International Journal of Energy Economics and Policy
Vol. 5, No. 1, 2015, pp.360-373
ISSN: 2146-4553
www.econjournals.com

Urban Energy Consumption in a City of Indonesia: General Overview

Iwan Sukarno
Department of Architecture and Civil Engineering,
Toyohashi University of Technology, Japan.
Email: iwan_sukarno81@yahoo.com

Hiroshi Matsumoto
Department of Architecture and Civil Engineering,
Toyohashi University of Technology, Japan.
Email: matsu@ace.tut.ac.jp

Lusi Susanti
Industrial Engineering Department,
Andalas University, Padang, Indonesia.
Email: susantilusi@gmail.com

Ryushi Kimura
Department of Environmental Civil Engineering and Architecture,
Kochi National College of Technology, Japan.
Email: kimura@ce.kochi-ct.ac.jp

ABSTRACT: This paper aims to investigate the energy consumption pattern in four sectors of Padang, Indonesia: residential, commercial, industrial and transportation sectors, under different urban population scenarios using a cohort model and statistical data. The analysis shows that the energy consumed in the residential sector has the major share in the total energy consumption in Padang. Details on energy consumption and the main driving forces in the four sectors have been presented. Decreasing urban energy consumption could be achieved by increasing efficiency of home appliances, promoting electricity saving behavior, increasing of public awareness for saving energy, and applying energy efficiency labeling for home appliances.

Keywords: Urban energy consumption; Cohort model; Residential; Transportation; Commercial and Industrial sectors
JEL Classifications: Q40; N75

1. Introduction

Since the last decades, the world has been facing global warming and energy crisis issues. With the challenge of environmental issue, the importance of reducing energy consumption and fuel emissions has been widely recognized. Data under the International Energy Outlook (IEO) 2011 shows that the world energy consumption of fossil fuels will increase from 383 billionGJ in 1990, to 812 billion GJ by 2035 (EIA, 2011). The most significant increase of energy consumption and fuel emission are taking place in cities (EIA, 2011; IGES, 2004; Fong et al., 2008). With rapidly expanding populations and material affluences, a comprehensive overview of the overall energy use in cities is believed to be playing an important role in combating these issues (Fong et al., 2008).

In relation to energy consumption in the end user sectors, IEO 2011 predicts steady energy consumption growth from 2010 to 2035 (EIA, 2011). Moreover, the United Nations (UN) estimates that 60% of the world's population now lives in an urban area and that percentage is expected to continue to rise (UN, 2008).The IEO prediction states that the world residential energy use will increase by 1.1% per year, from 54 billion GJ in 2008 to 72 billion GJ in 2035 (EIA, 2011).

Indonesia as one of the fastestgrowing and developing countries in Asia with a population of more than 241 million in 2010,is no doubt struggling with energy sustainability for the citizens and at the same time combating the environmental issues such as climate change and reducing CO_2 emissions. With an average growth 2.6% per year, the Indonesian population can be predicted to reach over 300 million by the year 2025. On the other hand, Indonesian economic development is increasing in all sectors such as industrial and commercial sectors as well as household and transportation sectors. The large population and recent economic growth has resulted in an improvement in the overall living standard in Indonesia. The increase of level in economic situation has led to an increase of demand on energy consumption.

One way of looking at the urban energy consumption, is considering the energy consumption trends of the end user. To limit the scope of discussion, Padang, the capital city of West Sumatera province, was selected for the case study. Padang is a typical medium sized city that faces rapid economic growth after a high magnitude earthquake devastating the city in 2009. After the recovery periodelapsed, the local government began to maintain establishment in all sectors of social economic, accelerated development of housing, health and educational facilities. To support the recovery and development process, a comprehensive study of urban energy consumption should be completed for this city.

This paper aims to investigate the urban energy consumption trends in four sectors: residential, commercial, industrial and transportation sectors, under different urban population scenarios and key indicators of urban energy consumption. This study can be integrated with long-term urban planning toward a sustainable development.

2. Methodology

2.1 Demography of Padang

Padang, capital of West Sumatera province, covers an area of about 694.96 km^2 and has a population of about 846,731 (Padang in figure, 2011). Padang consists of 11 districts, Bungus, East Padang, Koto Tangah, Kuranji, Lubuk Begalung, Lubuk Kilangan, Nanggalo, North Padang, Pauh, South Padang, and West Padang (Table 1 and Figure 1). As the center of the provincial government, Padang became the region with the highest population density in West Sumatra province. In addition, office activities, business and education are also concentrated on this area.

Table 1. Details of the case study city

Aspects	Information
Land area	694.96 (km^2)
Number of sub districts	11
Population (2011)	846,731 (Person)
Population density	1218.4 (Person/km^2)
GDP (2011)	12,792.18 million Rupiah
GDP per capita (2011)	32.50 billion Rupiah

Sources : Padang in figure, 2011

Figure 1. Case study (Padang, Indonesia)

2.2 Cohort Model

System dynamic modelling is one approach that can help urban planners to meet the challenges of decision-making and policy formulation for the system development (Kumar and Sonar, 2008). The value of a model arises by improving our understanding of obscure behavior characteristics more effectively than could be done by observing the real system (Hannon abd Ruth, 2001). With system dynamics, the real world system is easy to understand by mimicking real conditions using computer programs.When a model is simulated with a computer, each element of the model is specified by the initial conditions and the computer works out the systems responses according to the specified relation among the elements. Computer Modelling becomes "dynamic" not only when feedback processes among system components are captured through time, but also when model development is based on the dynamic exchange of data and information among a group of model developers and users (Hannon and Ruth, 2001).

