting Lamps EL(kWh)	Cooking EL(kWh)	Entertainment EL(kWh)		Space Cooling EL(kWh)			Other appliances EL(kWh)	TOTAL EL(kWh)
			TV	Computer	AC	Refrigerator	Electric Fan		
1	120.00	66.75	25.20	-	-	259.20	10.50	52.51	535.16
2	75.60	69.75	34.20	4.50	-	151.20	15.00	87.40	439.65
3	65.10	45.75	8.40	-	-	151.20	-	24.72	298.17
4	51.60	69.00	13.50	-	-	151.20	1.50	26.33	317.13
5	65.10	47.25	13.80	-	-	151.20	1.20	30.98	314.53
6	45.60	51.75	16.50	12.75	89.40	151.20	-	30.98	404.18
7	75.60	47.25	25.20	6.00	111.75	151.20	1.50	36.23	461.73
8	124.80	51.00	16.20	-	223.50	151.20	-	28.81	603.51
9	76.00	47.25	19.80	-	111.75	72.00	1.50	33.83	371.13
10	65.10	60.75	25.50	-	-	72.00	3.00	58.73	295.08
11	50.40	52.50	19.80	-	111.75	72.00	1.50	26.33	345.28
12	125.00	69.75	13.20	-	-	151.20	-	41.33	412.48
13	110.00	51.00	26.40	5.10	111.75	151.20	1.50	58.73	528.68
14	118.00	51.00	26.40	7.65	223.50	151.20	3.00	58.73	653.48
15	50.85	66.75	23.55	5.10	123.75	72.00	3.00	43.73	403.73
16	45.84	74.25	23.40	10.20	111.75	151.20	-	41.33	473.97
17	56.40	60.75	19.95	5.10	82.50	151.20	9.00	33.83	435.73
18	65.10	75.75	24.60	1.50	75.00	342.00	3.00	34.81	639.76
19	124.00	39.75	17.40	3.00	82.50	342.00	1.50	24.23	653.38
20	56.40	60.75	34.30	5.10	150.00	151.20	1.50	33.83	513.08
21	120.00	79.50	15.60	-	99.00	295.00	2.25	28.73	661.08
22	68.40	57.75	16.50	-	111.00	151.20	3.00	34.73	464.58
23	69.60	81.00	11.55	-	-	342.00	21.00	18.83	566.98
24	65.10	91.50	30.60	-	111.00	144.00	15.00	26.33	507.53
25	102.00	84.00	11.55	3.00	-	-	72.00	41.33	338.88
26	75.60	75.00	12.15	12.00	88.80	240.00	15.00	53.68	598.23
27	188.40	102.00	32.10	3.00	288.75	313.50	90.00	47.06	1091.81
28	84.00	75.00	12.30	24.00	247.50	576.00	48.00	24.60	1119.40
29	118.00	117.00	14.40	12.00	148.50	342.00	3.00	62.06	845.96
30	81.60	51.00	26.40	-	-	72.00	15.00	47.06	323.06
31	91.20	51.00	15.90	3.90	115.50	342.00	15.00	24.56	690.06
32	68.40	45.00	6.90	-	-	342.00	15.00	24.56	533.86

33	87.00	96.00	8.70	-	66.00	36.00	9.60	32.06	368.36
34	67.80	66.00	22.50	4.80	292.88	216.00	19.20	30.56	753.74
35	69.60	106.50	19.80	12.00	-	285.00	30.00	62.06	619.96
36	63.60	77.25	12.30	15.00	-	66.00	30.00	32.06	332.21
37	91.20	79.50	15.90	-	402.84	36.00	14.70	26.48	703.62
38	81.60	126.00	15.90	6.00	-	50.40	24.00	50.09	391.99
39	60.00	57.75	25.20	5.10	123.75	108.00	162.00	39.56	620.36
40	76.80	71.25	10.50	19.50	280.50	36.00	180.00	47.10	761.65
41	60.00	84.00	33.00	15.60	-	151.20	27.00	24.56	436.36
42	76.80	75.00	10.50	-	115.50	54.00	36.00	38.68	448.48
43	81.60	135.00	24.00	-	105.00	144.00	90.00	56.09	678.69
44	67.20	106.50	12.00	-	30.00	72.00	27.00	18.98	377.68
45	60.00	77.25	9.75	-	167.85	72.00	36.00	23.68	491.53
46	132.60	93.00	15.00	5.85	132.00	144.00	36.00	47.06	651.51
47	63.00	126.00	21.00	19.50	54.00	50.40	30.00	36.56	447.46
48	74.83	71.25	25.20	-	167.85	72.00	36.00	35.68	530.81
49	57.60	51.00	15.90	3.90	115.50	342.00	15.00	25.56	675.46
50	76.80	45.00	6.90	-	115.50	342.00	30.00	36.56	702.76
51	76.80	96.00	15.90	6.00	82.50	60.00	14.40	38.06	440.66
52	67.80	66.00	13.50	10.20	95.12	151.20	7.20	30.56	493.58
53	51.60	99.00	19.80	12.00	60.00	285.00	9.00	18.98	608.38
54	66.60	94.50	12.30	3.00	75.00	66.00	30.00	39.56	440.96
55	81.60	126.00	15.90	12.00	-	50.40	24.00	56.09	420.99
56	60.00	45.00	25.20	5.85	123.75	108.00	21.00	39.56	484.36
57	67.80	111.00	10.50	19.50	144.38	151.20	180.00	47.06	788.44
58	60.00	91.50	33.00	15.60	-	151.20	27.00	33.56	469.86
59	76.80	115.50	10.50	-	66.00	54.00	36.00	38.68	456.48
60	102.00	93.00	12.20	-	150.00	151.20	36.00	36.59	640.99
61	67.20	73.50	12.00	3.00	30.00	474.00	15.00	18.96	754.66
62	60.00	94.50	32.10	-	132.00	144.00	36.00	28.18	588.78
63	120.00	55.50	15.00	5.85	132.00	151.20	28.80	36.56	607.91
64	67.80	102.00	21.00	19.50	54.00	50.40	30.00	36.56	445.26
65	65.40	91.50	10.50	-	60.00	360.00	15.00	38.48	705.88
66	84.00	73.50	13.95	5.85	115.50	285.00	14.40	38.69	696.89
67	74.83	66.00	21.00	-	82.50	144.00	18.00	18.98	492.31
68	65.40	73.50	12.10	-	54.00	342.00	18.00	35.68	668.68
69	95.00	66.00	14.40	-	126.00	342.00	24.00	18.98	755.38

