LAPORAN PENELITIAN

MACRO INDICATORS IMPACT TOWARDS RESIDENTIAL ELECTRICITY CONSUMPTION IN INDONESIA

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2 July, 2012

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4	Lokasi Penelitian	: Universitas Kristen Petra
5	Institusi lain yang bekerjasama	: -
6	Jangka Waktu Penelitian	: 8 bulan
7	Biaya yang diusulkan	
	a. Sumber dari UK Petra	: Rp. 10.720.000,-
	b. Sumber lainnya	: -
	Total	: Rp. 10.720.000,-

Surabaya, 2 Juli 2012

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Abstract

Household electricity consumption has become the highest rank among other sectors in Indonesia over the past decade. Its consumption growth takes second place after industrial sector with 8.14% and 10.45%, respectively, during 2006-2010. In the other hand, the importance of achieving the predetermined electrification ratio, as it reflects part of millennium development goal, has been unavoidable.

Macro indicators impact towards electricity consumption in the residential sector is then considered prominent to be investigated in relation to the energy policy planning. The research objective includes establishment of appropriate model containing macro indicators as the variables through the utilization of econometric method. The study period is 1990 – 2010. In addition, the forecasting model for household electricity consumption is also developed using econometric method. Factors decomposition is then used to obtain several types of effect contributed in the electricity consumption growth during 2000 – 2010, such as intensity effect, structural effect, as well as activity effect.

From the econometric point of view, the results found that BI rate, GDP, inflation and population are not significantly affecting the total energy consumption in Indonesia. Meanhile, electrification ratio and private consumption are significantly affecting to total energy consumption in Indonesia. In conclusion, total energy consumption has strongly influenced by the electrification ratio and private consumption. Moreover, the forecasting results found that the best model through ARIMA model in forecasting BI rate is ARIMA (0,1,1) or IMA (1,1); electrification ratio is ARIMA (1,1,0) or ARI (1); inflation is ARIMA (0,1,1) or IMA (1,1) and total energy consumption is ARIMA (0,1,1) or IMA (1,1). Similarly, the best model through ARCH/GARCH model in forecasting electrification ratio is ARCH (1) and GARCH (1); GDP is ARCH (1) and GARCH (1); Inflation is ARCH (1) and GARCH (1); and total energy consumption is ARCH (1) and GARCH (1).

Meanwhile, using Log Mean Divisia Index (LMDI) method which is offer more benefits over Aritmetic Mean Divisia Index (AMDI). Using LMDI additive-technique for the case of total residential sector of Indonesia, we find total residential electricity consumption in the period 1990 – 2010 became 29.285,2 GWh. The activity effect which is based GDP changes is the dominant factors contributing electricity consumption growth with 56.634,3 GWh. Insignificant contribution to the increasing electricity consumption was given by the structural effect changes in portion of household expenditure to the GDP, with 3.217.9 GWh in aggregate. On the other hand, intensity changes has consistently shown yearly negative value throughout the study period except for 2005 – 2006. This reveals that the intensity change, which is considered to be due to efficiency improvements, has shown its contribution for a decrease of 30.567 GWh in electricity consumption over the period. For the case of residential sub-sector, total residential electricity consumption is equal to summation of all sub-sector. Increasing electricity consumption in all sub-sector are identified affected by activity changes. It implies that increasing electricity consumption in R1 is indirectly caused by the positive trend of electrified-residential expenditure whereas in R2 and R3, electricity consumption growth are also due to increasing R2 and R3 expenditure.

Keywords: Econometric, factors decompotition, household electricity consumption, LMDI

CHAPTER I
INTRODUCTION

Indonesian power sector consumer is devided into four major segmets, namely residential or household, industrial, commercial, and public sector. As reported by PLN on their 2010 annual report (PLN, 2011), commercial sector rank first with average growth of 10.45% on 2006 – 2010 electricity sales, followed by residential and industrial, with 9.14% and 3.86%, respectively. In 2010, the largest source of the electric power sales revenue still comes from the group of industrial and residential tariffs. In 2010 total revenue from electricity sales increased by 14.20% to Rp 102,974 billion, from Rp 90,712 billion in 2009. This increase was due to the increase of electricity tariff which came into effect on July 1, 2010. Based on this fact, the power sector management and its implications are believed to have strong interrelated between PLN as power sector operator and government as the regulator. Regarding to the economic growth impact towards power sector development, the electricity consumption growth at residential sector shall be seen to closely affect by it.

The needs of having a clear understanding on how sectoral electricity consumption developed in Indonesia is unavoidable due to global economic competition. Resources scarcity is one of prominent driving factor that spur efficiency in using resources on power sector. Regarding to this condition, there are at least two implications to follow; firstly, policy on power sector expansion should be made accordingly, by looking into other macro condition so that sectoral electricity growth can be controlled and matched with available resources. Secondly, the importance of achieving the predetermined electrification ratio, as it reflects part of millennium development goal, has been unavoidable. Hence, government should pay more attention to provide electricity across the country, particularly to areas unreachable by utility grid. In more extensive way, government has tried to meet the electrification ratio target by conducting development of small power generation plants spreadout in the remote areas. Based on the Electricity Law No. 30/2009, private sector is encouraged to be involved in the power sector infrastructure provisioning, particularly in the generation sector. They are becoming a PLN partner to develop distributed generation for which the generated electricity is supplied to the PLN mini grid. The ultimate objective is to increase the electrification rate coming from rural areas contribution.

It is believed that there is close relationship between good economic growths with power sector development in terms of macro indicators impact towards sectoral electricity consumption growth. The immediate impact is then how to allocate sufficient resources to powering the needs of electricity demand, which is in turn supporting economic growth. Which indicator contributes as dominant driver to construct the demand growth should be taking care of could be another important issue. The appropriate policy could be ascertained to match the needs if the indicator's effect towards the demand growth could be revealed. In viewing to these important implications to Indonesian power sector development, an investigation on residential electricity consumption pattern is proposed through this research. The focus of this research is to analyze the interrelation between macro indicators that built a pattern of residential electricity consumption for 1990 – 2010 through a model as empirical representation to the residential electricity consumption condition. In addition, a forecasting model based on econometric method is then developed to provide insight on the development of residential electricity consumption beyond the study period. Meanwhile, factors decomposition based on Log Mean Divisi Index (LMDI) is applied to analyze the dominant contributor to the increasing electricity consumption in the period 2000 – 2010, in terms of intensity, structural, and activity effect. In this research, factors decomposition is also performed using Aritmetic Mean Divisia Index method (AMDI) and it is then compared to the results obtained by LMDI in order to observe the benefit of LMDI over AMDI as mentioned in earlier. The study using factors decomposition method is focused on two broad objects, namely total residential sector and residential sub-sector. In the total residential sector, analysis is made up the household sector as one big sector nationwide whereas in residential sub-sector we considers residential sector with three group, based on the residential electricity tariff class, and analyze each sub sector's factors decomposition in order to get more insight on how the various effect change the household electricity consumption in that particular sub sector.

This report is organized as follows. Chapter 2 briefly reviews the literature. Chapter 3 describes reserach objectives and benefits. Chapter 4 decribes method used to construct residential electricity consumption model and its forecasting model as well as to decompose changes in electricity consumption growth. Chapter 5 presents analysis results and discussion. The report is finalized with conclusion and recomendations in Chpater 6.

CHAPTER II
LITERATURE REVIEW

II.1. Modeling Using Econometric Method

Literally interpreted, *econometrics* means "economic measurement." Econometrics is an amalgam of economic theory, mathematical economics, economic statistics, and mathematical statistics (Gujarati, 2004). Econometric analysis uses a mathematical model. A model is simply a set of mathematical equations. If the model has only one equation, it is called a single-equation model, whereas if it has more than one equation, it is known as a multiple-equation model. An anatomy of econometric modeling is given in Fig. 1 below.

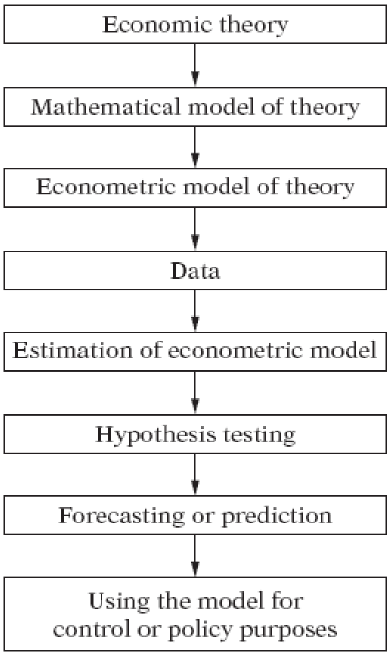


Fig.1. Anatomy of econometric model (Gujarati, 2004)

Linear-regression model and Multiple-regression model are examples of econometric model. Multiple-regression model is derived from Linear-regression one. Up to today, regression analysis is the main tool of statistical techniques used to obtain the estimates (Gujarati, 2004). The model primarily explains the linear relationship between dependent variable and independent variable(s) or explanatory variable(s). In Multiple-regression model, the explanatory variable consists of more than one variable to affect to the changes of dependent variable. To construct the model mathematically, certain functional form should be specified in the equation, giving certain relationship between dependent variable and explanatory variable(s). Some types of Multiple-regression model according to its functional form are: Linear model, the Log-linear model, Lag-linear model, Reciprocal model, and the Logaritmic reciprocal model (Gujarati, 2004). Example on Linear model on Multiple-regression is given below.

$$Y_{it} = c + \beta 1X1_{it} + \beta 2X2_{it} + \ldots + \beta nXn_{it}$$

where Y_{it} is dependent variable for sector *i* in period *t*, *c* is constant of the model, β1, β2,…, βn is regression coefficient of explanatory variable(s), X_{it} is explanatory variable of sector *i* for period *t*, *i* is sector, *t* is period (e.g. year).

Regression analysis is dealt with with the analysis of the dependence of the dependent variable on the explanatory variable(s). The study evaluates some statistical indices to be measured in the regression model, involves measurement on how success the model in predicting the dependent variable and some testing. In the analysis, the term R-square or coefficient of determination measures the portion of explained total sum of square by dividing explained deviation by total deviation. In other word, it measures how much fraction of dependent variable can be explained by explanatory variable. The ratio closer to 1 meaning the model is better in fitting the available data. Meanwhile, the adjusted R-square is the corrected measure of R-square since R-square would remain the same whenever additional explanatory variable is added to the equation. The value of adjusted R-square can be less than that of R-square if any additional explanatory variable do not contribute to the explained deviation of the model.

Several testing can be performed to check validity of the model with specific purposes. Hypothesis testing is conducted to test whether there is any relationship between dependent and explanatory variable. The level of significance T is the critical limit either to accept or to reject the null hypothesis. Another test is F-test of F-statistic, of which obtained from the hypothesis test for all of the slope coefficients, except the constant, are zero. Accordingly, the *p-value* or Probability (Fstatistic) is measuring the marginal significance level of the F-test. Comparing T and *pvalue*, if T is higher than *p-value*, then the null hypothesis should be rejected. T-test is performed to check the significance of independence variables that build up the model. Here, independence variable is said to be significant if the T-test value fall within the critical region based on α and degree of freedom used in the model.

There are four assumptions in the Least Squares Method which is utilized in the Multiple Regression (Stock and Watson, 2007). First, the conditional distribution of u_i given X_{1i}, X_{2i} ,…, X_{ki} has a mean of zero. Second, $(X_{1i}, X_{2i}, \ldots, X_{ki}, Y_i), i = 1, \ldots, n$ are independently and identically distributed (i.i.d) random variables. Third, large outliers are unlikely. Fourth, no perfect multicollinearity. All of these assumptions should be tested on the model. If the results found that there are one or more violation then the model cannot be utilize as an estimator. This condition called as a classical assumption violation which is divided into three indicators; multicollinearity, heteroscedasticity, and autocorrelation. There are several testing can be applied in order to check multicollinearity, heteroscedasticity, and autocorrelation. Correlation test is utilized in order to test the presence of multicollinearity and White heteroscedasticity used to check heteroscedasticity. In addition, Durbin-Watson (DW) test (Farebrother, 1980) or serial correlation LM test (Bruesch Godfrey Method) determines the presence of autocorrelation in the model. The calculated DW statistics, of which measuring serial correlation of the residual, will be compared with lower bound and upper bound of DW table to determine the presence of serial correlation. Lastly, if the sample size is small (less than 30 number of observation/data) we should apply the normality test in order to check whether the error term is closely normal distributed by using the Jarque-Berra (JB test). Other econometric models are Autoregressive Integrated Moving Average (ARIMA) and Autoregressive Conditional Heteroscedasticity (ARCH)/Generalized Autoregressive Conditional Heteroscedasticity (GARCH) will also be applied in the research. We will provide the detail explanation on the next part (II.2.Forecasting using Econometric Model).