Under the book entitled "Dynamic Modelling", Hannon et al. presented the principle of dynamic modelling using STELLA SOFTWARE.

a) Define the problem and the goals of the model
b) Designate the state variable
c) Select the control variable, the flow controls into and out of state variable
d) Select the parameters for the control variables
e) Examine the resulting model for possible violations of physical, economic, law, etc
f) Choose time horizons intended to examine dynamic behaviors of the model
g) Run the model
h) Vary the parameter to their reasonable extremes and see if the results in the graph still make sense
i) Compare the result with the experimental data
j) Revise the parameter or model to reflect a greater complexity and to meet exceptions to the experimental results.

As mentioned above, one fundamental key to understanding the energy issues in the urban sector is the population. The population increases in urban areas will have a particularly significant impact on energy consumption in an urban structure which is related to the sustainable issues regarding energy security and climate change.

Generally, population is estimated by birth, death, and migration (immigration and emigration). This identity can be written by:

Population = current population + birth –death + (immigration – emigration) (1)

The cohort model is divided into a female and male population and each population is classified by age: 0-14 years, 15-44 years, 45-64 years and over 65 years. This classification is used to provide complete information about the estimated population according to age levels.

2.3 Residential Sector

Residential energy consumption is strongly related to the urban population. As mentioned above, 60% of the world's population live in an urban area and that percentage is expected to continue rising. An increase of housing market will promote an increase of energy consumption.

In this respect, the number of population, the number of households, family size, and other related information are calculated from the population census of Padang from year 2000 to 2011. Population is projected by a cohort model as mentioned in the previous section. Characteristics of household appliances obtained through analysis of questionnaires distributed to samples reside in 11 sub-districts of Padang. 210 households were selected randomly and participated in this survey.

The size of the samples foreach district was chosen according to the size of district population. The survey information was mainly about household characteristics and structures, household appliances, energy consumption related daily life activities such asfor lighting, cooking and cooling. Calculation of energy consumption in the residential sector focused on the three types of energy sources: electricity, liquefied petroleum gas (LPG) and kerosene. Energy consumption patterns of daily life were also observed.

2.4 Transportation Sector

Energy consumption of the transportation sector was calculated based on the number of transportation vehicles, such as public transport (citybus and microbus) and private vehicles (motorcycles and cars). The travel distance for each type of vehicle, and fuel consumption per kilometer distance were also considered in the calculation.

Energy consumption was calculated based on vehicle mileages multiplied by fuel consumption of each vehicle, as shown in Equation (2).

$$\boldsymbol{E_T = (TD_{Pb} \times N_{Pb} \times FC_{Pb}) + (TD_{Pr} \times N_{Pr} \times FC_{Pr})} \quad (2)$$

Where:

E_T = Total energy consumption inthe transportation sector
TD_{Pb} = Total travel distance for public transportation
TD_{Pr} = Total travel distance for private transportation
N_{Pb} = Number of public transportation vehicles
N_{Pr} = Number of private vehicles
FC_{Pr} = Fuel consumption per kilometer for private transportation
FC_{Pb} = Fuel consumption per kilometer for public transportation

2.5 Industrial and Commercial Sectors

Energy consumption in industrial and commercial sectors is estimated from historical data considering population and economic growth. Industrial and commercial sectors are the sectors that contribute significantly to the GDP of Padang. From 2005 to 2010, the commercial sector contributed 22.5 % while the industrial sector accounted for only 20 % of the total GDP. The estimation of energy consumption in the industrial and commercial sectors is mainly focused on the electricity consumption because this type of energy source gave more than 65% of the energy share compared with the other energy sources.

3. Results and Analysis

3.1 Cohort Model of the Padang Population

A cohort model was used to estimate energy consumption based on population projection. It provides an overview of the development of the Padangpopulation by age group adopted from a scenario projection of West Sumatera for 2025.

The Population projection for the study area can be seen in Figure. 2 Population is projected to continue rising, despite several attempts taken to curb the population growth. In accordance with the

MDG scenario, the fertility rate is targeted at 2.11 in 2025. Figure 3 shows a comparison between the businesses as usual (BAU) and population scenario dealing with fertility rate.