70	112.00	73.50	30.60	9.00	60.00	213.75	15.00	32.33	616.18
71	95.00	48.00	10.50	3.00	82.50	213.75	24.00	24.60	572.35
72	75.00	45.00	14.40	12.00	60.00	342.00	30.00	53.68	704.08
73	73.30	73.50	32.10	15.00	156.75	342.00	24.00	44.06	833.71
74	84.00	75.00	12.20	24.00	247.50	576.00	24.00	24.60	1141.30
75	65.40	48.00	14.40	12.00	148.50	342.00	3.00	54.71	763.01
76	95.00	66.00	12.20	12.00	54.00	313.30	30.00	24.60	683.10
77	102.00	45.00	32.00	15.00	156.70	-	24.00	44.00	495.70
78	84.00	67.90	21.00	24.00	82.50	576.00	24.00	51.00	1008.40
79	65.00	45.00	16.00	15.60	94.00	342.00	3.55	24.00	684.15
80	122.00	70.00	32.50	12.30	-	344.00	24.00	35.00	719.80
Total Electricity Consumption per Month	6234.55	5766.65	1426.65	498.90	7713.32	15348.70	1988.80	2966.66	41944.23
Electricity Consumption per Household	77.93	72.08	17.83	6.24	96.42	191.86	24.86	37.08	524.30
Annual Electricity Consumption per Household	935.18	865.00	214.00	74.84	1157.00	828.83	298.32	445.00	4818.17
% of Electricity Consumption	19.41	17.95	4.45	1.55	24.01	17.20	6.19	9.24	100.00

Remark: *0.36 (Rated power for Refrigerator)

Results of urban household's electricity consumption survey in Myanmar (Low-Income Class)

Respondent	Lighting Lamps EL(kWh)	Cooking EL(kWh)	Entertainment EL(kWh)		Space Cooling EL(kWh)			Other appliances EL(kWh)	TOTAL EL(kWh)
			TV	Computer	AC	Refrigerator	Electric Fan		
1	57.60	35.30	12.80	5.40	-	-	24.00	61.00	196.10
2	84.00	90.00	9.00	2.60	-	-	54.00	83.60	323.20
3	95.50	70.50	14.30	5.40	-	-	24.00	24.10	233.80
4	57.60	90.00	9.00	5.40	111.80	151.20	18.00	37.60	480.60
5	75.60	74.30	26.40	5.10		151.20	30.00	37.60	400.20
6	84.00	51.80	12.80	-	223.50	151.20	16.80	39.00	579.10
7	57.60	59.30	9.00	-	-	-	24.00	38.40	188.30
8	55.20	89.30	16.40	-	-	151.20	18.00	24.10	354.20
9	112.00	74.30	9.00	-	-	-	30.00	38.40	263.70
10	57.60	51.80	16.40	-	-	151.20	36.00	52.50	365.50
11	75.60	74.30	8.10	7.20	178.80	151.20	24.00	45.50	564.70
12	62.10	54.80	14.30	-	-	-	36.00	26.70	193.90
13	57.60	90.80	9.00	-	-	-	30.00	18.70	206.10
14	93.60	107.30	12.80	4.50	111.80	151.20	24.00	26.30	531.50
15	97.50	47.30	14.30	21.60	66.00	151.20	18.00	41.40	457.30
16	57.60	39.80	9.00	3.60	178.80	151.20	36.00	21.20	497.20
17	95.50	87.80	13.50	7.20	-	25.20	18.00	45.50	292.70
18	75.60	15.00	12.80	-	-	-	15.00	24.10	142.50
19	57.60	17.30	9.00	-	-	-	24.00	26.40	134.30
20	120.00	53.30	14.40	-	45.00	129.60	18.00	15.20	395.50
21	63.60	83.60	12.80	10.20	-	151.20	24.00	37.60	383.00
22	65.70	17.30	17.10	10.20	-	151.20	36.00	26.50	324.00
23	92.10	17.30	17.10	10.20	-	75.60	12.00	45.50	269.80
24	75.90	17.30	36.50	10.20	-	75.60	24.00	45.10	284.60
25	47.70	17.30	18.80	-	-	151.20	36.00	24.10	295.10
26	51.30	9.80	17.60	-	-	126.00	36.00	45.50	286.20
27	65.70	89.30	28.80	-	-	113.40	30.00	26.50	353.70
28	120.00	27.00	9.00	-	-	-	36.00	14.40	206.40