II.2. Forecasting Using Econometric Model

In this section, we consider forecasts made using an autoregression, a regression model that relates a time series variable to its past values. If we want to predict the future of a time series, a good place to start is in the immediate past. Autoregressive Integrated Moving Average (ARIMA) model is utilized only to forecast the dependent variable in the short run. This also called the Box-Jenkins (ARIMA) Methodology (Hanke and Wichern, 2005). Gujarati (2004) stated that if a time series is stationary (even in the first different), then we can construct the model in several alternatives.

Hanke and Wichern (2005) confirmed that models for nonstationary series are called autoregressive integrated moving average models and denoted by ARIMA (p, d, q). Here p indicates the order of the autoregressive part, d indicates the amount of differencing, and q indicates the order of the moving average part. Consequently, from this point on, the ARIMA (p, d, q) notation is used to indicate models for both stationary (d = 0) and nonstationary (d > 0) time series.

Enders (2004) stated that conditionally heteroscedastic models (ARCH or GARCH) allow the conditional variance of a series to depend on the past realizations of the error process. A large realization of the current period's disturbance increases the conditional variance in subsequent periods. For a stable process, the conditional variance will eventually decay to the long-run (unconditional) variance. Therefore, ARCH and GARCH models can capture periods of turbulence and tranquility.

Min et al (2010) worked with econometric method to develop statistical model of residential energy end use characteristic for the United States. The authors utilized Ordinary Least Square (OLS) method with predictor variables such as energy price, residential characteristics, housing unit characteristics, geographical characteristics, appliance ownership and use pattern, and heating/cooling degree days. Dependent variables of the four regressions were natural log values of per-residential energy use for heating, water heating, appliance, and cooling.

Aydinalp et al (2003) developed a model of residential energy consumption at the national level. Three methods were used to model residential energy consumption at the national level: the engineering method (EM), the conditional demand analysis (CDA) method, and the neural network (NN) method. The EM involves developing a housing database representative of the national housing stock and estimating the energy consumption of the dwellings in the database using a building energy simulation program. CDA is a regression-based method in which the regression attributes consumption to end-uses on the basis of the total residential energy consumption. The NN method models the residential energy consumption as a neural network, which is an information-processing model inspired by the way the densely interconnected, parallel structure of the brain processes information.

II.3. Decomposition Analysis

Decomposition analysis has become the primary method which broadly is used in the study related with the energy consumption. Decomposition analysis is employed to separate changes in electricity consumption over time into mainly three driving factors, namely i) changes in the structure of the economy, ii) changes in efficiency and/or iii) production changes (Lotz and Blignaut, 2011). There are primarily two types of decomposition methodologies, namely the index decomposition analysis (IDA) and the structural decomposition analysis (SDA) (Wachsmann et al. 2009). The main difference between these two methods is that SDA can explain indirect effects of the final demand by dividing an economy into different sectors and commodities, and examining the effects on them individually (Wachsmann et al. 2009), while IDA explains only direct (first-round) effects to the economy. The IDA applies sectoral production and electricity and the SDA requires data-intensive energy input-output analysis. Because of the data constraint concerning SDA, the IDA is generally perceived as the method of choice by a number of studies (Liu and Ang 2007; Ang 2004; Ang and Zhang 2000).

From the researcher experience, the multiplicative and additive Log Mean Divisia Index method (LMDI) proposed by Ang and Liu (2001) should be the preferred method for the following reasons: it has a solid theoretical foundation; its adaptability; its ease of use and result interpretation; its perfect decomposition; there is no unexplained residual term; and its consistency in aggregation. Effects introduced in the LMDI can be in terms of activity effect, structure effect, intensity effect, energy mix effect, as well as emission factor effect. An example of LMDI effect could be explained as if the proportions of electricity-intensive sectors increased relative to those of less electricity-intensive sectors, the structural effect will be positive and hence the economic system will be considered more electricity intensive. Lastly, the effciency effect (also called either the intensity or technology effects in the literature) refers to the change in the level of intensity. A change in the effciency effect therefore refers to the weighted change in the level of electricity intensity.

Several recent research related with decompotition analysis particularly in residential sector is herein briefly discussed:

- Lotz and Blignaut (2011) worked on South Africa's electricity consumption using decomposition analysis. The authors conducted a sectoral decompotition analysis of the electricity consumption for the period 1993-2006 to determine the main drivers responsible for the increase. The result show that the increase was mainly due to output or production related factors, with structural changes playing a secondary role. The increasing at low rate electricity intensity was a decreasing factor to consumption. Another interesting finding also only 5 sectors' consumption was negatively affected by efficiency improvement.

- Study on residential energy use in Hongkong using the Divisia Decomposition analyisis was done by William Chung et al (2011). Using data of 1990-2007, the study evaluated the respective contributions of changes in the number of residentials, share of different types of residential residentials, efficiency gains, and climate condition to the energy use increase. The analysis reveals that the major contributor was the increase of the number of residentials, and the second major contributorwas the intensity effect.

- Achao and Schaeffer (2009) worked with decomposition analysis to measure the activity, intensity, and structure effects of variations in residential electricity consumption in Brezil for 1980-2007. The authors applied the Logarithmic mean Divisia Index (LMDI) to electricity consumption of the Brazilian residential sector, to explain its evolution in terms of the activity, structure, and intensity effects. Among the main results is measurement of the impact of government programs for income transfer and universal service on variations in residential consumption.

- Pachauri and Muller (2008) studied regional decomposition of domestic electricity consumption in India for 1098-2005. The study objective was to understand the relative importance of changes in the size of population and residentials, increases in connectivity, and changes in level of consumption per connected residential in rural and urban sector across regions of India. Among findings are rural residential access and use remains very low and most of past change is due to increase in connections and population, in urban areas population growth and increase in consumption per connected residentials explain most of the change, and huge regional variations in electrification achievements and consumption levels are relative importance of key drivers in explaining change.

CHAPTER III
RESEARCH OBJECTIVES AND BENEFITS

Regarding to the proposed research topic, there are no findings made publicly available under this topic for the case of Indonesia, to the researcher best knowledge. Hence, as this research observes residential electricity consumption trend in Indonesia, the study tries to obtain several findings on it as follows:

- Econometric based mathematic model which is suited to represent residential electricity consumption in Indonesia for 1990 – 2010.
- Forecasting on annual residential electricity energy consumption based on appropriate econometric model.
- Dominant contributors in terms of intensity, structural, and activity change which affect the residential electricity consumption in Indonesia for 2000 – 2010, through a factors decomposition analysis using Aritmetic Mean Divisia Index (AMDI) and Logarithmic Mean Divisia Index (LMDI), and compared the both methods. The analysis is performed through establishment of software tool that will be developed here as one of research activity. The analysis is taken into account total residential sector, i.e. factors decomposition for a whole residential sector and residential sub-sector, in which analysis is conducted for each residential tariff group to find the corresponding effect influencing electricity consumption in particular group.

Findings to be obtained from this research can be served as part of useful references, at least for the preliminary consideration to develop power sector policy in Indonesia for the next long term period after 2010, in conjunction to the economic growth projection as well as other important indicators. The residential sector is selected as the case study to deconstruct macro indicators contribution towards its electricity demand growth. For instance, the appropriate-well tested econometric model for the study period of 1990 – 2010 would provide the decison maker and government insight on how the selected macro indicators give their influence in developing residential electricity consumption pattern. Due to limitations of available data, we agree that to construct an appropriate model within considerably short time frame is the most challenging part, as the model is ussualy well developed using long time frame, such as 30 – 40 years. Therefore, not all proposed variables may be suited to be used in developing appropriate short-term model. Rather, the resulting econometric model would be likely containing well-tested variables that lineary matched with the circumstances during the study period. Forecasting on annual residential electricity consumption would also give additional advantage as utility may have better prediction to serve residential power demand. Similarly, factors decomposition provides explanation on changes that affect annual total residential electricity consumption. We can observe, for instance in particular household tarriff group, what kind of effect responsible in increasing or decreasing their consumption in a certain year. Here, the policy maker can use the findings to formulate appropriate strategy as a response to the increasing or decreasing power demand. The same approach can be utilized as well to another utility, in Indonesia case is PLN customer segment or for the whole electricity demand growth in Indonesia. By knowing the patterns as well as the dominant contributor to the electricity demand in the past period, the future certain macro indicators could be strived for its accomplishment so that the desired demand growth would be well planned.

CHAPTER IV
RESEARCH METHODOLOGY

This study can be classified into three broad stages, namely: preliminary stage, modeling stage, and reporting stage. Preliminary stage consists of: problem identification, problem definition and research scope, research objective, and literature review. Modeling stage consists of: data gathering, analysis and result whereas reporting stage will be covering conclusion, suggestion, and dissemination through publication. In this report, we seperate methodology based on two broad analysis. The first part discusses development of econometric model and forecasting whereas the second part involves factors decomposition analysis.

To begin working with both parts, relevant economic, social, and electrical data considered to have influence on constructing econometric model in the period of 1990 – 2010 are gathered as:

- Gross Domestic Product (GDP)
- Household expenditure as part of GDP
- Number of employment
- Bank Indonesia rate
- Inflation
- Number of residential
- Number of residential customer
- Electrification rate
- Total annual electricity consumption

As factors decomposition analysis requires several data for three residential tariff class, namely R1, R2, and R3, we breakdwon number of total residential customer and total annual electricity consumption into those classification since 1998 as the classification began. All data are collected from PLN and BPS, and those are enclosed in the appendix. The decomposition analysis is performed using AMDI and LMDI method, of which results obtained from both methods are then compared. The formula for both methods are given in the appendix, along with the explanation on how to use the program that developed in this research as a tool to calculate and analyze factors decomposition. For each part of the research work, the research stages, expected output, and measurable indicator are elaborated in the following table.

Table 3.1 Research stages for Econometric model and forecasting development

Research stages	Activity and Expected Output	Measurable Indicator
Problem identification	Observe residential electricity consumption trend in Indonesia; observe its relationship with power sector as well as national macro indicators.	Increasing electricity consumption in residential sector can be presented; List of possible macro indicator thought to affect it.

Problem definition and research scope	Determine the suggested method to capture macro indicators that affect electricity consumption in residential sector, Determine sufficient data time frame for analysis purposes, research target, and type of data	Mathematical model under Econometric method and a decomposition analysis Indicative study time frame of 1990– 2010 to analyze residential electricity consumption in Indonesia
Research objective	Determine the appropriate model for residential's electricity consumption, determine the macro indicators that affect electricity consumption in residential sector mostly and forecast all the variables in the future	Econometric model using Multiple Linear Regression model, Autoregressive Integrated Moving Average (ARIMA) and Autoregressive Conditional Heteroscedasticity (ARCH)/Generalized Autoregressive Conditional Heteroscedasticity (GARCH) Model
Literature review	Collect articles and relevant text books that have appropriate method related to the typical problem, further study regarding to the selected method and analysis.	Articles and textbooks or discussess econometric analysis for energy sector
Data gathering	Collect relevant data from PLN, BPS, Bank Indonesia, IMF as they will be served as final data	Availability of several macro indicators as they were appeared initially in earlier stage and have throughly been evaluated, for 1990-2010.
Analysis and Result	Develop an econometric model representing residential electricity consumption for 1990-2010 Econometric testing for validating the model Determine the best model in estimating and forecasting all variables	Establishment of a Multiple-Linear Regression Model, Autoregressive Integrated Moving Average (ARIMA) and Autoregressive Conditional Heteroscedasticity (ARCH)/Generalized Autoregressive Conditional Heteroscedasticity (GARCH) Model using Eviews. Appropriate parameter testing result includes R, R square, T, F, DW testing, Correlation test, White heteroscedasticity test, serial

		correlation LM test (Bruesch Godfrey Method), and normality test (Jarque-Berra-JB test), stationarity (unit root test-ADF test).
Conclusion and suggestion	Establish conclusion and suggestion which is retrieved from the analysis result/findings.	
Preparing research report and dissemination	Writing a research report draft and publication draft	Research report, article draft for publication in a journal

Table 3.2 Research stages for Factors Decomposition Analysis

Research stages	Activity and Expected Output	Measurable Indicator
Problem identification	Observe residential electricity consumption growth in Indonesia and analyze its relationship with Indonesian economic and power sector development	A graphical depiction of electricity consumption growth in residential sector during certain study period
Problem definition and research scope	Discussing evergrowing residential electricity consumption and correlate its growth with the factors thought to contribute, determine research scope that can be studied considering available data and methods	Preliminary list of factors thought to contribute national residential electricity consumption, a certain period of year to be adopted as study period,
Reserach objective	Research objectives are proceed through determine appropriate factors decomposition analysis through application of simple decomposition software tool that is developed in this research.	Several preliminary decomposition methods that will be selected later as the working method, establishment of a decomposition software tool
Literature review	Reading, observing journal articles, resources related to factors decomposition to highlight previous findings and study decomposition analysis methods and to select the most reliable/appropriate method.	A list of reference, articles, and resources related to the topic of decomposition analysis for energy sector, summary of related articles in the research report, choice of certain method to be applied in this research: factors decomposition using additive/multiplicative Log-Mean Divisia Index (LMDI), and to be compared to Arithmetic Mean Divisia Index (AMDI), obtain general decomposition equation and

		study further to modified the LMDI and AMDI equation model as the proposed model.
Data gathering	Collecting relevant data as required for the purpose of decoposition analysis, in which capturing activity, intensity, and structural effect, considering the whole residential and residential sub-sector classification.	Sets of annual data collecting from PLN and BPS during 1990 – 2010, which will be used for decomposition analysis for Residential and Residential sub-sector.
Result and analysis	Performing calculation / analysis through LMDI and AMDI methods using the selves-designed software tool, conducting analysis to compare and describe the results.	Establishment of total residential decomposition of electricity consumption for 1990 – 2010 and residential sub-sector decomposition for the same period using LMDI and AMDI, result comparison of both methods, Lists of numerical index for AMDI and LMDI method, graphical presentation of the total residential and residential sub-sector index involve intensity, activity, and structural effect
Conclusion and suggestion	Establish conclusion and suggestion which is retrieved from the analysis result/findings.	Remarks to explain role of decomposition effect to the increasing residential electricity consumption in Indonesia.
Preparing report and dissemination	Writing a research report draft and publication draft	Research report, article draft for publication in a journal or conference.