Figure 2. Estimated population by the cohort method

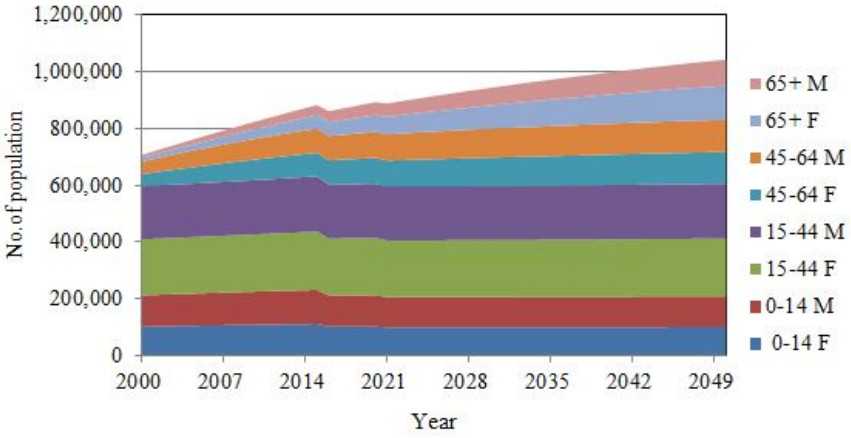
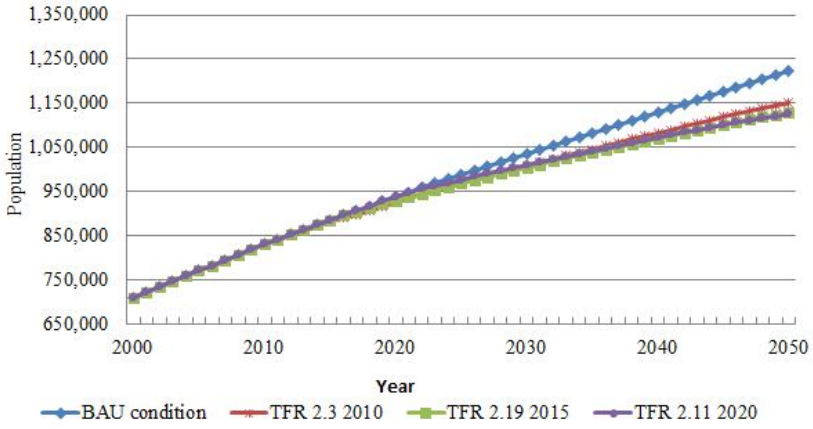


Figure 3. Estimated population by the cohort method under population scenarios



Under TFR scenarios, when fertility rate is setto 2.11 in 2025, the total population is expected to successfully suppress to 7% per year. Since Padang demography is dominated by younger ages (Figure 4.), to realize the target of TFR 2.11, aseriouseffortmust bemade by the government to educate this productive age group. The followings are several programs designed by the government to decrease the fertility rate:

a. Decrease birth rate through a birth control program

Since 1970, this program has been announced by the government, as one of the efforts to reduce the high rate of population growth in Indonesia. The aims are to promote awareness to a new family for the birth plan, realigned to their economic level and readiness. Since the program started, the birth rates (TFR) significantly decreased from 5.6 in 1970 to 2.8 in 2000.

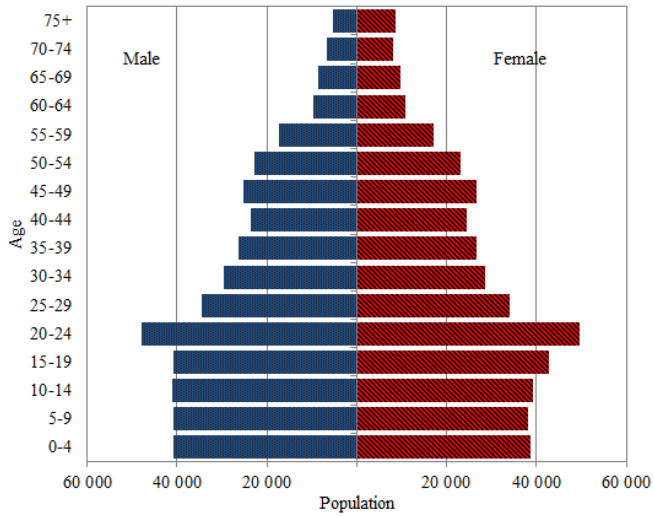
b. Delaying the age of marriage

It is well documented that early pregnancy usually increases both maternal and infant mortality. In developing countries such as Indonesia, early childbirth occurs within the context of early marriage. Delaying the age of marriage for women to their mid twenties not only results in a significant drop inthe fertility rate, but also will most likely prevent a surprisingly large portion of maternal and infant mortalities.

c. Increase the education level

One of the most effective ways to lower population growth and reduce poverty is to provide adequate education for both girls and boys. Countries in which more children are enrolled in school—even at the primary level—tend to have strikingly lower fertility rates.

Figure 4. Population structure of Padang



3.2 Residential Sector

According to the projection result, it can be seen that household numbers of Padang gradually increased following the population trend. In other words, this condition will provide a significant influence on residential energy consumption. Also, direct and indirect lifestyle aspects are factors that influence the residential energy consumption pattern (Fong, 2008; Bill and Danni, 2009; Pereira and Assis, 2013).

Electricity, LPG and kerosene are the main sources of residential energy consumption. Padang Statistical data (2011) report that from 2000 to 2011, electricity was the biggest share of energy sources. Electricity consumption spread to the residential sector (92%), followed by commercial sectors (5.32%), public sectors (1.92%), the government (1.28%), and only 0.04% in the industrial sector (Figure 5).

Figure 5. Household electricity consumption

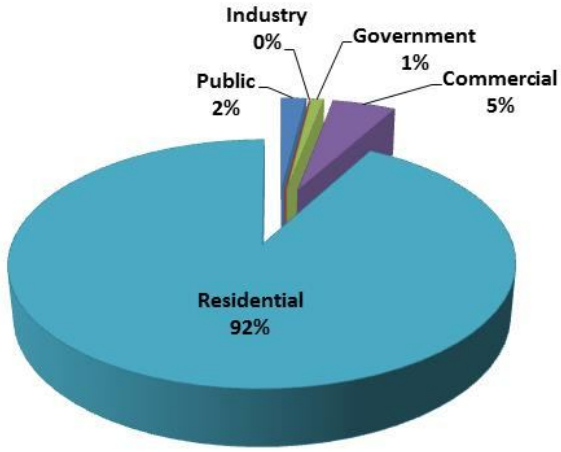


Figure 6 shows the share of electricity for different end users in Padang. Cooking is the most energy consuming activity with a share of 53%, followed by a 17% share for cooling devices, 10% for entertainment devices, 5% for lighting and 16% for other devices.