29	58.50	95.30	21.00	10.20	-	151.20	30.00	26.40	392.60
30	79.20	17.30	9.00	-	-	75.60	36.00	45.50	262.60
31	43.20	81.80	21.00	-	-	-	30.00	18.90	194.90
32	62.10	13.50	14.70	-	-	72.00	24.00	23.40	209.70
33	67.20	17.30	15.00	-	45.00	72.00	24.00	41.40	281.90
34	63.60	13.50	13.40	-	-	72.00	36.00	26.30	224.80
35	40.80	81.80	20.90	10.20	-	72.00	30.00	26.40	282.10
36	75.90	17.30	14.30	-	-	72.00	30.00	26.30	235.80
37	51.60	45.00	21.50	-	-	-	15.00	37.40	170.50
38	51.30	9.80	14.60	-	-	-	37.50	21.10	134.30
39	67.20	9.80	24.90	-	-	-	37.50	15.10	154.50
40	95.00	15.00	21.50	-	-	-	30.00	30.10	191.60
41	46.80	57.80	18.30	12.00	-	-	15.00	26.40	176.30
42	65.70	45.80	0.00	-	-	-	15.00	15.10	141.60
43	58.50	45.80	30.00	2.40	-	111.00	12.00	37.50	297.20
44	40.80	45.80	16.40	-	-	111.00	36.00	15.20	265.20
45	58.50	40.50	20.70	-	45.00	-	30.00	18.10	212.80
46	43.20	69.00	31.10	-	-	-	36.00	37.50	216.80
47	67.20	81.80	16.40	-	-	-	12.00	5.30	182.70
48	39.60	45.80	24.90	-	-	-	30.00	7.60	147.90
49	75.90	42.00	21.50	-	-	-	24.00	37.60	201.00
50	32.40	45.60	22.40	-	45.00	-	18.00	51.20	214.60
51	95.00	35.30	12.80	-	-	-	24.00	61.00	228.10
52	75.50	118.50	24.80	2.60	-	129.60	10.50	83.60	445.10
53	30.60	70.50	32.30	-	-	-	24.00	24.10	181.50
54	57.60	90.00	30.00	5.40	111.80	151.20	36.00	37.60	519.60
55	65.70	47.30	26.40	5.10	-	151.20	12.00	37.60	345.30
56	84.00	90.00	38.40	-	223.50	151.20	16.80	39.00	642.90
57	57.60	59.30	20.40	-	-	-	15.00	5.30	157.60
58	55.20	89.30	30.80	-	-	151.20	36.00	15.30	377.80
59	29.40	74.30	19.50	-	-	-	30.00	38.40	191.60

60	27.60	51.80	16.40	-	-	151.20	18.00	52.50	317.50
61	75.60	90.00	8.10	7.20	178.80	151.20	36.00	15.30	562.20
62	39.60	54.80	14.30	-	-	-	24.00	26.70	159.40
63	20.40	90.80	9.00	-	-	-	30.00	18.70	168.90
64	93.60	90.00	36.00	4.50	88.80	151.20	24.00	26.30	514.40
65	51.60	47.30	42.00	21.60	45.00	151.20	18.00	41.40	418.10
66	38.40	39.80	9.00	3.60	178.80	151.20	15.00	21.20	457.00
67	14.70	87.80	13.50	7.20	-	25.20	18.00	4.70	171.10
68	28.80	15.00	17.00	-	-	-	15.00	14.60	90.40
69	18.30	17.30	49.20	-	-	-	30.00	26.40	141.20
70	62.10	53.30	14.40	-	45.00	129.60	18.00	15.20	337.60
71	63.60	83.60	39.20	10.20	-	151.20	24.00	37.60	409.40
72	65.70	17.30	17.10	10.20	-	151.20	12.00	26.50	300.00
73	92.10	17.30	17.10	10.20	-	75.60	24.00	26.50	262.80
74	75.90	17.30	36.50	10.20	-	75.60	24.00	45.10	284.60
75	47.70	17.30	18.80	-	-	151.20	12.00	19.00	266.00
76	51.30	9.80	17.60	-	-	126.00	36.00	15.20	255.90
77	25.20	89.30	15.00	-	-	113.40	30.00	26.30	299.20
78	40.80	27.00	15.00	-	-	-	15.00	14.40	112.20
79	58.50	95.30	21.50	10.20	-	151.20	30.00	18.90	385.60
80	79.20	17.30	46.20	-	-	75.60	24.00	37.50	279.80
81	43.20	81.80	21.00	-	-	126.00	15.00	18.90	305.90
82	34.20	13.50	14.70	-	-	72.00	24.00	23.40	181.80
83	31.80	17.30	15.00	-	45.00	72.00	36.00	41.40	258.50
84	25.50	13.50	13.40	-	-	72.00	15.00	26.30	165.70
85	40.80	81.80	20.90	10.20	-	72.00	24.00	26.40	276.10
86	34.80	17.30	14.30	-	-	72.00	24.00	26.30	188.70
87	95.50	45.00	21.50	-	-	-	36.00	37.40	235.40
88	97.50	9.80	14.60	-	-	-	37.50	21.10	180.50
89	67.20	9.80	24.90	-	-	-	37.50	15.10	154.50
90	47.70	15.00	21.50	-	-	-	30.00	30.10	144.30