CHAPTER V
RESULT AND ANALYSIS

In this chapter, results regarding to residential electricity consumption growth are presented in terms of appropriate annual electricity consumption model and corresponding forecasting model based on econometric method as well as decomposition analysis. Under econometric method, the study period is taken into account 1990 – 2010 whereas for the purpose of decomposition analysis, the study time frame is taken 2000 – 2010. The increasing historical total residential annual electricity consumption growth in Indonesia up to 2010, which is the focus of this research, is presented in below.

Table 5.1. The historical residential annual electricity consumption in Indonesia

Year	Total Residential Electricity Consumption (MWh)	GDP (Million Rupiah)	Private Consumption Expenditure (Million Rupiah)
1990	8.785.293	195.597.200	106.312.300
1991	9.766.337	227.450.200	125.035.800
1992	11.199.029	259.884.500	135.880.300
1993	12.537.109	302.017.800	158.342.700
1994	14.460.106	382.219.700	221.119.300
1995	16.927.060	454.514.100	279.876.400
1996	19.610.853	532.568.000	325.585.300
1997	22.764.024	627.695.400	387.170.700
1998	24.835.703	955.753.500	647.823.600
1999	26.853.883	1.099.731.600	813.183.300
2000	30.538.269	1.389.769.900	856.798.300
2001	33.318.312	1.646.322.000	1.039.655.000
2002	33.978.744	1.821.833.400	1.231.964.500
2003	35.697.122	2.013.674.600	1.372.078.000
2004	38.579.255	2.295.826.200	1.532.888.300
2005	41.181.839	2.774.281.100	1.785.596.400
2006	43.748.580	3.393.216.800	1.668.718.895
2007	47.321.668	3.950.893.200	1.916.235.454
2008	50.182.040	4.948.688.397	2.234.595.269
2009	54.944.089	5.603.871.170	2.520.631.070
2010	59.823.487	5.501.126.146	2.863.609.098

Figure below presents total residential electricity consumption growth rate versus GDP growth in Indonesia. The graph shows that increasing electricity consumption growth rate in Indonesia is developed in the similar way with that shown by GDP growth rate. The annual percentage of electricity consumption growth rate is increased several-fold to the GDP growth rate in the respective year, except for some years. During the economic crisis period, i.e. 1997 – 1998, slower growth rate shown by residential electricity consumption is less compared to that shown by GDP. In addition, subsequent figure shows the increasing electricity consumption for total residential and sub-residential sector during 1990 – 2010. The residential sub-sector, which comprise of 3 group were classified started on 1998. However, for the purpose of decomposition analysis, the data taken into account started from 1990, which mean require data of 1989 in order to be involved in the calculation. Hence, residential sub-sector electricity consumption shown in the graph is started on 1989.

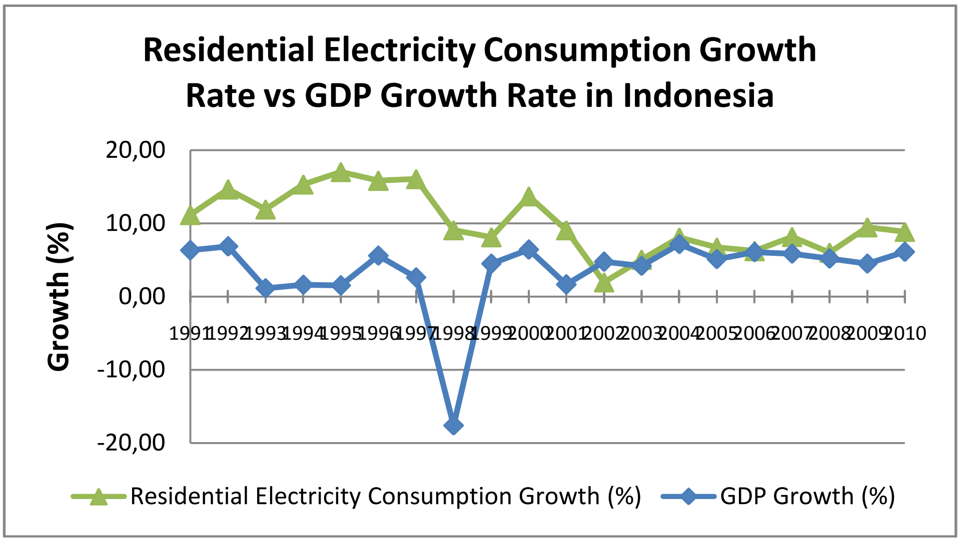


Fig. 5.1. Residential Electricity Consumption Growth Rate (1991 – 2010)

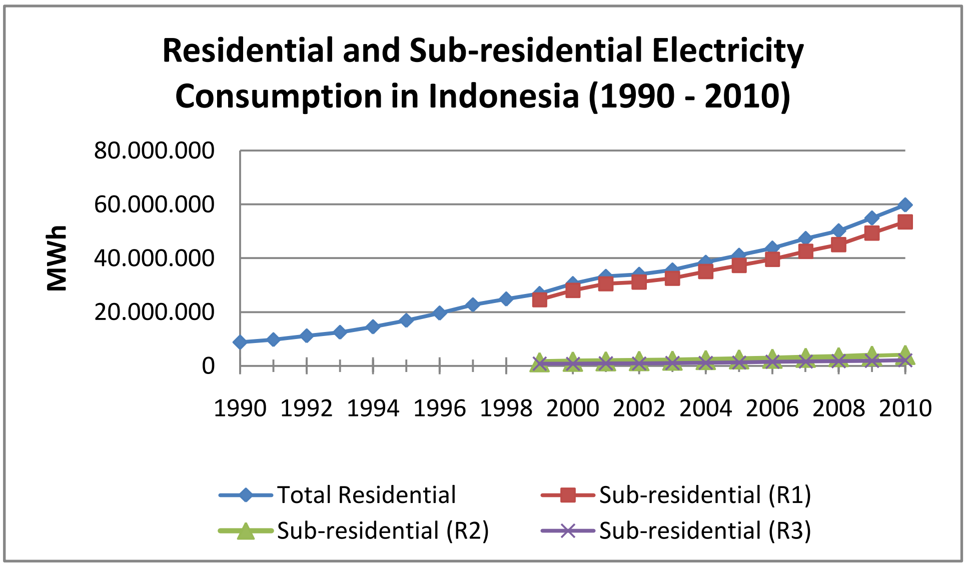


Fig. 5.2. Total residential and Residential sub-sector Electricity Consumption

As seen on Fig. 5.2., the total residential electricity consumption is primarily contributed by the R1 group, in which the biggest share of residential customer. Here, the main factors to influence electricity consumption in each residential group may not be the same as the consumption growth in fact are different one another.

As residential electricity consumption pattern is observed in two part, i.e. through econometric and decomposition analysis, the total residential electricity consumption model along with its forecasting model are analyze using econometric approach whereas factors to influence for both total residential as well as residential sub-sector are studied using decomposition analysis. Both parts are described belows.

V.1. Econometric Model

The first part of estimation, we constructed a multiple linear model given as:

$$TEC = \alpha + \beta_1 Emp + \beta_2 Res + \beta_3 ResCus + \beta_4 Pop + \beta_5 PriCons + \beta_6 ElctR + \beta_7 BIRate + \beta_8 GDP + \beta_9 Inf + \varepsilon$$

Where:

α	: constanta; β_1 , β_2 , β_3, β_4 , β_5 , β_6 , β_7 , β_8, β_9 : intercepts; ε : error term
TEC	: Total Energy Consumption
Emp	: Employment
Res	: Residents
$ResCus$	: Residential Customers
Pop	: Total number of population
$PriCons$	: Private Consumption
$ElctR$	: Electrification ratio
$BIRate$	: Bank Indonesia Rate
GDP	: Total Gross Domestic Product
Inf	: Inflation Rate

The first model was the general model in multiple linear models. Therefore, the next part was to test whether each variables had a problem in least square assumption or known as classical assumption. The first indicator should be tested on each variables was the multicollinearity. As we stated earlier, that the data series should not have a collinearity to each other. If there is a collinearity between the past data and the current data, then this series might not be able as a regressor and the estimation result will not be BLUE (Best Linear Unbiased Estimator).

V.1.1. Correlation Test

To check whether all variables have a multicollinearity problem, we used the correlation test. The results found that employment, total residents, and residential customers have a problem of collinearity. This value of collinearity of those variables are greater than 0.8. Therefore, we cannot use these variables in estimating the model. Meanwhile, the BI rate, Electrification ratio, GDP, Inflation, Population, and Private Consumption had collinearity value less than 0.8. According to these results, we concluded that only BI rate, Electrification ratio. GDP, Inflation, Population, and Private Consumption can be use as regressors in order to estimate the impact on the total energy consumption. The detail results of correlation test are provided in appendix.

V.1.2. White Heteroscedasticity Test

We applied two steps in testing heteroscedasticity problem on the model. First, we used the actual, fitted, and residual graph on the residual testing. The elaborated results from the graph given as:

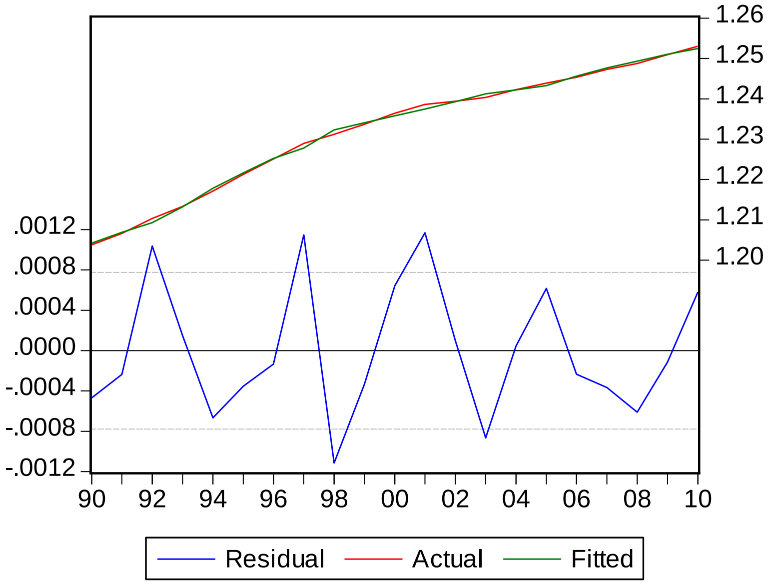


Fig. 5.3. The Actual, Fitted, Residual Graph Result

Figure 5.3. showed that the residual (blue line) is approximately constant and have no trend. This result confirmed us that there is no heteroscedasticity problem occurred in the model. Rather, all variables are homoscedastic.

The second step, we applied White Heteroscedasticity which is provided by Eviews program. The results found that p value observation* R^2 = 0,348489. This p value is greater than 0,05 (95% level of confidence) and we should accept null hypothesis which is no heteroscedasticity. This result also confirmed us that all variables are homoscedastic.