In respect to the household energy consumption, Wijaya and Tezuka carried out a survey of household electricity consumption based on home appliances in the Bandung and Yogyakarta cities of Indonesia (Wijaya and Tezuka, 2011). The questionnaire survey method was used in this study, which involved 100 respondents in each city. Among the main findings of this study was, that a majority of electricity consumption came from cooking and cooling device. Figure 7 shows a comparison of electricity consumption by household activities between Padang and other cities in Indonesia.

Figure 6. Electricity consumption

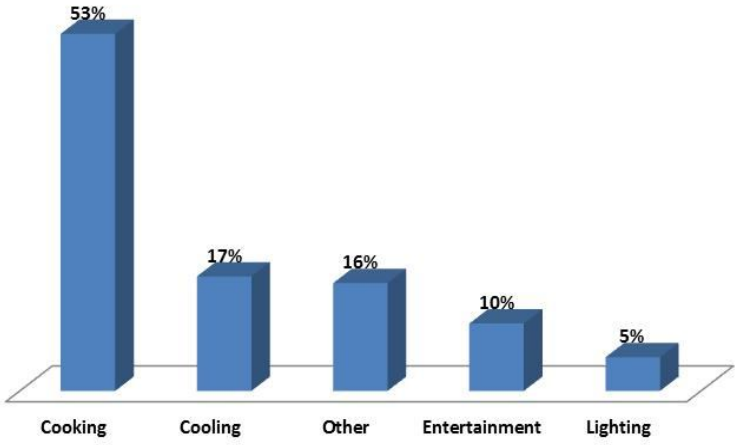
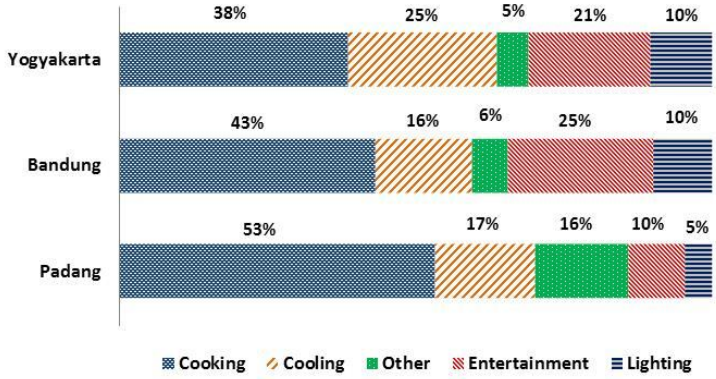


Figure 7. Comparison of electricity consumption



Another activity that contributes to electricity consumption is entertainment. Fig. 7 shows that the leisure activities in Yogyakarta and Bandung cites contributed to 21% and 25% of energy consumption. Characteristics of households such as family lifestyle and family pattern respectively affect the high percentageof electricity consumption.

LPG and kerosene, the main fuel are used by most Indonesian families. According to the Handbook of Energy and Economic Statistics of Indonesia 2011, the average share of energy consumption of kerosene in the household sector from the years 2000 to 2010 was about 57%, of electricity about 30%, of LPG about 13%, and only 0.1% of natural gas. Based on the survey results, 37.6% of households consumed LPG as the main fuel for cooking, however 36.7% of households still used kerosene and 23.8% of householdsused both of LPG and kerosene, with only 1.9% of households still using wood as the primary fuel for cooking. The majority of households used 12 kg tube LPG, and the average household spent one tube per month. Padang statistical data also showed that from 2003 to 2009 there was an increase in households that using LPG, going from 36,922 households in 2003 to 47,230 households in 2009 (Padang in figure 2011). As a whole, according to data from Energy

Statistics of Indonesia, LPG consumption increased from 696,000 tons in 2000 to 3,577,000 tons in 2010.

3.3 Transportation Sector

As mentioned above, energy consumption in the transportation sector focused on two parts, private transportation and public transportation. The number of vehicles per year, travel distances of public transportation, fuel consumption per kilometer of travel distances and other supporting data were derived from Padang statistical data and the Transportation Department of Padang. Figures 8 and 9 illustrate the increases in the number of public and private vehicles in Padang.However, the main obstacle of evaluating transportation energy consumption is the lack of available data for each public transportation type. Therefore, the authors placed more emphasis on two kinds of public transportation commonly used in Padang, the city bus and microbus in public transportation, and the motorcycle and a car with 4-7 seats in private transportation. The ratio of motorcycles to people is 1:4, which means that every 4th person has one motorcycle. Otherwise, for public transportation, the ratio is 1:330, which means that there is one public vehicle for every 330 persons (Indonesia Bank, 2013).