91	46.80	57.80	18.30	12.00	-	-	18.00	10.20	163.10
92	62.10	45.80	0.00	-	-	-	30.00	15.10	153.00
93	75.90	45.80	30.00	2.40	-	111.00	37.50	37.50	340.10
94	65.70	45.80	16.40	-	-	111.00	24.00	15.20	278.10
95	97.50	40.50	20.70	-	45.00	-	24.00	18.10	245.80
96	75.90	69.00	15.00	-	-	-	36.00	37.50	233.40
97	62.10	81.80	16.40	-	-	-	45.00	15.20	220.50
98	39.60	45.80	24.90	-	-	-	15.00	14.60	139.90
99	75.90	42.00	9.00	-	-	-	7.50	26.40	160.80
100	95.60	45.60	22.40	-	45.00	-	18.00	15.20	241.80
101	95.50	39.80	9.00	3.60	178.80	151.20	15.00	37.60	530.50
102	65.00	87.80	13.50	7.20	-	72.00	18.00	26.50	290.00
103	28.80	15.00	17.00	-	-	-	15.00	26.50	102.30
104	112.00	17.30	13.50	-	-	-	30.00	45.10	217.90
105	62.10	53.30	14.40	-	45.00	129.60	18.00	19.00	341.40
106	63.60	83.60	9.00	10.20	-	151.20	24.00	15.20	356.80
107	65.70	17.30	9.00	10.20	-	151.20	24.00	26.30	303.70
108	92.10	17.30	14.70	10.20	-	75.60	12.00	14.40	236.30
109	95.50	17.30	18.80	10.20	-	75.60	24.00	18.90	260.30
110	95.50	17.30	18.80	-	-	151.20	45.00	45.10	372.90
111	67.20	9.80	17.60	-	-	126.00	36.00	18.90	275.50
112	112.50	89.30	18.80	-	-	113.40	30.00	23.40	387.40
113	67.20	27.00	9.00	-	-	-	36.00	41.40	180.60
114	85.50	95.30	18.80	10.20	-	151.20	30.00	26.30	417.30
115	79.20	17.30	9.00	-	-	75.60	12.00	26.40	219.50
116	120.00	81.80	21.00	-	-	-	24.00	45.10	291.90
117	95.50	13.50	14.70	-	-	126.00	18.00	37.40	305.10
118	105.00	17.30	9.00	-	44.47	72.00	24.00	21.10	292.87
119	95.50	13.50	13.40	-	-	113.40	30.00	15.10	280.90
120	75.50	81.80	9.00	10.20	-	75.60	24.00	30.10	306.20
121	112.00	17.30	14.30	-	-	75.60	37.50	54.00	310.70

122	110.00	45.00	13.50	-	-	75.60	36.00	45.10	325.20
123	112.00	9.80	14.60	-	-	-	37.50	37.50	211.40
124	67.20	9.80	9.00	-	-	-	37.50	26.30	149.80
125	75.50	15.00	14.30	-	-	-	30.00	18.10	152.90
126	110.00	57.80	14.60	10.20	-	-	36.00	45.10	273.70
127	95.50	45.80	14.60	-	-	-	36.00	26.50	218.40
128	67.20	45.80	18.30	2.40	-	126.00	42.00	26.50	328.20
129	115.50	45.80	9.00	-	-	111.00	24.00	26.40	331.70
130	67.20	40.50	14.30	-	44.47	-	24.00	45.10	235.57
131	125.00	69.00	14.30	-	-	-	24.00	37.60	269.90
132	85.50	81.80	13.50	-	-	-	36.00	26.50	243.30
133	97.50	45.60	9.00	-	-	-	24.00	26.50	202.60
134	115.00	40.50	14.30	-	-	-	36.00	37.50	243.30
135	96.50	45.60	13.50	-	66.00	-	45.00	26.50	293.10
136	120.00	39.80	9.00	3.60	132.00	126.00	36.00	54.00	520.40
137	67.20	87.80	14.30	7.20	82.50	113.00	45.00	45.10	462.10
138	112.00	45.60	14.40	-	-	75.60	30.00	37.50	315.10
139	95.00	42.00	14.30	-	-	-	36.00	26.50	213.80
140	112.00	42.00	13.50	-	-	129.60	42.00	45.10	384.20
Total Electricity Consumption per Month	9868.90	6704.00	2431.30	371.80	2650.64	9236.00	3738.60	4198.80	39200.04
Electricity Consumption per Household	70.49	47.89	17.37	2.66	18.93	65.97	26.70	29.99	280.00
Annual Electricity Consumption per Household	845.90	574.70	208.40	31.90	**227.20**	285.00	320.40	359.90	2853.40
% of Electricity Consumption	29.65	20.14	7.30	1.12	7.96	9.99	11.23	12.61	100.00

Remark: *0.36 (Rated power for Refrigerator)

Results of rural household's electricity consumption survey in Myanmar (High-Income Class)