V.1.3. Serial Correlation LM Test

In order to determine whether the variables or regressors have an autocorrelation, we applied two steps. First, we checked t-statistic value, F-value, and Durbin Watson (DW) value particularly. From the estimation result (Table 5.2 below), we found that DW statistic is 1,892522 where is closely to 2 but still less than 2. This result confirmed that the problem of autocorrelation is might not be very significant because the DW statistic is almost 2.

Second, we applied the Serial Correlation LM Test (Bruesch Godfrey Method). The result is p value observation* R^2 = 0,001362. This p value is less than 0,05 (95% level of confidence) and even 0,01. Therefore, we should reject null hypothesis that is no autocorrelation. In conclusion, the model had an autocorrelation problem.

Now we tried to redeem the autocorrelation problem. The first way was to re-construct the model into logarithm normal form. To do so, we changed the form of each variables into logarithm normal form and re-run the estimation testing. After we did the estimation, the result is given in Table 5.2 below. The DW statistic is a little bit higher than before which now is 1,965824. However, the value is still less than 2. The next way was to change the form of regressors into first difference. After we re-estimated and re-runed the first difference model, the result found that, there is no autocorrelation problem.

V.1.4. Normality Test

The research had a limitation on data period. We only had 21 observations, which is less than 30 observation (normaly number of observation). Therefore, we applied normality test in order to determine whether the error term is normaly distributed (least square assumption). To do the normality test, we utilized the Jarque-Bera Test and histogram. The result found that p value of Jarque-Bera Test is 0,602798 which is greater than 0,05 (95% level of confidence). Therefore, we cannot reject null hypothesis that is the error term has normaly distributed. In conclusion, the error term of the model is normaly distributed. The result given as seen on Figure 5.4 below:

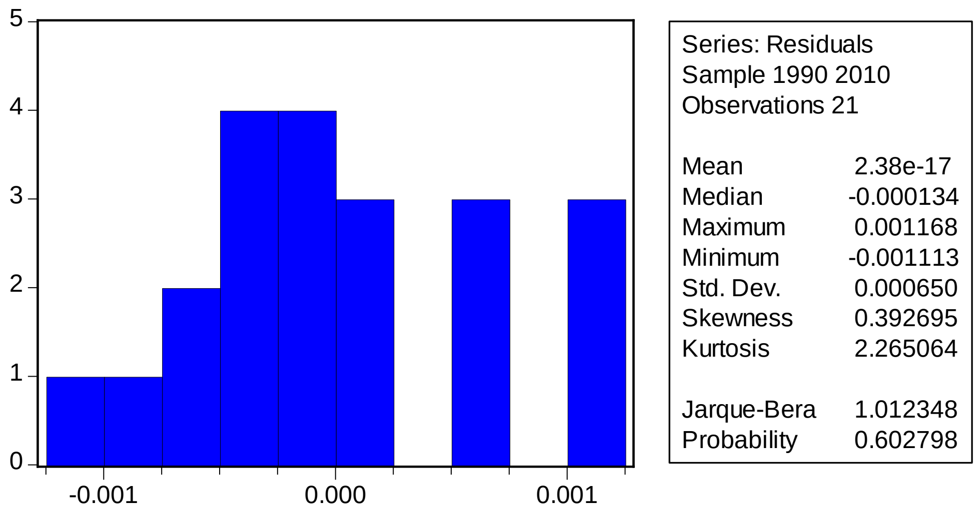


Fig. 5.4. The Histogram-Normality Test Result

V.1.5. Estimation

After we determined all least square assumptions namely multicollinearity, heteroscedasticity, autocorrelation, and normality, the result confirmed that the research model is relatively become the best estimator in terms of estimating the total energy consumption using a regression method. Therefore, we provide the result of final estimation in Table 5.2 below.

Table 5.2. The estimation results

Variables	Model 1	Model 2
C	-5.707133 (-0.406615)	-0.339025 (-0.334382)
BI Rate	-0.046825 (-1.281687)	-0.006906 (-1.529439)
Electrification Ratio	0.740182** (5.543516)	0.158202** (5.964230)
GDP	0.104364 (1.401251)	0.152207 (1.583736)
Inflation	0.006798 (0.469427)	0.001049 (0.901230)
Population	0.734259 (0.937171)	0.786775 (0.936861)
Private Consumption	0.187530* (2.938624)	0.208004* (2.626346)
R-squared	0.998048	0.998151
Adjusted R-squared	0.997211	0.997359
Durbin-Watson stat	1.892522	1.965824
Akaike info criterion	-3.838870	-11.22037
Schwarz criterion	-3.490696	-10.87220
Prob(F-statistic)	0.000000	0.000000

** Significant at level 0.01
* Siginficant at level 0.05

According to the results, we found that the t-statistic of BI rate, GDP, Inflation, and population are less than 1,96 and the probability of these variables are greater than 0,05 (95% level of significance). These results indicate the acception of null hypotheses which is there is no different between BI rate, GDP, inflation and population to the total energy consumption. We concluded that BI rate, GDP, inflation and population were not significantly affecting the total energy consumption.

Meanwile, the t-statistic of electrification ratio and private consumption were greater than 1,96 and the probability was less than 0,05 (95% level of significance). Therefore, we concluded that only electrification ratio and private consumption were significantly affecting to total energy consumption in Indonesia.

However, the R-squared of the model was very high which is 0,998151. It means that the model is the best predictor in estimating the dependent variable. In conclusion, total energy consumption had strongly influenced by the electrification ratio and private consumption. The final equation given as follows:

$$TEC = -0{,}3390 - 0{,}0069\, BIRate + 0{,}1582\, ElctR + 0{,}1522\, GDP + 0{,}0010\, Inf + 0{,}7867\, Pop + 0{,}2080\, PriCon$$

There were several interesting findings from the result equation. First, the coefficient of BI rate showed a negative relationship. It means that if BI rate tends to decrease then total energy consumption will increase. It also confirmed that as a theorethical analysis, BI rate has become a main anchor to analyze the macroeconomic performance. The theory says that when the interest rate tends to fall it will generate high investment including in real sectors. This theory assumed that investors utilize loanable fund from banking system or other financial institutions. In addition, when interest rates decrease then the cost of capital, which is equal to loanable fund, will also tend to decrease. Investors attempt to boost up their investment either in real sector or in financial sector. Furthermore, when the total investment is high, it will also generate new investment in energy contruction in order to expand the energy supply and its capacity. Finally, when the supply of energy increases it will affect the demand for energy to become increase. In terms of supply and demand analysis, when supply getting up the demand also move in the same way in order to keep the price in the same level. Therefore, these concepts are fitted with the research finding. However, BI rate found to be statistically not significant in affecting total energy consumption.

Second, the coefficient of electrification ratio found to be a positive relationship. Since the estimation results confirmed that, the electrification ratio was statistically significant in affecting the total energy consumption, therefore the relationship become more meaningful. The concept stated that the energy consumption would move up as the electrification ratio rose up. The demand for energy occurred when people were realized how important the electricity was in their daily life. When the number of customers increased relatively then it will push up the demand for energy consumption. The result finding was confirmed these concepts particularly.

Third, a positive relationship founded in GDP and total energy consumption. According to the basic concept in consumer behavior, when total income tend to increase then it will moved up the total utility. Satisfaction occurred when the total number of product or services that we consumed is increase. John Maynard Keynes introduced this theory in terms of consumer behavior. GDP is the total income in such a country, which also identify as the total income of people in Indonesia as an aggregate concept. When GDP tend to increase, people will spend their additional income relatively in consumption activity rather than investment. Therefore, the consumption in total energy will tend to increase particularly. However, the result could not statistically confirm that GDP was significant in affecting total energy consumption.

Fourth, there was a positive relationship between inflation and total energy consumption. The result was unexpected regarding to the basic concept and theory. The theory stated that inflation causes the declines in real income. Consumers could not afford to fulfill their consumption or daily needs. It will affect the declines in total consumption including total energy. Therefore, the expected result was a negative rather than a positive relationship.

Fifth, a positive relationship occurred between number of population and total energy consumption. It was clearly become the expected result regarding the basic theory. It is obvious that additional number of population will cause the shock in total consumption. However, the result could not statistically confirm it.

Sixth, there was a positive relationship between private consumption and total energy consumption. This result also confirmed that households become one of the important parties in macroeconomics point of view. Private consumption is the household's total consumption in terms of aggregate concept. Other consumptions are investments, government expenditure and international activity such as export and import. In conclusion, the result confirmed that private consumption was statistically significant in affecting the total energy consumption.

According to the final equation result, we continued to forecast the total energy consumption by using the research period as the sample of forecasting. We can see from Figure 5.5 below, the root mean squared error (RMSE) and theil inequality coefficient are very small which is 0,000635 and 0,000257. It means that the model had a strong power to predict in the future because of the error term are very small. It is one of the purposes of regression method, which is minimizing the error term.

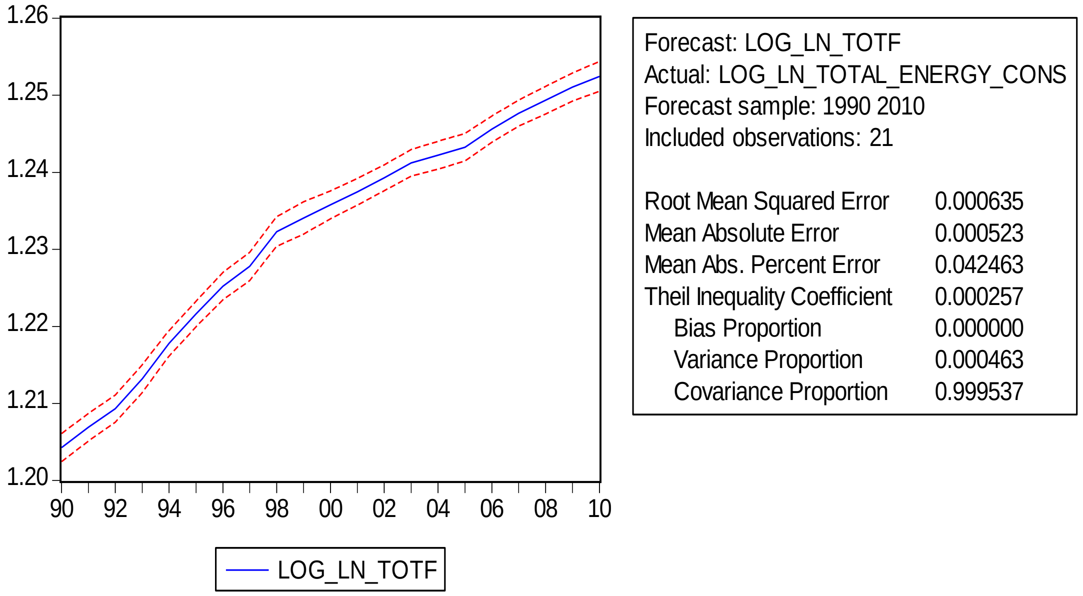


Fig. 5.5. The forecasting result of total energy consumption by using the multiple linear regression model

V.2. Forecasting Model

V.2.1. ARIMA Model

The research used the Box-Jenkins method in order to forecast each variable in the model by itself. In forecasting, first we assumed that all variables could be forecasted by other variables not just by the variable itself. The second assumption was the current value of each variable could be affected by the past value of the variable. These two assumption are known as the autoregressive distributed lag model (ADL model). Nevertheless, the paper had a limitation of data observation, which is stated earlier. Therefore, we could not utilize the autoregressive distributed lag model in order to estimate and forecast the total energy consumption. However, we continued to forecast by using the simple Box-Jenkins method that is autoregressive (AR) model, moving average (MA) model, and the integrated and combination of AR and MA model, namely ARIMA model.

First, we constructed the autoregressive (AR) model and moving average (MA) model. In order to construct the model, we had to check the stationarity of each variable by using the unit root test. We applied the Augmented-Dickey Fuller Test to test the stationarity of each variable. The result found that all variables, total energy consumption, electrification ratio, GDP, inflation, population, private consumption, and BI rate are stationary at first difference with trend and intercept (95% level of confidence). These results indicated that we could continue to forecast using the autoregressive dan moving average model.

After we checked the stationarity, then we determined the lag of autoregressive (AR) model by using the correlogram test. The summary of the results given as follows:

Table 5.3. Summary of ARIMA Model

Variables	Model Results
BI rate	ARIMA (0,1,1) or IMA (1,1)
Electrification ratio	ARIMA (1,1,0) or ARI (1)
GDP	no available model
Inflation	ARIMA (0,1,1) or IMA (1,1)
Population	no available model
Private consumption	no available model
Total energy consumption	ARIMA (0,1,1) or IMA (1,1)

Table 5.3. showed that the best model in forecasting each variable are choosen from many alternatives models. For example, we found that there are two best alternatives model for inflation. There are ARIMA (1,1,0) and ARIMA (0,1,1). In order to determine which model is the best one, then we should apply the residual test with correlogram Q-statistic to test the autocorrelation. The result was not significant or in other words that there is no autocorrelation. Further, we continued to check the error term by using the Schwarz-Criterion. The smallest value is preferable. The result confirmed that ARIMA (0,1,1) is the best model in forecasting inflation. The similar interpretation is applicable to all variables. The detail results of estimation are provided in appendix.