Figure 8. Number of public vehicles from 1994 to 2010

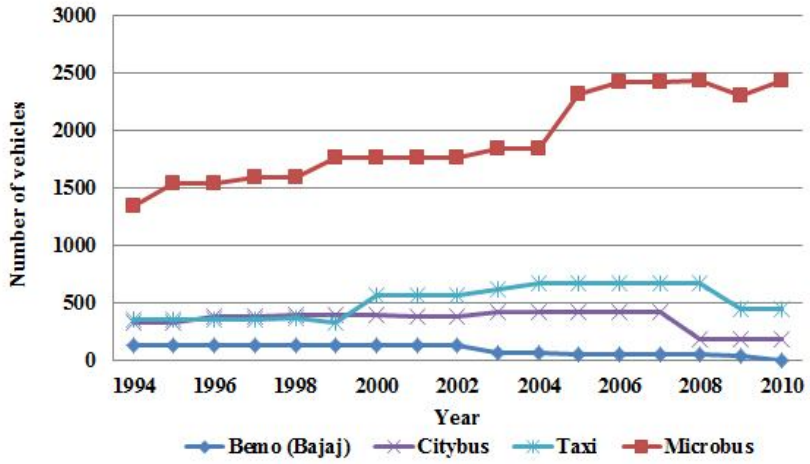
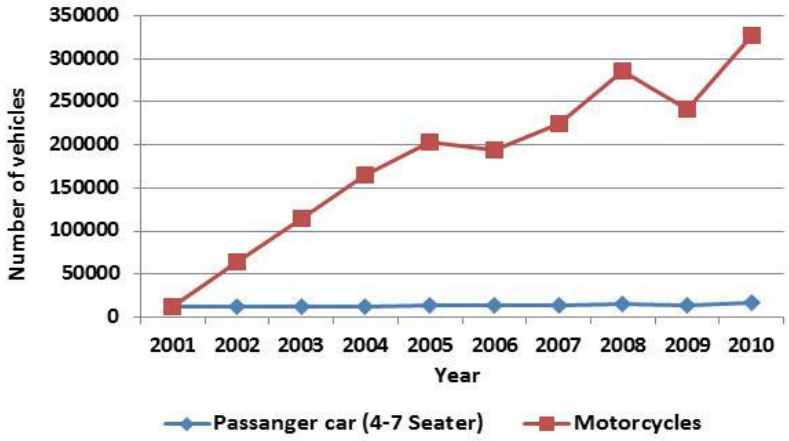
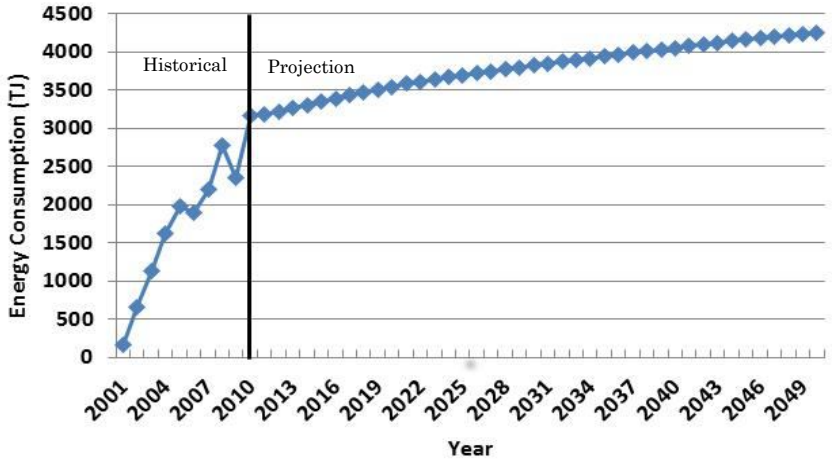


Figure 9. Number of private vehicles from 2001 to 2010



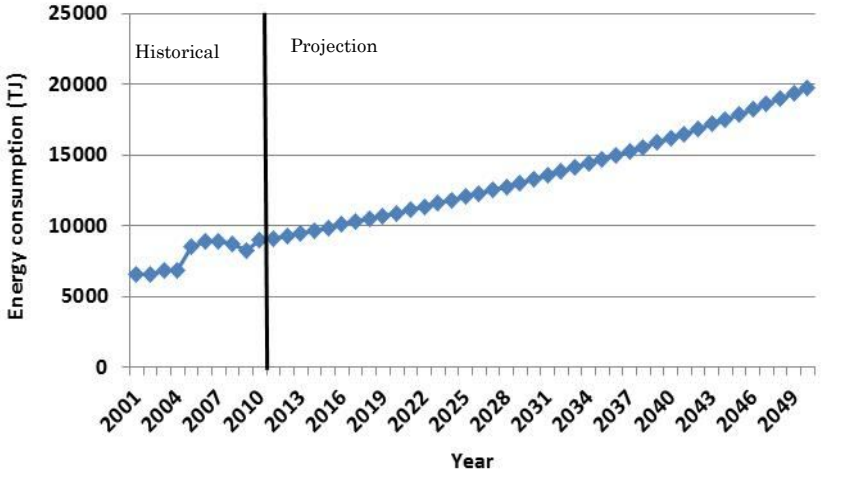
As illustrated in Figure 10, withan increase in population and demand for public transportation growing up 2% p.a., energy consumption is predicted to riseto 20,000 TJ in 2050. Micro buses contributed more than 90% to total energy consumption compared to other forms of public transportation.