Respondent	Lighting Lamps EL(kWh)	Cooking EL(kWh)	Entertainment EL(kWh)		Space Cooling EL(kWh)			Other appliances EL(kWh)	TOTAL EL(kWh)
			TV	Computer	**AC**	Refrigerator	Electric Fan		
1	42.60	36.00	19.50	-	-	-	12.60	26.33	139.53
2	37.20	51.00	21.15	-	-	-	15.75	25.53	154.13
3	75.00	-	7.80	-	-	-	6.75	31.91	220.76
4	36.60	43.50	11.40	-	-	-	12.60	23.53	131.63
5	41.40	51.00	10.65	-	-	-	15.00	25.53	151.13
6	75.50	-	10.65	-	-	-	18.00	32.21	144.91
7	42.60	43.50	9.90	-	-	-	15.00	25.53	210.58
8	75.00	42.00	13.20	-	-	170.10	6.00	37.58	278.83
9	44.16	36.00	12.00	-	-	-	18.00	33.83	152.99
10	42.60	43.50	14.25	-	-	-	6.00	31.91	226.41
11	75.00	36.00	11.40	10.20	-	211.50	9.00	25.53	240.53
12	44.16	-	8.70	10.50	-	-	-	27.50	101.96
13	75.00	43.50	14.25	11.40	-	-	6.00	30.15	184.45
14	57.60	36.00	14.70	-	-	252.00	6.00	25.53	228.38
15	55.80	36.00	9.15	15.30	-	-	4.50	31.91	160.01
16	44.16	43.50	11.70	-	-	-	6.00	30.15	226.06
17	42.00	51.00	12.00	-	-	151.20	12.00	25.53	310.73
18	46.80	43.50	12.00	-	142.05	240.00	-	19.91	459.71
19	57.60	43.50	12.00	-	-	-	-	31.91	169.41
20	75.00	59.25	25.65	-	-	-	12.00	19.91	213.31
21	55.80	48.00	15.60	-	-	240.00	10.50	37.50	422.4
22	60.00	47.25	15.60	-	-	151.20	15.00	31.91	348.06
23	44.25	47.00	17.10	-	-	-	12.00	43.50	294.85
24	97.50	40.50	15.60	10.50	156.00	-	13.50	37.50	299.1
25	44.40	36.00	8.40	-	-	126.00	15.00	37.50	378.4
26	97.50	42.00	9.75	17.40	-	151.20	12.00	45.90	389.45
27	48.60	36.00	10.20	-	-	-	-	19.91	199.91
28	75.50	43.50	9.75	10.20	-	-	15.00	43.50	220.35
29	42.75	47.25	7.35	-	-	-	15.00	43.50	190.25
30	42.00	43.50	6.00	-	-	126.00	30.00	26.33	383.93

31	46.20	51.00	9.30	-	-	-	30.00	37.01	278.76
32	43.80	-	7.50	-	-	240.00	15.00	31.91	445.21
33	75.50	36.00	10.50	-	156.00	-	15.00	43.91	358.29
34	65.50	-	7.50	9.00	150.00	-	24.00	43.50	314
35	46.20	51.00	11.10	-	-	-	22.50	38.96	259.66
36	75.50	-	10.50	9.00	-	-	16.80	36.00	251.6
37	46.50	43.50	10.20	-	-	-	-	37.01	215.31
38	75.00	36.00	16.50	7.80	150.00	296.40	22.50	32.06	370.96
39	55.80	-	10.20	-	-	-	30.00	37.03	174.28
40	75.00	43.50	7.50	8.70	134.10	266.40	22.50	32.06	361.56
41	46.50	51.00	7.50	-	-	-	21.60	32.06	273.91
42	75.50	43.50	13.50	7.80	-	-	22.50	29.53	280.83
43	85.50	44.50	16.50	-	-	220.80	21.60	36.00	299.75
44	65.50	43.50	7.20	-	-	-	6.00	37.01	274.16
45	60.00	36.00	10.20	-	-	-	15.00	36.00	204.45
46	55.80	-	9.00	-	-	-	6.00	34.31	228.36
47	65.00	43.50	10.50	-	-	-	9.60	38.53	288.38
48	73.20	-	7.50	9.00	156.00	-	-	34.31	302.66
49	60.00	36.00	11.40	9.38	-	-	15.00	37.01	282.66
50	72.00	-	34.50	-	-	-	12.00	34.31	198.31
Total Electricity Consumption per Month	2958.08	1728.75	606.00	146.18	1044.15	2842.80	646.80	1647.49	11620.25
Electricity Consumption per Household	59.16	34.58	12.12	2.92	20.88	56.86	12.94	32.95	145.25
Annual Electricity Consumption per Household	710.00	415.00	145.44	35.00	250.00	**245.00**	155.00	395.00	2350.44
% of Electricity Consumption	30.21	17.66	6.19	1.49	10.64	10.42	6.59	16.80	100.00

Remark: *0.36 (Rated power for Refrigerator)

Results of rural household's electricity consumption survey in Myanmar (Medium-Income Class)

Respondent	Lighting Lamps	Cooking	Entertainment EL(kWh)		Space Cooling EL(kWh)			Other appliances	TOTAL
	EL(kWh)	EL(kWh)	TV	Computer	**AC**	Refrigerator	Electric Fan	EL(kWh)	EL(kWh)
1	31.65	30.00	10.20	-	-	-	15.00	20.74	109.09
2	31.20	21.00	9.00	-	-	-	11.25	26.33	213.68
3	42.00	-	7.80	-	-	207.90	6.75	31.91	184.76
4	45.00	-	9.00	-	-	-	6.30	20.74	81.04
5	38.40	51.00	8.25	-	-	-	15.00	26.33	138.98
6	26.85	-	14.25	-	-	-	18.00	31.91	93.26
7	33.60	-	8.25	-	-	-	-	20.74	70.09
8	42.00	30.00	10.65	-	-	-	13.50	26.33	117.53
9	48.60	-	8.25	-	-	-	18.00	33.83	108.68
10	31.20	30.00	9.75	-	-	-	-	31.91	187.01
11	42.00	-	9.00	10.20	-	135.60	10.80	0.00	126.90
12	38.40	-	8.70	5.10	-	-	5.25	20.74	78.19
13	48.60	-	9.00	7.65	-	-	12.00	30.15	96.30
14	42.00	30.00	10.20	-	-	-	11.25	0.00	96.00
15	48.60	21.00	11.25	-	-	-	2.10	31.91	117.41
16	48.60	66.00	9.00	-	111.75	151.20	37.50	20.74	444.79
17	42.00	15.00	7.50	-	-	-	-	0.00	73.50
18	46.80	43.50	9.00	-	-	-	16.50	19.91	123.71
19	44.40	42.00	10.50	-	-	240.00	-	31.91	374.21
20	46.80	-	9.00	10.95	-	151.20	12.00	20.74	241.24
21	31.50	-	15.60	-	-	240.00	4.50	37.50	329.10
22	42.00	47.25	9.00	-	-	151.20	15.00	37.50	304.50
23	32.25	47.25	10.20	-	83.81	-	12.00	0.00	185.51
24	44.40	-	-	5.55	-	-	6.00	37.50	90.90
25	46.80	-	8.40	10.20	111.75	-	15.00	37.50	224.55
26	44.40	30.00	6.75	-	-	-	12.00	45.90	144.15
27	41.40	72.00	9.00	-	-	-	15.00	0.00	137.40
28	33.60	-	9.75	5.10	-	-	15.00	37.50	166.95