V.2.2. ARCH/GARCH Model

The research also utilized the ARCH/GARCH model in order to forecast each variable. The main assumption in forecasting through this model is ignoring the violation of homoscedasticity. In addition, if the data series found to have heteroscedasticity problem, then we can continue to forecast using the ARCH/GARCH model. According to one of our purposes that are, find the best model in forecasting, therefore we also applied this model into our estimation and forecasting.

First, we had to check the volatility of each variable. This volatility called as the ARCH effect. We used the residual test namely ARCH LM test. If the result found that the variable significantly proved had a volatility or ARCH effect then we continued to estimate the variable using the ARCH model. The summary of the results given as follows:

Table 5.4. Summary of ARCH/GARCH Model

Variables	ARCH/GARCH Effect	Model Results
BI rate	No	-
Electrification ratio	Yes	ARCH (1) and GARCH (1), α = 0,1
GDP	Yes	ARCH (1) and GARCH (1), α = 0,1
Inflation	Yes	ARCH (1) and GARCH (1), α = 0,1
Population	No	-
Private consumption	No	-
Total energy consumption	Yes	ARCH (1) and GARCH (1), α = 0,1

Table 5.4. showed that electrification ratio, GDP, inflation, and total energy consumption had the ARCH effect and the best model in forecasting are ARCH (1) and GARCH (1) in terms of 10% level of confidence. These results also confirmed that each of variables could affect the variable itself. The detail results are provided in appendix.

V.3. Factors Decomposition for Total Residential Sector

In this section, total residential electricity consumption for 1990 – 2010 is decomposed using AMDI and LMDI methods. The general equation of energy decomposition is given in the appendix. If it is applied for the case of residential electicity consumption decomposition, we should note that the general equation is considered suitable for a system with 100% electrification rate. For the case of Indonesia, of which having less than 100% electrification rate, we modifiy the general equation as:

$$E_i = \sum e_{it} \,.\, s_{it} \,.\, Y_t$$

$$E_i = \sum \frac{E_{it}}{adj\ Y_{it}} \,.\, \frac{adj\ Y_{it}}{Y_t} \,.\, Y_t$$

$$adj\ Y_{it} \equiv \frac{N_{elect\ t}}{N_t} \times Y_{it}$$

To determine the structural, intensity, and activity effect under AMDI and LMDI, the calculation for both methods needs several variables: GDP (Y), Number of total residential (N), Number of residential customer or electrified household (N_{elect}), Total residential electricity consumption (Ei), and residential GDP or private expenditure (Yi). The purpose of modifying the general equation is to adjust Residential GDP (Yi) that taken into account both electrified and unelectrified households becomes Adjusted-Yi, which is an approximation value to Yi, obtained from the ratio of N_{elect} to N multiply with Yi. Fig. 5.3. shows entered and calculated data required for further decomposition process of Indonesia's residential electricity consumption.

Year	Decomposition of Energy							
	Y	N	N_{elect}	Household				
				Ei	Yi	adj Yi	ei	si
2000	1.389.769.900,00	52.008.300,00	26.796.675,00	30.538.269,00	856.798.300,00	441.455.413,57	0,0692	0,3176
2001	1.646.322.000,00	53.560.200,00	27.905.482,00	33.318.312,44	1.039.655.000,00	541.672.247,09	0,0615	0,3290
2002	1.821.833.400,00	55.041.000,00	28.903.325,00	33.978.744,15	1.231.964.500,00	646.933.564,65	0,0525	0,3551
2003	2.013.674.600,00	55.623.000,00	29.997.554,00	35.697.121,64	1.372.078.000,00	739.963.394,59	0,0482	0,3675
2004	2.295.826.200,00	58.253.000,00	31.095.970,00	38.579.255,40	1.532.888.300,00	818.269.421,15	0,0471	0,3564
2005	2.774.281.100,00	59.927.000,00	32.174.924,00	41.181.838,57	1.785.596.400,00	958.690.214,17	0,0430	0,3456
2006	3.393.216.800,00	55.942.000,00	33.118.262,00	43.748.579,82	1.668.718.895,12	987.899.423,92	0,0443	0,2911
2007	3.950.893.200,00	57.006.400,00	34.684.540,00	47.321.668,41	1.916.235.454,00	1.165.899.710,45	0,0406	0,2951
2008	4.948.688.397,22	57.716.100,00	36.025.071,00	50.182.040,30	2.234.595.269,00	1.394.783.313,88	0,0360	0,2818
2009	5.603.871.170,00	58.421.900,00	37.099.830,00	54.944.088,72	2.520.631.069,82	1.600.683.719,34	0,0343	0,2856
2010	5.501.126.146,00	61.363.100,00	39.324.520,00	59.823.486,56	2.863.609.098,33	1.835.142.834,37	0,0326	0,3336

Fig. 5.3. Entered and Calculated Data for Energy Decomposition for Residential Electricity Consumption for AMDI and LMDI methods.

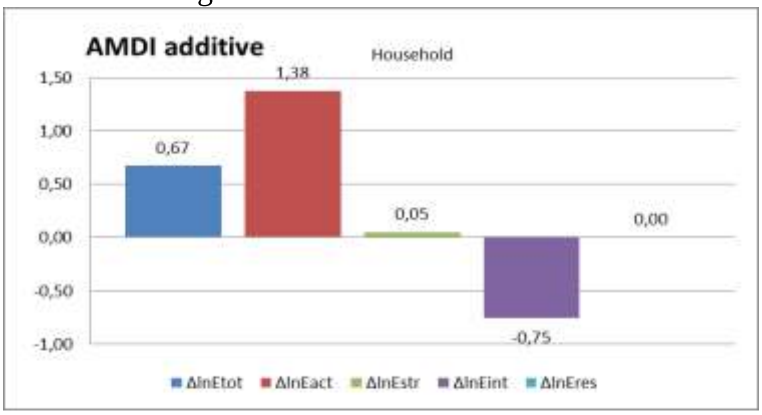
In this research, the AMDI and LMDI analysis are conducted for both additive and multiplicative form. The output given by the tool for both methods are presented in the followings.

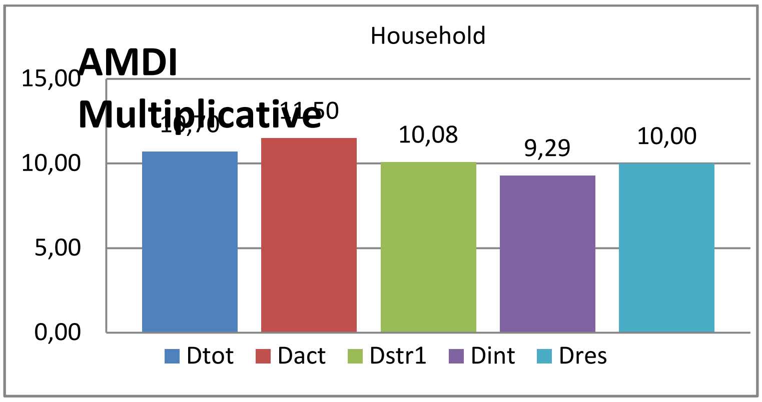
Year	Arithmetic Mean Divisia									
	Additive					Multiplicative				
	ΔlnE_{tot}	ΔlnE_{act}	ΔlnE_{str}	ΔlnE_{int}	ΔlnE_{res}	D_{tot}	D_{act}	D_{str}	D_{int}	D_{res}
2000-2001	0,0871	0,1694	0,0352	-0,1175	0,0000	1,0910	1,1846	1,0358	0,8892	1,0000
2001-2002	0,0196	0,1013	0,0763	-0,1580	0,0000	1,0198	1,1066	1,0793	0,8539	1,0000
2002-2003	0,0493	0,1001	0,0342	-0,0850	0,0000	1,0506	1,1053	1,0348	0,9185	1,0000
2003-2004	0,0776	0,1311	-0,0305	-0,0229	0,0000	1,0807	1,1401	0,9699	0,9773	1,0000
2004-2005	0,0653	0,1893	-0,0309	-0,0931	0,0000	1,0675	1,2084	0,9696	0,9111	1,0000
2005-2006	0,0605	0,2014	-0,1714	0,0304	0,0000	1,0623	1,2231	0,8425	1,0309	1,0000
2006-2007	0,0785	0,1522	0,0135	-0,0872	0,0000	1,0817	1,1644	1,0136	0,9165	1,0000
2007-2008	0,0587	0,2252	-0,0459	-0,1206	0,0000	1,0604	1,2525	0,9551	0,8864	1,0000
2008-2009	0,0907	0,1243	0,0134	-0,0470	0,0000	1,0949	1,1324	1,0134	0,9541	1,0000
2009-2010	0,0851	-0,0185	0,1552	-0,0516	0,0000	1,0888	0,9817	1,1679	0,9497	1,0000
Total	0,6724	1,3758	0,0490	-0,7524	0,0000	10,6978	11,4991	10,0819	9,2876	10,0000

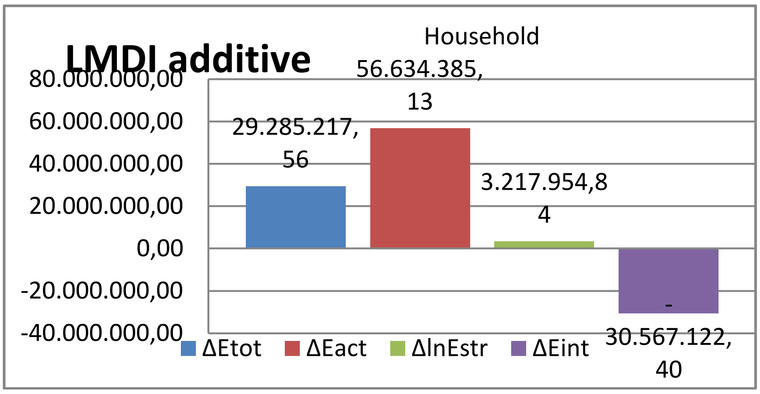
Year	Log-Mean Divisia							
	Additive				Multiplicative			
	ΔE_{tot}	ΔE_{act}	ΔE_{str}	ΔE_{int}	D_{tot}	D_{act}	D_{str}	D_{int}
2000-2001	2.780.043,4400	5.405.409,5772	1.122.481,5352	-3.747.847,6725	1,0910	1,1846	1,0358	0,8892
2001-2002	660.431,7100	3.408.474,6373	2.566.723,2639	-5.314.766,1913	1,0198	1,1066	1,0793	0,8539
2002-2003	1.718.377,4900	3.487.191,8627	1.192.583,0089	-2.961.397,3817	1,0506	1,1053	1,0348	0,9185
2003-2004	2.882.133,7600	4.867.543,6735	-1.133.654,4400	-851.755,4735	1,0807	1,1401	0,9699	0,9773
2004-2005	2.602.583,1700	7.546.662,5314	-1.232.769,5130	-3.711.309,8484	1,0675	1,2084	0,9696	0,9111
2005-2006	2.566.741,2500	8.549.325,3231	-7.275.209,2670	1.292.625,1940	1,0623	1,2231	0,8425	1,0309
2006-2007	3.573.088,5900	6.925.218,0403	614.597,8042	-3.966.727,2545	1,0817	1,1644	1,0136	0,9165
2007-2008	2.860.371,8900	10.974.836,0637	-2.238.768,5652	-5.875.695,6086	1,0604	1,2525	0,9551	0,8864
2008-2009	4.762.048,4200	6.530.959,6333	701.589,7650	-2.470.500,9783	1,0949	1,1324	1,0134	0,9541
2009-2010	4.879.397,8400	-1.061.236,2147	8.900.381,2445	-2.959.747,1898	1,0888	0,9817	1,1679	0,9497
Total	29.285.217,5600	56.634.385,1280	3.217.954,8366	-30.567.122,4045	10,6978	11,4991	10,0819	9,2876

Fig. 5.4. Result of AMDI (above) and LMDI (below) result for both additive and multiplicative form.