Figure 10. Energy consumption projection of public transportation



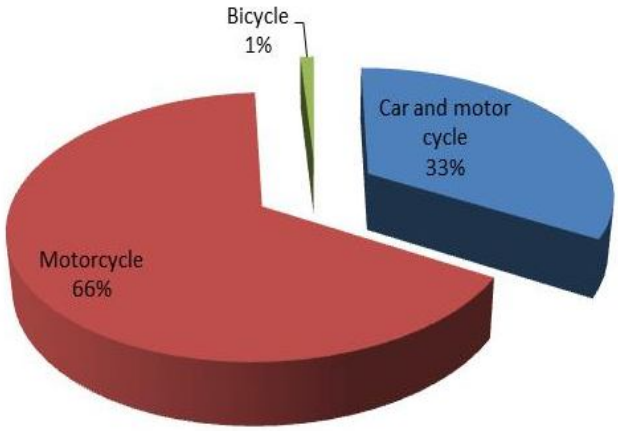
In terms of private vehicles, because of the availability of data, the calculation of energy consumption builds from average fuel consumption per day for motorcycles and cars (ESDM, 2012). Figure. 11 shows the increase in energy consumption of private vehicles. It can be seen that if every 2.75 people have one motorcycle and every 50 persons have a car, energy consumption is predicted to growth 2% per year.

Figure 11. Energy consumption projection of private transportation



The motorcycle is the biggest contributor of fuel consumption compared to passenger cars. Figure 12 provides an overview of vehicle ownership in Padang. The simplicity of having motorcycles, absence of vehicle restriction policy, and public transportation management is not a good reasonfor society to use motorcyclesrather than public transportation. This result is closely related to the increasing air pollution. According to the Environment Impact Control (BAPEDALDA, 2012) report 70% of air pollution was caused by motor vehicles, 20% by industrial activities, and the remaining 10% from garbage and cigarettes.

Figure 12. Households vehicle



Generally, the high number of vehicles in Indonesia is mainly caused by:

a. The ease of obtaining motorcycles

Indonesia is one of the countries with the highest density of motorcycles in the world. According to the Indonesian motorcycle association, production of motorcycles reached 15 million per year and 86% of the products are used in the domestic market. On the other hand, on the consumer side, many conveniences were provided by distributors of motorcycles as light credit, a small down payment. This condition encourages people to purchase a motorcycle.

b. High flexibility

Motorcycle is a transportation vehicle which has a high flexibility compared to cars. Generally, Indonesia has many roads that can only be passed by motorcycle. Moreover, in the cities context of the high mobility and traffic jams are a problem, and motorcycles are practical and efficient vehicles.

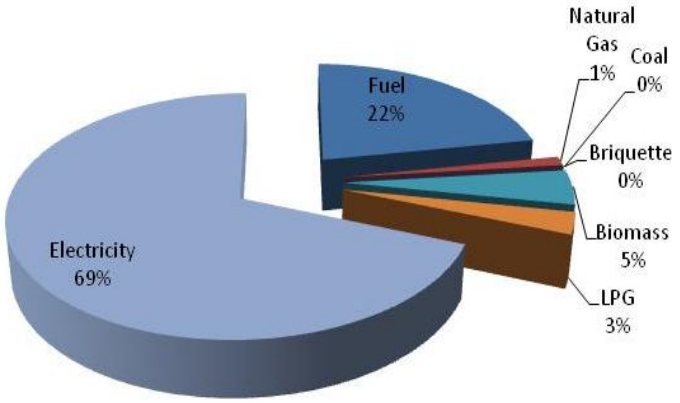
c. The impact of inadequate public transport

According to Indonesian transportation department, the ratio of private vehicles to public vehicles is 98% : 2%. In Padang case, the number of public transportations with 25 seats was decreased 4% per years since 2007. Moreover, people prefer using private vehicles rather than public transportation. On the other hand, the growth rate of roads was only 0.5% per year. This condition provides several problemssuch as traffic jam, air pollution, and also the increasing of fuel consumption

3.4 Commercial and Industrial Sector

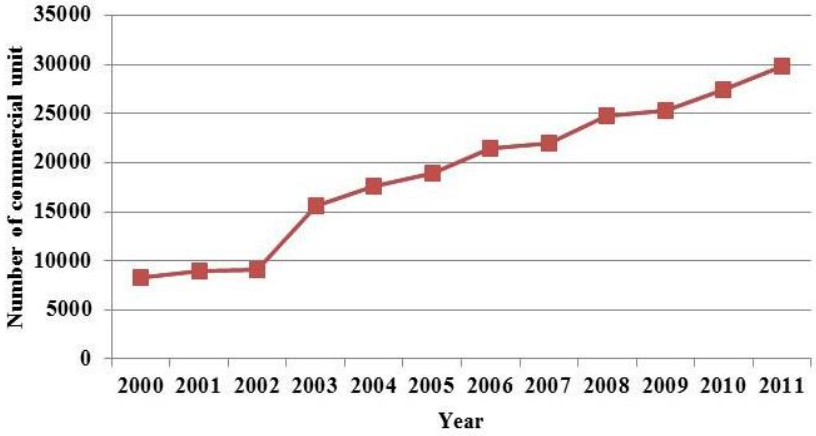
Energy consumption by the commercial sector is dominated by electricity usage. Figure. 13 shows the share of commercial energy consumption by each energy source type. Statistical data showed that electricity was consumed more than 69%, fuel consumption was approximately 22%, natural gas was approximately 1%, biomass approximately 5%, coal approximately 0%, and LPG was consumed at approximately 3%.