29	46.80	47.25	10.20	-	-	-	15.00	20.74	139.99
30	36.00	72.00	6.00	-	-	126.00	9.00	26.33	280.43
31	42.00	51.00	9.30	-	-	-	15.00	37.91	155.21
32	48.80	30.00	8.40	-	-	-	18.00	31.91	128.11
33	44.40	30.00	8.40	-	-	-	-	43.91	135.71
34	46.80	30.00	8.25	-	-	186.24	9.00	37.50	191.55
35	42.00	42.00	7.05	9.60	-		5.25	37.91	198.71
36	46.80	39.00	8.25	-	-	-	7.20	30.00	131.25
37	42.00	21.00	9.00	-	-	-	7.20	20.74	103.84
38	64.50	39.00	7.95	-	149.81	216.00	8.10	0.00	419.36
39	46.80	30.00	7.35	-	-	-	9.00	20.74	181.03
40	42.00	-	6.00	-	134.28	162.00	8.10	32.06	317.30
41	64.00	36.00	7.20	7.80	-	-	9.00	0.00	120.10
42	67.00	30.00	6.00	6.90	-	-	12.96	23.53	143.39
43	42.00	30.00	8.20	-	-	-	14.70	20.74	111.44
44	29.40	22.50	7.40	-	-	-	-	31.91	98.41
45	42.00	22.50	8.25	-	-	-	16.50	0.00	146.49
46	36.60	30.00	8.25	-	-	-	-	31.91	117.71
47	64.00	-	8.60	7.80	-	-	11.25	31.91	119.66
48	42.00	-	7.20	-	-	-	-	24.41	83.06
49	48.60	22.50	-	-	-	-	16.50	20.74	100.84
50	64.00	28.50	7.20	-	-	-	11.25	24.41	135.36
Total Electricity Consumption per Month	2183.55	1229.25	421.70	86.85	591.40	1967.34	508.71	1229.58	8218.38
Electricity Consumption per Household	43.67	24.59	8.43	1.74	11.83	39.35	10.17	24.59	164.37
Annual Electricity Consumption per Household	524.00	295.00	101.21	21.00	142.00	**170.00**	122.00	295.00	1670.21
% of Electricity Consumption	31.37	17.66	6.06	1.26	8.50	10.18	7.31	17.66	100.00

Remark: *0.36 (Rated power for Refrigerator)

Results of rural household's electricity consumption survey in Myanmar (Low-Income Class)

Respondent	Lighting Lamps EL(kWh)	Cooking EL(kWh)	Entertainment EL(kWh)		Space Cooling EL(kWh)			Other appliances EL(kWh)	TOTAL EL(kWh)
			TV	Computer	AC	Refrigerator	Electric Fan		
1	20.70	22.50	4.95	-	-	-	12.75	20.68	81.58
2	24.00	42.00	4.95	-	-	-	12.75	15.15	98.85
3	24.60	-	7.80	-	-	-	9.00	7.58	48.98
4	24.60	-	5.10	-	-	-	9.00	15.15	53.85
5	20.70	-	-	-	-	-	-	11.33	38.78
6	48.00	-	-	-	-	-	15.75	15.08	72.08
7	24.00	-	-	-	-	-	7.50	15.08	46.58
8	24.60	-	-	-	-	-	7.50	13.17	45.27
9	19.80	-	-	-	-	-	9.00	5.59	34.39
10	24.60	-	-	-	-	-	9.00	15.08	48.68
11	25.20	-	4.95	-	-	-	15.00	13.17	58.32
12	19.20	-	8.55	-	-	-	14.40	30.17	72.32
13	21.30	-	8.55	-	-	-	15.00	15.08	59.93
14	26.40	-	8.10	-	-	-	12.00	15.08	61.58
15	21.30	-	9.45	-	-	-	12.75	37.55	81.05
16	17.70	-	8.25	-	-	-	12.00	18.72	56.67
17	48.00	-	6.87	-	-	-	9.00	15.08	78.95
18	48.00	-	9.00	-	-	-	6.75	30.17	93.92
19	48.00	-	6.00	-	-	-	15.00	37.43	106.43
20	25.20	-	6.15	-	-	-	12.60	4.58	48.53
21	19.95	-	7.95	-	-	-	-	4.58	32.48
22	26.40	-	11.85	-	-	-	9.00	26.33	73.58
23	16.05	-	9.00	-	-	-	9.00	26.33	60.38
24	48.00	42.00	10.20	-	-	-	12.00	15.15	127.35
25	15.60	45.00	9.00	-	-	-	-	20.89	97.99
26	26.40	51.00	9.00	-	-	-	16.50	20.67	116.07
27	12.15	22.50	8.55	-	-	-	15.00	13.24	71.44
28	17.55	42.00	9.00	-	-	-	12.00	20.89	101.44