Using LMDI additive-technique, we find total residential electricity consumption (ΔE_{tot}) in the period 1990 – 2010 became 29.285,2 GWh. The activity effect (ΔE_{act}) which is based GDP changes is the dominant factors contributing electricity consumption growth with 56.634,3 GWh. Insignificant contribution to the increasing electricity consumption was given by the structural effect (ΔE_{str}), changes in portion of household expenditure to the GDP, with 3.217.9 GWh in aggregate. On the other hand, intensity changes (ΔE_{int}) has consistently shown yearly negative value throughout the study period except for 2005 – 2006. This reveals that the intensity change, which is considered to be due to efficiency improvements, has shown its contribution for a decrease of 30.567 GWh. In multiplicative-LMDI, D_{tot}, which is the ratio of E_t – E_{t-1} obtained from multiplication of D_{act}, D_{str}, and D_{int} can be observed without resulting residual variable. The method confirms that the intensity changes is the lowest compared to other changes. Comparison of AMDI and LMDI method in graphical presentation in the period 1990 – 2010 are given in the followings.







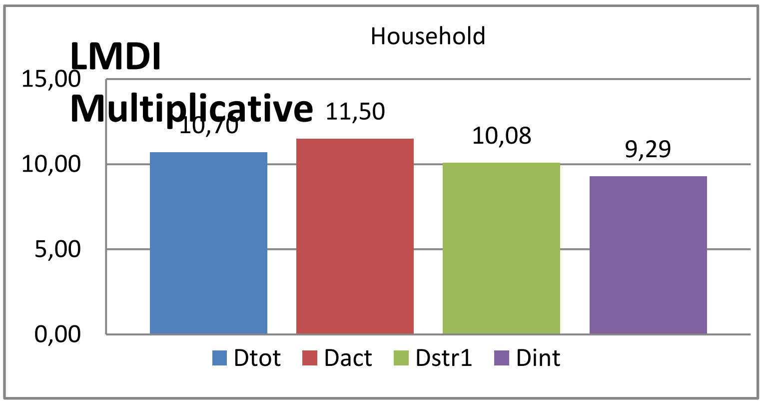


Fig. 5.5. Graphical illustration for AMDI and LMDI additive and multiplicative form of Indonesia's total residential electricity decomposition

V.4. Factors Decomposition for Residential Sub-sector

To proceed Indonesia's residential sub-sector factor decomposition which consists of three groups – R1, R2, and R3, several general variables are required to be entered in the tool, such as: GDP (Y_{nas}), Total residential or private expenditure (Y), Number of total residential (N), Number of PLN's residential customer (N_{elect}), as well as residential sub-sector variables, such as Number of R1/R2/R3-residential customer (Ni) and R1/R2/R3-residential electricity consumption (Ei). Total residential electricity consumption (E) will be determined as summation of R1, R2, and R3-residential electricity consumption (Ei). Fig. 5.6. shows entered required data for processing residential-sub sector decomposition and preliminary calculated data (in black color cell) for both general required variables and and sub-sector's variables. Only R1-

residential sub-sector is shown on the figure to represent other sub-sectors in similar manner. Equations to calculate variables for R1 (H1), Yi, ei, s1, s2, s3, and also applies similarly to R2 and R3 are:

$$E_{R1} = \sum e_{R1\,t} \,.\, s1_{R1\,t} \,.\, s2_{R1\,t} \,.\, s3_{R1\,t} \,.\, Y_{nas\,t}$$

$$E_{R1} = \sum \frac{E_{R1\,t}}{Y_{R1\,t}} \cdot \frac{Y_{R1\,t}}{Y_{elect\,t}} \cdot \frac{Y_{elect\,t}}{Y_t} \cdot \frac{Y_t}{Y_{nas\,t}} . Y_{nas\,t} \quad , \quad Y_{R1} \equiv \frac{N_{R1}}{N} \times Y \quad , \quad Y_{elect} \equiv \frac{N_{elect}}{N} \times Y$$

Year	Y_{nas}	E	Y	N	N_{elect}
2000	1.389.769.900,00	30.538.269,00	856.798.300,00	52.008.300,00	26.796.675,00
2001	1.646.322.000,00	33.318.312,44	1.039.655.000,00	53.560.200,00	27.905.482,00
2002	1.821.833.400,00	33.978.744,15	1.231.964.500,00	55.041.000,00	28.903.325,00
2003	2.013.674.600,00	35.697.121,64	1.372.078.000,00	55.623.000,00	29.997.554,00
2004	2.295.826.200,00	38.579.255,40	1.532.888.300,00	58.253.000,00	31.095.970,00
2005	2.774.281.100,00	41.181.838,57	1.785.596.400,00	59.927.000,00	32.174.924,00
2006	3.393.216.800,00	43.748.579,82	1.668.718.895,12	55.942.000,00	33.118.262,00
2007	3.950.893.200,00	47.321.668,41	1.916.235.454,00	57.006.400,00	34.684.540,00
2008	4.948.688.397,22	50.182.040,30	2.234.595.269,00	57.716.100,00	36.025.071,00
2009	5.603.871.170,00	54.944.088,72	2.520.631.069,82	58.421.900,00	37.099.830,00
2010	5.501.126.146,00	59.823.486,56	2.863.609.098,33	61.363.100,00	39.324.520,00

H1						
Ni	Ei	Yi	ei	s1	s2	s3
26.484.133,00	28.063.539,00	436.306.515,14	0,0643	0,9883	0,5152	0,6165
27.553.000,00	30.581.615,23	534.830.232,43	0,0572	0,9874	0,5210	0,6315
28.556.684,00	31.161.756,13	639.174.813,79	0,0488	0,9880	0,5251	0,6762
29.629.557,00	32.610.638,86	730.885.844,16	0,0446	0,9877	0,5393	0,6814
30.701.676,00	35.078.627,38	807.893.841,19	0,0434	0,9873	0,5338	0,6677
31.743.229,00	37.325.639,51	945.827.347,05	0,0395	0,9866	0,5369	0,6436
32.660.655,00	39.555.721,49	974.249.260,40	0,0406	0,9862	0,5920	0,4918
34.183.894,00	42.532.237,03	1.149.070.799,74	0,0370	0,9856	0,6084	0,4850
35.482.955,00	45.049.197,03	1.373.794.199,07	0,0328	0,9850	0,6242	0,4516
36.511.814,00	49.298.803,21	1.575.313.585,90	0,0313	0,9842	0,6350	0,4498
38.672.726,00	53.527.188,87	1.804.725.804,77	0,0297	0,9834	0,6408	0,5205

Fig. 5.6. Entered and calculated required data for R1-residential-sub sector decomposition

Outputs given by the tool are determined based on additive and multiplicative form. Fig. 5.7. presents the tool output for R1-residential sub-sector electricity decomposition whereas output calculated for R2 and R3 are included in the appendix.

Year	Arithmetic Mean Divisia													
	Additive							Multiplicative						
	ΔlnE_{tot}	ΔlnE_{act}	ΔlnE_{str1}	ΔlnE_{str2}	ΔlnE_{str3}	ΔlnE_{int}	ΔlnE_{res}	D_{tot}	D_{act}	D_{str1}	D_{str2}	D_{str3}	D_{int}	D_{res}
2000-2001	0,0859	0,1870	-0,0009	0,0102	0,0221	-0,1081	-0,0244	1,0897	1,1683	0,9991	1,0103	1,0223	0,8976	1,0070
2001-2002	0,0188	0,1635	0,0006	0,0072	0,0628	-0,1463	-0,0690	1,0190	1,0974	1,0006	1,0072	1,0648	0,8639	1,0016
2002-2003	0,0454	0,1227	-0,0003	0,0244	0,0070	-0,0811	-0,0272	1,0465	1,0960	0,9997	1,0247	1,0070	0,9221	1,0039
2003-2004	0,0730	0,0913	-0,0004	-0,0093	-0,0185	-0,0248	0,0347	1,0757	1,1269	0,9996	0,9907	0,9817	0,9755	1,0065
2004-2005	0,0621	0,1431	-0,0007	0,0052	-0,0333	-0,0867	0,0345	1,0641	1,1875	0,9993	1,0053	0,9672	0,9169	1,0057
2005-2006	0,0580	0,0268	-0,0004	0,0885	-0,2436	0,0257	0,1610	1,0597	1,2000	0,9996	1,0925	0,7838	1,0261	1,0055
2006-2007	0,0726	0,1488	-0,0006	0,0247	-0,0125	-0,0834	-0,0045	1,0752	1,1470	0,9994	1,0250	0,9876	0,9200	1,0072
2007-2008	0,0575	0,1604	-0,0006	0,0229	-0,0642	-0,1088	0,0477	1,0592	1,2242	0,9994	1,0232	0,9378	0,8969	1,0059
2008-2009	0,0901	0,1228	-0,0007	0,0155	-0,0035	-0,0419	-0,0020	1,0943	1,1181	0,9993	1,0156	0,9965	0,9589	1,0093
2009-2010	0,0823	0,1218	-0,0007	0,0082	0,1309	-0,0481	-0,1298	1,0858	0,9836	0,9993	1,0082	1,1398	0,9531	1,0086
Total	0,6457	1,2883	-0,0045	0,1975	-0,1529	-0,7035	0,0208	10,6692	11,3489	9,9955	10,2026	9,8885	9,3309	10,0611

Log-Mean Divisia											
Additive						Multiplicative					
ΔE_{tot}	ΔE_{act}	ΔE_{str1}	ΔE_{str2}	ΔE_{str3}	ΔE_{int}	D_{tot}	D_{act}	D_{str1}	D_{str2}	D_{str3}	D_{int}
2.518.076,23	4.964.352,09	-28.710,27	326.523,31	704.368,70	-3.448.457,60	1,0897	1,1846	0,9990	1,0112	1,0243	0,8890
580.140,90	3.127.198,85	19.946,17	242.686,80	2.112.224,10	-4.921.915,02	1,0190	1,1066	1,0006	1,0079	1,0708	0,8526
1.448.882,73	3.191.828,36	-8.857,05	849.327,05	242.244,74	-2.825.660,37	1,0465	1,1053	0,9997	1,0270	1,0076	0,9152
2.467.988,52	4.436.132,43	-14.125,50	-346.294,46	-686.883,99	-920.839,96	1,0757	1,1401	0,9996	0,9898	0,9799	0,9731
2.247.012,13	6.850.822,35	-27.033,07	209.094,32	-1.328.196,29	-3.457.675,17	1,0641	1,2084	0,9993	1,0058	0,9640	0,9089
2.230.081,98	7.739.271,23	-15.593,36	3.754.953,55	-10.340.832,05	1.092.282,60	1,0597	1,2231	0,9996	1,1026	0,7641	1,0288
2.976.515,54	6.242.649,23	-25.671,90	1.122.516,06	-568.494,73	-3.794.483,13	1,0752	1,1644	0,9994	1,0277	0,9862	0,9117
2.516.960,00	9.858.117,40	-27.283,53	1.118.476,28	-3.129.444,21	-5.302.905,94	1,0592	1,2525	0,9994	1,0259	0,9310	0,8859
4.249.606,18	5.861.413,87	-38.365,90	812.852,95	-183.189,29	-2.203.105,46	1,0943	1,1324	0,9992	1,0174	0,9961	0,9543
4.228.385,66	-950.851,43	-37.877,10	468.519,23	7.506.086,35	-2.757.491,39	1,0858	0,9817	0,9993	1,0092	1,1573	0,9478
25.463.649,87	51.320.934,39	-203.571,51	8.558.655,08	-5.672.116,66	-28.540.251,44	10,6692	11,4991	9,9950	10,2245	9,8814	9,2673

Fig. 5.7. AMDI and LMDI output of R1-residential sub-sector electricity decomposition

In the case of R1-residential sub-sector, ΔE_{tot} is obtained 25.463,6 GWh using LMDI-additive method. If we sum up all residential sub-sector, we will find that ΔE_{tot} is equal to $\Delta E_{tot}(R1) + \Delta E_{tot}(R2) + \Delta E_{tot}(R3)$. However, the changes found in each sub-sector decomposition should not be summed due to reciprocal addition rule. In the case of R1, $\Delta E_{tot}(R1)$, which is 25.463,6 GWh is affected by 2 positive changes, i.e. activity changes (ΔE_{act}), obtained for 51.320,9 GWh, and second-term structural changes (ΔE_{str2}), obtained for 8.558,6 GWh. In other sub-sectors (results included in the appendix), which are R2 and R3, increasing electricity consumption was not only contributed by ΔE_{str2}, but also by ΔE_{str1}. It implies that increasing electricity consumption in R1 is indirectly caused by the positive trend of electrified-residential expenditure whereas in R2 and R3, electricity consumption growth are also due to increasing R2 and R3 expenditure, as in the following modified general equations:

$$E_i = \sum e_{it} \, . \, s1_{it} \, . \, s2_{it} \, . \, s3_{it} \, . \, Y_t \,, \qquad E_i = \sum \frac{E_{it}}{Y_{it}} \cdot \frac{Y_{it}}{Y_{elect\,t}} \cdot \frac{Y_{elect\,t}}{Y_t} \cdot \frac{Y_t}{Y_{nas\,t}} \cdot Y_{nas\,t}$$

The residential sub-sectoral additive and multiplicative decomposition for AMDI and LMDI are enclosed in the appendix. Meanwhile, results comparison between two methos are graphically depicted in Fig. 5.8.