Figure 13. Share of commercial and industrial energy consumption



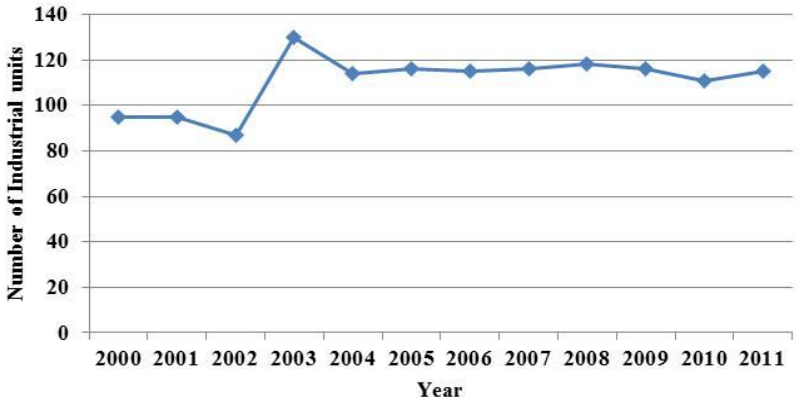
In this study, the authors put more emphasis on the calculation of electricity consumption. Historical data from 2000 to 2011 shows increases of an electricity users in the commercial and industrial sectors. Figures 14 and 15 show that in the commercial sector the electricity user was growth of 14% p.a, while in the industrial sector only about 5% p.a.

Figure 14. Electricity commercial user



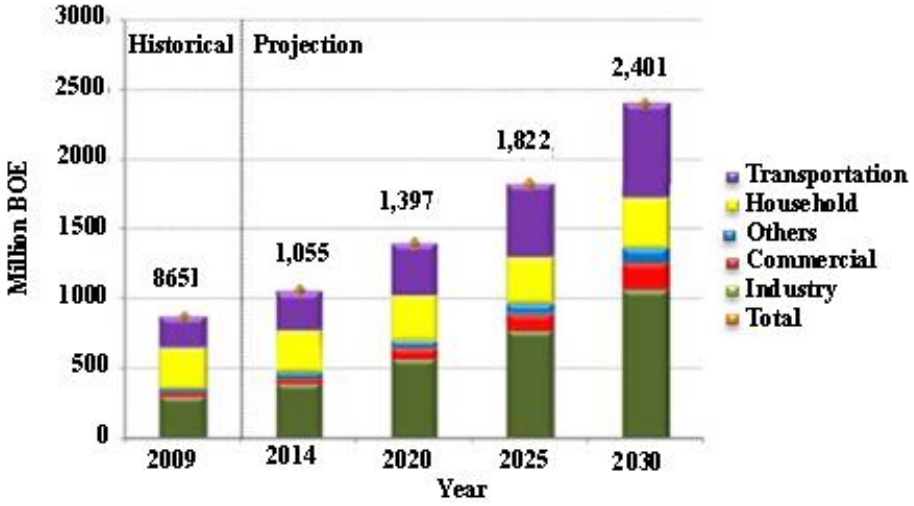
As mentioned above, the Indonesian economy grew by an average of 6.5% p.a. This growth was supported by business sectors and industries. From 12.08 billion Rupiah of GDP, the business sector contributed an average of 21% per year, and is expected to continued rising.

Figure 15. Electricity industrial user



Indonesia Energy Outlook (IEO, 2011) provides an overview of the growth of Indonesia's energy future . Related to energy consumption inthe commercial and industrial sectors, the commercial sector and the industrial sector will grow by 4.9% and 6.2%, respectively. Based on the Agency for Assessment and Application of Technology (BPPT, 2011), from 2014 to 2030 energy demand was projected at average increase of 5.3 p.a and increased almost three times compared to 2009 (Figure. 16).

Figure 16. Projection of final energy demand



3.5 Policy implications of urban energy consumption

As it has been known that urban energy consumption is unique for each country to measure and determine by country features such as climate, socio-economic condition, population, and physical characteristic. One part that the government should focus on is that increase of population, income, and lifestyle will lead to an increase of energy consumption (Sukarno et al., 2013; Feng et al, 2012; Crompton and Wu, 2005).

The survey of household energy consumption shows that utilization of energy such as LPG, biogas and renewable energy is still low compared to fossil-based energy. Since 2007, the Indonesian government has implemented a transition from kerosene to LPG. As it is already known, the government initially encouraged the use of LPG 12 kg tubes, and after the implementation of the conversion from kerosene to LPG, the government distributed 3 kg tubes available to the lower class. However, the study found that 38% households use kerosene. A high percentage of households who used kerosene were influenced by a lack of understanding the benefits of using LPG rather than kerosene. Furthermore, the lack of disseminating the safe use of the LPG was also one of the factors contributing to concern about using LPG rather than kerosene.

Related household appliances, ownership and utilization of electrical equipment are believed to have a significant effect on the increase of electricity consumption (Sukarno et al., 2013; Feng et al, 2012; Crompton and Wu, 2005). This condition will be a matter of concern with the increase of population, economic growth and human lifestyle.Since 2004, theMinistry of Environment was started for eco-label vision in Indonesia. For this vision, three missions are executed: (a) materialize synergy of environmentally negative impact control in product life cycle, (b) to encourage supply and demand quality and environmentally friendly products, (c) preparing criteria and an eco-label certification system which is competent and credible based on one stakeholder. This program should be integrated with strong regulation, standards, and policies that are required to support the eco-label vision in indonensia.