29	10.20	42.00	11.85	-	-	-	15.00	20.89	99.94
30	16.20	-	9.75	-	-	-	-	7.65	39.00
31	18.75	-	5.40	-	-	-	9.00	25.50	58.65
32	22.95	42.00	11.25	-	-	-	12.90	13.24	96.94
33	26.40	42.00	9.75	-	-	-	9.00	13.24	100.39
34	24.60	51.00	11.10	-	-	-	9.00	13.24	105.94
35	21.15	-	9.60	-	-	-	9.00	20.67	60.42
36	30.15	42.00	6.00	-	-	-	-	41.33	122.48
37	12.75	75.00	6.30	-	-	-	9.00	25.50	128.55
38	26.55	60.00	11.10	-	-	-	9.00	20.74	127.39
39	42.15	-	5.25	-	-	-	9.00	15.08	71.48
40	27.15	51.00	8.70	-	-	-	-	20.67	115.02
41	24.75	-	6.60	-	-	-	13.50	20.67	58.02
42	33.15	-	6.00	-	-	-	12.00	15.08	66.23
43	30.00	22.50	8.70	-	-	-	14.40	20.67	87.87
44	24.90	30.00	9.75	-	-	-	-	15.76	88.81
45	30.00	45.00	5.25	-	-	-	15.00	20.67	108.42
46	22.95	45.00	5.25	-	-	-	12.00	15.08	100.28
47	48.00	22.50	8.85	-	-	-	8.19	20.67	103.17
48	24.75	42.00	8.70	-	-	-	11.25	15.76	102.46
49	30.00	37.00	7.35	-	-	-	-	20.67	100.06
50	48.00	22.50	8.70	-	-	-	-	15.08	101.78
Total Electricity Consumption per Month	1333.50	938.50	354.42	- -	-	-	467.49	916.86	4010.77
Electricity Consumption per Household	26.67	18.77	7.09	- -	-	-	9.35	18.34	80.22
Annual Electricity Consumption per Household	320.00	225.00	85.00	- -	-	-	112.00	220.00	962.00
% of Electricity Consumption	33.26	23.39	8.84	-	-	-	11.64	22.87	100.00

Remark: *0.36 (Rated power for Refrigerator)

Estimation of Potential Energy Savings from Energy Efficiency Improvements (EE) of High-Income Level in Urban Households

	2020				2030			
	BAU Scenario	Assumption of EE Improvement	EE Scenario	Potential Energy Savings	BAU Scenario	Assumption of EE Improvement	EE Scenario	Potential Energy Savings
	(million GJ)	(%)	(million GJ)	(million GJ)	(million GJ)	(%)	(million GJ)	(million GJ)
Lighting Lamps	1.93	4.15%	1.85	0.08	2.47	8.91%	2.25	0.22
Cooking								
Rice Cooking Stove	1.76	4.55%	1.68	0.08	2.25	9.78%	2.03	0.22
LPG Cooking Stove	4.25	-	4.25	-	5.43	-	5.43	-
Charcoal Cooking Stove	1.36	9.56%	1.23	0.13	1.74	20.11%	1.39	0.35
Entertainment								
TV	0.77	3.90%	0.74	0.03	0.98	8.16%	0.90	0.08
Computer	0.22	-	0.22	-	0.28	-	0.28	-
Space Cooling								
Air Conditioning	4.69	5.12%	4.45	0.24	5.99	10.02%	5.39	0.60
Refrigerator	1.61	3.73%	1.55	0.06	2.06	9.22%	1.87	0.19
Electric Fan	0.37	-	0.37	-	0.47	-	0.47	-
Other Appliances	1.03	-	1.03	-	1.31	-	1.31	-
	17.99	3.45%	17.37	0.62	22.98	7.22%	21.32	1.66

Estimation of Potential Energy Savings from Energy Efficiency Improvements (EE) of Medium-Income Level in Urban Households

	2020				2030			
	BAU Scenario	Assumption of EE Improvement	EE Scenario	Potential Energy Savings	BAU Scenario	Assumption of EE Improvement	EE Scenario	Potential Energy Savings
	(million GJ)	(%)	(million GJ)	(million GJ)	(million GJ)	(%)	(million GJ)	(million GJ)
Lighting Lamps	11.09	3.97%	10.65	0.44	12.67	9.08%	11.52	1.15
Cooking								
Rice Cooking Stove	10.26	5.07%	9.74	0.52	11.72	9.98%	10.55	1.17
LPG Cooking Stove	9.15	-	9.15	-	10.45	-	10.45	-
Charcoal Cooking Stove	13.19	10.01%	11.87	1.32	15.06	19.99%	12.05	3.01
Entertainment								
TV	2.54	2.76%	2.47	0.07	2.90	6.90%	2.70	0.20
Computer	0.89	-	0.89	-	1.01	-	1.01	-
Space Cooling								
Air Conditioning	13.72	5.03%	13.03	0.69	15.67	9.96%	14.11	1.56
Refrigerator	9.83	3.97%	9.44	0.39	11.23	8.99%	10.22	1.01
Electric Fan	3.54	-	3.54	-	4.04	-	4.04	-
Other Appliances	5.70	-	5.70	-	6.51	-	6.51	-
	79.91	4.29%	76.48	3.43	91.26	8.88%	83.16	8.10

Estimation of Potential Energy Savings from Energy Efficiency Improvements (EE) of Low-Income Level in Urban Households