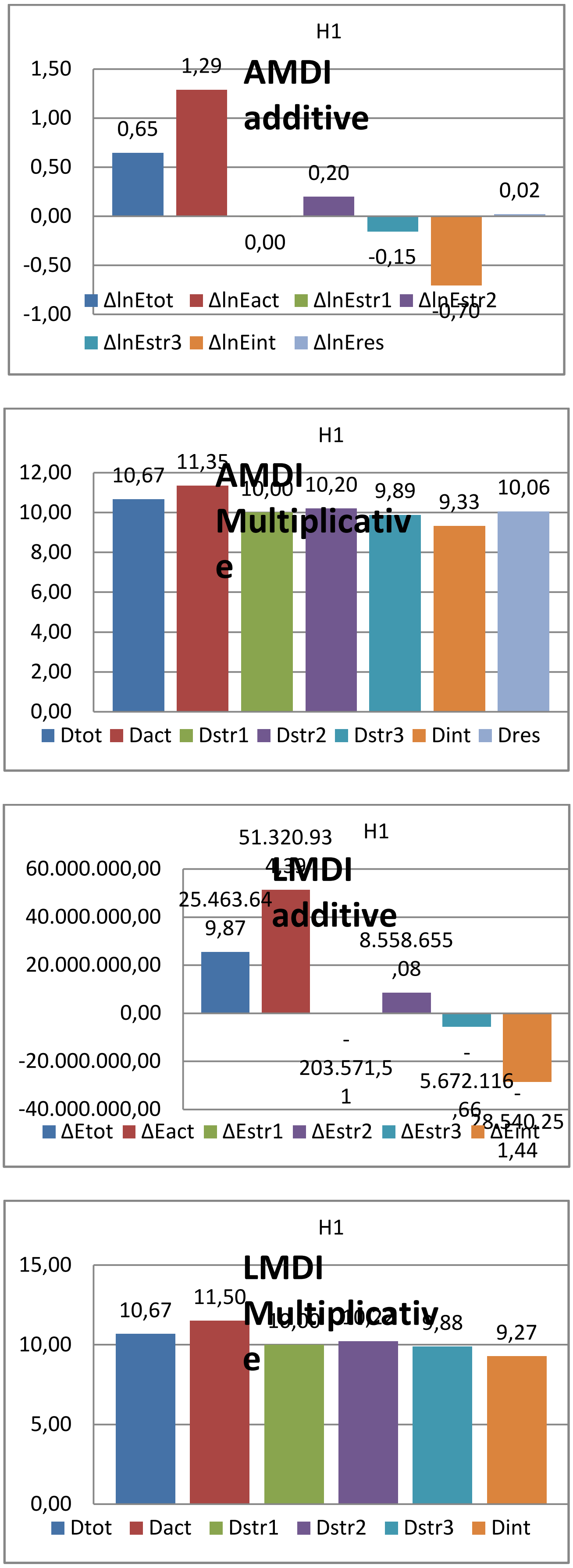


Fig. 5.8. AMDI and LMDI graphical output for R1-electricity consumption decomposition

CHAPTER VI
CONCLUSION AND RECOMMENDATION

In this research, econometric model and forecasting model for Indonesia's electricity consumption growth are constructed and analyzed. In addition, LMDI and AMDI techniques are used to decompose changes in residential electricity consumption in the period 1990 – 2010. Several findings related to the econometric and decomposition analysis in this study are as follows:

1. BI rate, GDP, inflation and population were not significantly affecting the total energy consumption in Indonesia.
2. Electrification ratio and private consumption were significantly affecting to total energy consumption in Indonesia.
3. Total energy consumption had strongly influenced by the electrification ratio and private consumption.
4. The best model through ARIMA model in forecasting BI rate was ARIMA (0,1,1) or IMA (1,1); electrification ratio was ARIMA (1,1,0) or ARI (1); inflation used ARIMA (0,1,1) or IMA (1,1) and total energy consumption utilized ARIMA (0,1,1) or IMA (1,1).
5. The best model through ARCH/GARCH model in forecasting electrification ratio used ARCH (1) and GARCH (1); GDP used ARCH (1) and GARCH (1); Inflation used ARCH (1) and GARCH (1); and total energy consumption used ARCH (1) and GARCH (1).
6. The AMDI method use an arithmetic mean weight function where as the LMDI use a log mean weight function.
7. The LMDI method is preffered than AMDI as using LMDI we can perform perfect decomposition without having residual term, of which accumulates over time in yearly decomposition. In addition, LMDI can work in the case of some available data are zero.
8. Using LMDI additive-technique for the case of total residential sector of Indonesia, we find total residential electricity consumption (ΔE_{tot}) in the period 1990 – 2010 became 29.285,2 GWh. The activity effect (ΔE_{act}) which is based GDP changes is the dominant factors contributing electricity consumption growth with 56.634,3 GWh. Insignificant contribution to the increasing electricity consumption was given by the structural effect (ΔE_{str}), changes in portion of household expenditure to the GDP, with 3.217.9 GWh in aggregate. On the other hand, intensity changes (ΔE_{int}) has consistently shown yearly negative value throughout the study period except for 2005 – 2006. This reveals that the intensity change, which is considered to be due to efficiency improvements, has shown its contribution for a decrease of 30.567 GWh.
9. In the case of residential sub-sector, we find that ΔE_{tot} is equal to $\Delta E_{tot}(R1)$ + $\Delta E_{tot}(R2)$ + $\Delta E_{tot}(R3)$. Increasing electricity consumption in all sub-sector are identified affected by activity changes. It implies that increasing electricity consumption in R1 is indirectly caused by the positive trend of electrified-residential expenditure whereas in R2 and R3, electricity consumption growth are also due to increasing R2 and R3 expenditure.

Recommendations

1. According to the result that monetary variables such as Bank Indonesia (BI) rate and inflation rate were not statistically significant in affecting total energy consumption, we recommend to utilize other real sector variables rather than monetary variables in order to analyze the behavior of total energy consumption. In macroeconomics, there is monetary and real sector mechanism of transmission that should be running automatically. However, government and the central bank as the policy makers should be able to analyze the flow of mechanism. Furthermore, they should be achieving macroeconomic final objective that is inflation rate.
2. The result found that the total energy consumption had strongly influenced by the electrification ratio and private consumption, therefore we recommend pushing up the electrification ratio through expanding the electric capacity in Indonesia. This recommendation might be actualize through direct investment in electricity plant and also building a comprehensive infrastructure that can boost up the electrification ratio particularly.
3. According to the result of forecasting, we recommend to utilize all those alternatives models in order to policymaking in energy. The forecasting result also showed important findings in terms of supply capacity that should be prepared by the government. Furthermore, the government should be able to anticipate the risk that might be happen related to the energy policy in the future.

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APPENDIX

Data collected in this research

- Electricity

PERIOD	Σ RESIDENTIALS	Σ RESIDENTIAL CUSTOMERS	ELECTRIFICATION RATIO (%)	NUMBER OF CUSTOMERS			ENERGY CONSUMPTION BY TARIFF CATEGORY (MWh)			TOTAL RESIDENTIAL ELECTRICITY CONSUMPTION (MWh)
				R-1	R-2	R-3	R-1	R-2	R-3	
1990	39.546.000,00	10.513.575,00	26,5857							8.785.293,00
1991	40.816.161,00	11.352.455,00	27,8136							9.766.337,00
1992	41.843.500,00	12.213.087,00	29,1875							11.199.029,00
1993	42.913.200,00	13.597.003,00	31,6849							12.537.109,00
1994	44.060.000,00	15.766.880,00	35,7850							14.460.106,00
1995	45.653.000,00	18.213.171,00	39,8948							16.927.060,00
1996	46.401.200,00	20.669.844,00	44,5459							19.610.853,00
1997	48.281.100,00	23.199.125,00	48,0501							22.764.024,00
1998	49.383.300,00	24.908.697,00	50,4395	24.625.376,00	200.330,00	47.093,00	22.393.105,00	1.596.077,00	846.521,00	24.835.703,00
1999	51.203.700,00	25.834.618,00	50,4546	25.541.032,00	220.645,00	46.055,00	24.657.704,00	1.408.343,00	787.836,00	26.853.883,00
2000	52.008.300,00	26.796.675,00	51,5238	26.484.133,00	242.766,00	47.851,00	28.063.539,00	1.614.772,00	859.958,00	30.538.269,00
2001	53.560.200,00	27.905.482,00	52,1012	27.553.000,00	266.570,00	51.261,00	30.581.615,23	1.798.548,88	938.148,33	33.318.312,44
2002	55.041.000,00	28.903.325,00	52,5124	28.556.684,00	282.227,00	53.929,00	31.161.756,13	1.851.990,42	964.997,60	33.978.744,15
2003	55.623.000,00	29.997.554,00	53,9301	29.629.557,00	301.640,00	57.846,00	32.610.638,86	2.047.804,13	1.038.678,65	35.697.121,64
2004	58.253.000,00	31.095.970,00	53,3809	30.701.676,00	325.519,00	63.197,00	35.078.627,38	2.288.798,74	1.211.829,28	38.579.255,40
2005	59.927.000,00	32.174.924,00	53,6902	31.743.229,00	356.221,00	71.430,00	37.325.639,51	2.511.107,99	1.345.091,07	41.181.838,57
2006	55.942.000,00	33.118.262,00	59,2011	32.660.655,00	377.770,00	76.689,00	39.555.721,49	2.708.754,47	1.484.103,86	43.748.579,82
2007	57.006.400,00	34.684.540,00	60,8432	34.183.894,00	413.617,00	84.763,00	42.532.237,03	3.107.544,49	1.681.886,89	47.321.668,41
2008	57.716.100,00	36.025.071,00	62,4177	35.482.955,00	450.335,00	90.498,00	45.049.197,03	3.346.539,18	1.786.304,09	50.182.040,30
2009	58.421.900,00	37.099.830,00	63,5033	36.511.814,00	491.182,00	95.850,00	49.298.803,21	3.740.222,35	1.905.063,16	54.944.088,72
2010	61.363.100,00	39.324.520,00	64,0850	38.672.726,00	523.180,00	126.970,00	53.527.188,87	4.144.214,81	2.152.082,88	59.823.486,56

- Social

PERIOD	POPULATION	Σ EMPLOYMENT
1990	178.500.000,00	75.850.580,00
1991	182.226.619,00	76.423.179,00
1992	186.042.700,00	78.518.372,00
1993	189.135.600,00	79.200.542,00
1994	192.216.500,00	79.852.355,00
1995	194.755.000,00	80.110.060,00
1996	198.342.900,00	85.701.813,00
1997	201.353.100,00	87.049.756,00
1998	204.392.500,00	87.672.449,00
1999	206.517.000,00	88.816.859,00
2000	205.132.500,00	89.837.730,00
2001	207.995.000,00	90.807.417,00
2002	212.003.000,00	91.647.166,00
2003	215.276.000,00	90.784.917,00
2004	216.382.000,00	93.722.036,00
2005	219.205.000,00	94.948.118,00
2006	222.192.000,00	95.456.935,00
2007	225.642.000,00	99.930.217,00
2008	228.523.300,00	102.552.750,00
2009	231.523.300,00	104.870.663,00
2010	237.556.400,00	107.405.572,00

- **Economy**

PERIOD	PRIVATE CONSUMPTION EXPENDITURE (MILLION RUPIAH)	GDP (MILLION RUPIAH)	GDP GROWTH (%)	BI RATE (%)	INFLATION (%)
1990	106.312.300,00	195.597.200,00	6,1588	18,830	9,917
1991	125.035.800,00	227.450.200,00	6,3186	18,470	9,611
1992	135.880.300,00	259.884.500,00	6,8465	13,500	4,993
1993	158.342.700,00	302.017.800,00	1,144	8,820	10,215
1994	221.119.300,00	382.219.700,00	1,610	12,440	9,633
1995	279.876.400,00	454.514.100,00	1,516	13,990	8,797
1996	325.585.300,00	532.568.000,00	5,608	12,800	6,362
1997	387.170.700,00	627.695.400,00	2,632	20,000	9,173
1998	647.823.600,00	955.753.500,00	-17,599	38,440	78,389
1999	813.183.300,00	1.099.731.600,00	4,517	12,510	1,654
2000	856.798.300,00	1.389.769.900,00	6,406	14,530	8,816
2001	1.039.655.000,00	1.646.322.000,00	1,643	17,620	12,643
2002	1.231.964.500,00	1.821.833.400,00	4,747	12,930	10,275
2003	1.372.078.000,00	2.013.674.600,00	4,212	8,310	5,547
2004	1.532.888.300,00	2.295.826.200,00	7,159	7,430	6,383
2005	1.785.596.400,00	2.774.281.100,00	5,107	12,750	17,793
2006	1.668.718.895,12	3.393.216.800,00	6,056	9,750	6,049
2007	1.916.235.454,00	3.950.893.200,00	5,849	8,000	6,395
2008	2.234.595.269,00	4.948.688.397,22	5,183	10,830	11,433
2009	2.520.631.069,82	5.603.871.170,00	4,500	6,500	2,780
2010	2.863.609.098,33	5.501.126.146,00	6,100	6,500	6,960