The Agency for Assessment and Application of Technology (BPPT, 2011) predicts that by 2030 Indonesia will become an energy importing country. Some of the main energy sources are not able to satisfy domestic needs. Coal and petroleum reserves are predicted to only be able to meet domestic demand until 2050. Moreover, LPG demand is predicted to increase to 10 million tons by 2030 and 70% is still met from imports. Dependency on high energy based on fossil fuel will lead increase of CO_2 emission. Under the BPPT prediction, by 2030 total CO_2 emissions will reach1.2 billion tons, where coal accounts for CO2 emissions by 844 million tons, or 67 percent of total energy. This condition should receive serious attention from the Indonesia government. This will require essential policies and real programs to encourage the use of modern clean energy. Increased use of geothermal energy, solar energy, hydro energy, combustion energy and other renewable options should be placedas the priority programs for sustainable energy consumption.

4. Conclusion

In this study, urban energy consumption was calculated based on a cohort model of Padang Indonesia. Although it was a basic model with various primary data related to energy consumption calculations, it provided an overview of urban energy consumption in the residential, commercial, industrial and transportation sectors.

One of the parameters that can be used as the basis for calculating energy consumption is the population growth. As one of the biggest users of energy, population growth has a significant influence on the increase of energy consumption. The cohort models provide an overview of the growth of the urban population every year. From the simulation results, several conclusions can be summarized:

(a) Based on TFR scenarios, from 2015 to 2050 the Padang population can be reduced to 7% per years;
(b) Energy consumption has a positive correlation with population size;

Based on the energy consumption calculation, the main driving forces of urban energy consumption have been identified. In terms of the residential sector, cooking activities and cooling device are the main factorsfor electrical energy consumption. Although, from year 2007, the Indonesian government carried the conversion program from kerosene to LPG; however, the consumption of kerosene was still high over the last five years. In the transportation sector, the number of motorcycles is extremely high and became the largest contributor to air pollution in the city. In the commercial and industrial sectors, electricity is one of the highest energy consumptions compared to other energy sources.

Decreasing urban energy consumption could be achieved by increasing efficiency of household appliances, promoting electricity saving behaviors, increasing public awareness for energy saving, and applying energy efficient labeling for home appliances. Hence, these elements should be prioritized in the future urban energy study and integrated with the long-term urban planning toward sustainable development.

Acknowledgment

The authors would like to acknowledge Industrial Engineering of Andalas University students who helped the authors to distribute and collect questionnaires, and also all the individuals who participated as a respondent in this research. The authors would also like to convey their gratitude to the Indonesian Scholarship (DIKTI) program for providing scholarships during the study.

References

Bapedalda.(2012). *http://www.padang.go.id.*

Bill, M., Danni, M. (2009). How are we using Energy in homes today? Results from the 2009 Residential Energy Consumption Survey (RECS). 2012 AEIC Annual Load Research Conference. July 11, 2012.

Crompton, P., Wu, P. (2005). Energy consumption in China: Past trends and future directions. Energy Economics, 27(1), 195-208.

EIA, Energy International Outlook (2011). Energy Information Administration, U.S. Energy Information Administration.

ESDM.(2012). *http://www.esdm.go.id/berita/migas/40-migas/5368-pengendalian-konsumsi-bbm-untuk-ketahanan-energi-nasional.html.*

Feng, Y.Y., Chen,S.Q., Zhang, L.X. (2012). System dynamic modelling for urban energy consumption and CO2 emissions: Case study of Beijing, China. Journal of Ecological Modelling 44-54.

Fong, W.K. (2008). A study on the prediction and control of urban energy consumption and carbon dioxide emissions. Doctoral thesis of Toyohashi University of Technology, Japan.

Fong, W.K., Matsumoto, H, Ho, S.C., Lun,Y.F. (2008). Energy Consumption and Carbon Dioxide Emission Considerations in the Urban Planning Process in Malaysia. Journal of the Malaysian Institute of Planners, VI, 101-130.

Handbook of Energy and Economic Statistics of Indonesia. (2011). Ministry of Energy and Mineral Resources.

Hannon, B.,Ruth, M. (2001). Dynamic Modeling. Springer-Verlag, New York.
IGES. (2004). Urban Energy Use and Greenhouse Gas Emission in Asian Mega-Cities: Policies for a sustainable Future. Institute of Global Environmental Strategies.
Indonesia Bank. Monetary Policy. (2013). *http://www.bi.go.id/NR/rdonlyres/25236949-066E-497F-AC99-A9A980527022/27869/TKM_0114.pdf.*
Indonesia Energy Outlook (IEO). (2011). Pusat Teknologi Pengembangan Sumberdaya Energi. Badan Pengkajian dan Penerapan Teknologi.
Kumar, S., Sonar (2008). Urban Sprawl A System Dynamic Approach, 44th ISOCARP Congress 2008.
Padang in figure (2011). Badan Pusat Statistik Kota Padang.
Pereira, I.M., Assis, E.S. (2013). Urban energy consumption mapping for energy management. Energy Policy, 59, 257-259.
Sukarno, I., Matsumoto., H, Kimura., R, Susanti., L. (2013). Residential energy consumption in a local city of Indonesia. Proceeding of 23rd Pacific Conference of the Regional Science Association International (RSAI) and the 4th Indonesian Regional Science Association (IRSA) Institute (PRSCO 2013), Bandung, Indonesia, 2-4 July 2013.
UN. (2008). World urbanization prospects: the 2007 revision population database. New York: United Nations Population Division. *Http://esa.un.org/unup/.*
Wijaya, M.E., Tezuka, T. (2012). Electricity saving potential in Indonesia Households: A Techo-Socio-economic Analysis. In: 4th International Conference on Sustainable Energy and Environment (SEE 2011), Bangkok, Thailand, 27-29 February 2012.