	2020				2030			
	BAU Scenario	Assumption of EE Improvement	EE Scenario	Potential Energy Savings	BAU Scenario	Assumption of EE Improvement	EE Scenario	Potential Energy Savings
	(million GJ)	(%)	(million GJ)	(million GJ)	(million GJ)	(%)	(million GJ)	(million GJ)
Lighting Lamps	1.94	3.61%	1.87	0.07	1.97	9.14%	1.79	0.18
<u>Cooking</u>								
Rice Cooking Stove	1.32	5.30%	1.25	0.07	1.34	10.45%	1.20	0.14
LPG Cooking Stove	1.24	-	1.24	-	1.26	-	1.26	-
Charcoal Cooking Stove	2.91	10.31%	2.61	0.30	2.94	20.07%	2.35	0.59
<u>Entertainment</u>								
TV	0.48	2.08%	0.47	0.01	0.48	6.25%	0.45	0.03
Computer	0.07	-	0.07	-	0.07	-	0.07	-
<u>Space Cooling</u>								
Air Conditioning	0.52	5.77%	0.49	0.03	0.53	9.43%	0.48	0.05
Refrigerator	0.65	3.08%	0.63	0.02	0.66	9.09%	0.60	0.06
Electric Fan	0.74	-	0.74	-	0.75	-	0.75	-
Other Appliances	0.83	-	0.83	-	0.84	-	0.84	-
	10.70	4.67%	10.20	0.50	10.84	9.69%	9.79	1.05

Estimation of Potential Energy Savings from Energy Efficiency Improvements (EE) of High-Income Level in Rural Households

	2020				2030			
	BAU Scenario	Assumption of EE Improvement	EE Scenario	Potential Energy Savings	BAU Scenario	Assumption of EE Improvement	EE Scenario	Potential Energy Savings
	(million GJ)	(%)	(million GJ)	(million GJ)	(million GJ)	(%)	(million GJ)	(million GJ)
Lighting Lamps	1.25	2.40%	1.22	0.03	1.63	7.98%	1.50	0.13
Cooking								
Rice Cooking Stove	0.73	2.74%	0.71	0.02	0.95	8.42%	0.87	0.08
Charcoal Cooking Stove	1.70	10.59%	1.52	0.18	2.20	20.00%	1.76	0.44
Fuelwood Cooking Stove	5.12	15.82%	4.31	0.81	6.65	21.05%	5.25	1.40
Entertainment								
TV	0.26	-	0.26	-	0.33	-	0.33	-
Computer	0.01	-	0.01	-	0.02	-	0.02	-
Space Cooling								
Air Conditioning	0.11	9.09%	0.10	0.01	0.14	7.14%	0.13	0.01
Refrigerator	0.22	4.55%	0.21	0.01	0.28	7.14%	0.26	0.02
Electric Fan	0.27	-	0.27	-	0.36	-	0.36	-
Other Appliances	0.70	-	0.70	-	0.90	-	0.90	-
	10.37	10.22%	9.31	1.06	13.46	15.45%	11.38	2.08

Estimation of Potential Energy Savings from Energy Efficiency Improvements (EE) of Medium-Income Level in Rural Households

	2020				2030			
	BAU Scenario	Assumption of EE Improvement	EE Scenario	Potential Energy Savings	BAU Scenario	Assumption of EE Improvement	EE Scenario	Potential Energy Savings
	(million GJ)	(%)	(million GJ)	(million GJ)	(million GJ)	(%)	(million GJ)	(million GJ)
Lighting Lamps	11.46	2.97%	11.12	0.34	13.52	7.99%	12.44	1.08
Cooking								
Rice Cooking Stove	6.45	3.10%	6.25	0.20	7.62	8.14%	7.00	0.62
Charcoal Cooking Stove	16.79	10.01%	15.11	1.68	19.82	19.98%	15.86	3.96
Fuelwood Cooking Stove	57.19	16.00%	48.04	9.15	67.51	20.99%	53.34	14.17
Entertainment								
TV	2.21	-	2.21	-	2.61	-	2.61	-
Computer	0.05	-	0.05	-	0.05	-	0.05	-
Space Cooling								
Air Conditioning	0.77	2.60%	0.75	0.02	0.92	8.70%	0.84	0.08
Refrigerator	0.74	2.70%	0.72	0.02	0.88	7.95%	0.81	0.07
Electric Fan	2.67	-	2.67	-	3.15	-	3.15	-
Other Appliances	6.45	-	6.45	-	7.62	-	7.62	-
	104.78	10.89%	93.37	11.41	123.70	16.15%	103.72	19.98

Estimation of Potential Energy Savings from Energy Efficiency Improvements (EE) of Low-Income Level in Rural Households

	2020				2030			
	BAU Scenario	Assumption of EE Improvement	EE Scenario	Potential Energy Savings	BAU Scenario	Assumption of EE Improvement	EE Scenario	Potential Energy Savings
	(million GJ)	(%)	(million GJ)	(million GJ)	(million GJ)	(%)	(million GJ)	(million GJ)
Lighting Lamps	2.74	2.92%	2.66	0.08	2.73	8.06%	2.51	0.22
Cooking								
Rice Cooking Stove	1.93	3.11%	1.87	0.06	1.92	7.81%	1.77	0.15
Charcoal Cooking Stove	4.45	9.89%	4.01	0.44	4.44	20.05%	3.55	0.89
Fuelwood Cooking Stove	20.61	16.01%	17.31	3.30	20.53	20.99%	16.22	4.31
Entertainment								
TV	0.73	-	0.73	-	0.73	-	0.73	-
Computer	-	-	-	-	-	-	-	-
Space Cooling								
Air Conditioning	-	-	-	-	-	-	-	-
Refrigerator	-	-	-	-	-	-	-	-
Electric Fan	0.96	-	0.96	-	0.95	-	0.95	-
Other Appliances	1.88	-	1.88	-	1.88	-	1.88	-
	33.30	11.65%	29.42	3.88	33.18	16.79%	27.61	5.57