Formula Used in This Research

To get the general total energy consumption in the household sector with the electrification of 100% in year t we can use the following equation (According to Shrestha,Ram.Factor Decomposition Methods.AIT.April.2006)

$$E_i = \sum e_{it} \cdot s_{it} \cdot Y_t$$

$$E_i = \sum \frac{E_{it}}{Y_{it}} \cdot \frac{Y_{it}}{Y_t} \cdot Y_t$$

Therefore, using AMDI method the Factors Decomposition for energy consumption in the Household sector can be determined by:

Additive form

$$\ln\frac{E(t)}{E(t-1)} = \sum \overline{w_i}(t)\,\ln\frac{e_i(t)}{e_i(t-1)} + \sum \overline{w_i}(t)\,\ln\frac{s_i(t)}{s_i(t-1)} + \sum \overline{w_i}(t)\,\ln\frac{Y_i(t)}{Y_i(t-1)} + \Delta \ln E_{res}$$

$$\Delta \ln E_{tot} = \Delta \ln E_{int} + \Delta \ln E_{str} + \Delta \ln E_{act} + \Delta \ln E_{res}$$

Where, $\overline{w_i}(t) = \frac{w_i(t) + w_i(t-1)}{2}$ and $w_i(t) = \frac{E_i(t)}{E(t)}$

Multiplicative form

$$D_{tot} = D_{int} D_{str} D_{act} D_{res}$$

$$D_{tot} = \frac{E(t)}{E(t-1)}$$

$$D_{int} = exp\left\{\sum_i \overline{w_i}(t)\ \ln\frac{e_i(t)}{e_i(t-1)}\right\}$$

$$D_{str} = exp\left\{\sum_i \overline{w_i}(t)\ \ln\frac{s_i(t)}{s_i(t-1)}\right\}$$

$$D_{act} = exp\left\{\sum_i \overline{w_i}(t)\ \ln\frac{Y(t)}{Y(t-1)}\right\}$$

Where, $\overline{w_i}(t) = \frac{w_i(t) + w_i(t-1)}{2}$ and $w_i(t) = \frac{E_i(t)}{E(t)}$

Therefore, using LMDI method the Factors Decomposition for energy consumption in the Household sector can be determined by:

(According to Ang.Index Decomposition Analysis Using LMDI: A Simple Guide.ISE.January.2008)

Additive form

$$\Delta E_{tot} = \Delta E_{int} + \Delta E_{str} + \Delta E_{act}$$

$$\Delta E_{tot} = E(t) - E(t-1)$$

$$\Delta E_{int} = \sum_i w_i(t)\ \ln\frac{e_i(t)}{e_i(t-1)}$$

$$\Delta E_{str} = \sum_i w_i(t)\ \ln\frac{s_i(t)}{s_i(t-1)}$$

$$\Delta E_{act} = \sum_i w_i(t)\ \ln\frac{Y(t)}{Y(t-1)}$$

Where $w_i = \frac{E_i(t) - E_i(t-1)}{\ln E_i(t) - \ln E_i(t-1)}$

Multiplicative form

$$D_{tot} = D_{int} D_{str} D_{act}$$

$$D_{tot} = \frac{E(t)}{E(t-1)}$$

$$D_{int} = exp\left\{\sum_i w_i(t)\ \ln\frac{e_i(t)}{e_i(t-1)}\right\}$$

$$D_{str} = exp\left\{\sum_i w_i(t)\ \ln\frac{s_i(t)}{s_i(t-1)}\right\}$$

$$D_{act} = exp\left\{\sum_i w_i(t)\ \ln\frac{Y(t)}{Y(t-1)}\right\}$$

Where $$w_i = \frac{E_i(t) - E_i(t-1) \big/ \ln E_i(t) - \ln E_i(t-1)}{E(t) - E(t-1) \big/ \ln E(t) - \ln E(t-1)}$$

To get the general total energy consumption in the household sector with the electrification less than 100% in year t we can use the following equation

$$E_i = \sum e_{it} . s_{it} . Y_t$$

$$adj\ Y_{it} \equiv \frac{N_{elect\,t}}{N_t} \times Y_{it}$$

$$E_i = \sum \frac{E_{it}}{adj\ Y_{it}} . \frac{adj\ Y_{it}}{Y_t} . Y_t$$

Therefore, using AMDI method the Factors Decomposition for energy consumption in the Household sector can be determined by:

Additive form

$$\ln\frac{E(t)}{E(t-1)} = \sum \overline{w_i}(t) \ln\frac{e_i(t)}{e_i(t-1)} + \sum \overline{w_i}(t) \ln\frac{s_i(t)}{s_i(t-1)} + \sum \overline{w_i}(t) \ln\frac{Y(t)}{Y(t-1)} + \Delta \ln E_{res}$$

$$\Delta \ln E_{tot} = \Delta \ln E_{int} + \Delta \ln E_{str} + \Delta \ln E_{act} + \Delta \ln E_{res}$$

Where, $\overline{w_i}(t) = \frac{w_i(t) + w_i(t-1)}{2}$ and $w_i(t) = \frac{E_i(t)}{E(t)}$

Multiplicative form

$$D_{tot} = D_{int} D_{str} D_{act} D_{res}$$

$$D_{tot} = \frac{E(t)}{E(t-1)}$$

$$D_{int} = exp\left\{\sum_i \overline{w_i}(t) \ln\frac{e_i(t)}{e_i(t-1)}\right\}$$

$$D_{str} = exp\left\{\sum_i \overline{w_i}(t) \ln\frac{s_i(t)}{s_i(t-1)}\right\}$$

$$D_{act} = exp\left\{\sum_i \overline{w_i}(t) \ln\frac{Y(t)}{Y(t-1)}\right\}$$

Where, $\overline{w_i}(t) = \frac{w_i(t) + w_i(t-1)}{2}$ and $w_i(t) = \frac{E_i(t)}{E(t)}$

Therefore, using LMDI method the Factors Decomposition for energy consumption in the Household sector can be determined by:

Additive form

$$\Delta E_{tot} = \Delta E_{int} + \Delta E_{str} + \Delta E_{act}$$

$$\Delta E_{tot} = E(t) - E(t-1)$$

$$\Delta E_{int} = \sum_i w_i(t) \ln\frac{e_i(t)}{e_i(t-1)}$$

$$\Delta E_{str} = \sum_i w_i(t) \ln\frac{s_i(t)}{s_i(t-1)} \qquad \Delta E_{act} = \sum_i w_i(t) \ln\frac{Y(t)}{Y(t-1)}$$

Where $w_i = \frac{E_i(t) - E_i(t-1)}{\ln E_i(t) - \ln E_i(t-1)}$

Multiplicative form

$$D_{tot} = D_{int} D_{str1} D_{str2} D_{str3} D_{act} D_{res}$$

$$D_{tot} = \frac{E(t)}{E(t-1)}$$

$$D_{int} = exp\left\{\sum_i \overline{w_i}(t)\ \ln\frac{e_i(t)}{e_i(t-1)}\right\}$$

$$D_{str1} = exp\left\{\sum_i \overline{w_i}(t)\ \ln\frac{s1(t)}{s1(t-1)}\right\}$$

$$D_{str2} = exp\left\{\sum_i \overline{w_i}(t)\ \ln\frac{s2(t)}{s2(t-1)}\right\}$$

$$D_{act} = exp\left\{\sum_i \overline{w_i}(t)\ \ln\frac{Y_{nas}(t)}{Y_{nas}(t-1)}\right\}$$

$$D_{str3} = exp\left\{\sum_i \overline{w_i}(t)\ \ln\frac{s3(t)}{s3(t-1)}\right\}$$

Where, $\overline{w_i}(t) = \frac{w_i(t) + w_i(t-1)}{2}$ and $w_i(t) = \frac{E_i(t)}{E(t)}$

Therefore, using LMDI method the Factors Decomposition for energy consumption in the Household sector can be determined by:

Additive form

$$\Delta E_{tot} = \Delta E_{int} + \Delta E_{str1} + \Delta E_{str2} + \Delta E_{str3} + \Delta E_{act}$$

$$\Delta E_{tot} = E(t) - E(t-1)$$

$$\Delta E_{int} = \sum_i w_i(t)\ \ln\frac{e_i(t)}{e_i(t-1)}$$

$$\Delta E_{str1} = \sum_i w_i(t)\ \ln\frac{s1(t)}{s1(t-1)}$$

$$\Delta E_{str2} = \sum_i w_i(t)\ \ln\frac{s2(t)}{s2(t-1)}$$

$$\Delta E_{str3} = \sum_i w_i(t)\ \ln\frac{s3(t)}{s3(t-1)}$$

$$\Delta E_{act} = \sum_i w_i(t)\ \ln\frac{Y_{nas}(t)}{Y_{nas}(t-1)}$$

Where $w_i = \frac{E_i(t) - E_i(t-1)}{\ln E_i(t) - \ln E_i(t-1)}$

Multiplicative form

$$D_{tot} = D_{int} D_{str1} D_{str2} D_{str3} D_{act}$$

$$D_{tot} = \frac{E(t)}{E(t-1)}$$

$$D_{int} = exp\left\{\sum_i w_i(t)\ \ln\frac{e_i(t)}{e_i(t-1)}\right\} \qquad D_{act} = exp\left\{\sum_i w_i(t)\ \ln\frac{Y_{nas}(t)}{Y_{nas}(t-1)}\right\}$$

$$D_{str1} = exp\left\{\sum_i w_i(t)\ \ln\frac{s1(t)}{s1(t-1)}\right\} \qquad D_{str2} = exp\left\{\sum_i w_i(t)\ \ln\frac{s2(t)}{s2(t-1)}\right\}$$

$$D_{str3} = exp\left\{\sum_i w_i(t)\ \ln\frac{s3(t)}{s3(t-1)}\right\}$$

Where $$w_i = \frac{E_i(t) - E_i(t-1) \Big/ \ln E_i(t) - \ln E_i(t-1)}{E(t) - E(t-1) \Big/ \ln E(t) - \ln E(t-1)}$$

In the case of sectoral breakdown analysis for example Household Energy consumption decomposition for tariff class R1(<= 2200 VA) the formula used are:

$$E_{R1} = \sum e_{R1\,t} \,.\, s1_{R1\,t} \,.\, s2_{R1\,t} \,.\, s3_{R1\,t} \,.\, Y_{nas\,t} \qquad Y_{R1} \equiv \frac{N_{R1}}{N} \times Y$$

$$E_{R1} = \sum \frac{E_{R1\,t}}{Y_{R1\,t}} \cdot \frac{Y_{R1\,t}}{Y_{elect\,t}} \cdot \frac{Y_{elect\,t}}{Y_t} \cdot \frac{Y_t}{Y_{nas\,t}} \cdot Y_{nas\,t} \qquad Y_{elect} \equiv \frac{N_{elect}}{N} \times Y$$

Therefore, using LMDI method the Factors Decomposition for energy consumption in the Household sector can be determined by:
Additive form

$$\Delta E_{tot\,R1} = \Delta E_{int\,R1} + \Delta E_{str1\,R1} + \Delta E_{str2\,R1} + \Delta E_{str3\,R1} + \Delta E_{act\,R1}$$

$$\Delta E_{int\,R1} = \sum_{R1} w_{R1}(t)\ \ln\frac{e_{R1}(t)}{e_{R1}(t-1)} \qquad \Delta E_{str1\,R1} = \sum_{R1} w_{R1}(t)\ \ln\frac{s1_{R1}(t)}{s1_{R1}(t-1)}$$

$$\Delta E_{str2\,R1} = \sum_{R1} w_{R1}(t)\ \ln\frac{s2_{R1}(t)}{s2_{R1}(t-1)} \qquad \Delta E_{str3\,R1} = \sum_{R1} w_{R1}(t)\ \ln\frac{s3_{R1}(t)}{s3_{R1}(t-1)}$$

$$\Delta E_{act\,R1} = \sum_{R1} w_{R1}(t)\ \ln\frac{Y_{nas}(t)}{Y_{nas}(t-1)}$$

Where $$w_{R1} = \frac{E_{R1}(t) - E_{R1}(t-1)}{\ln E_{R1}(t) - \ln E_{R1}(t-1)}$$

Correlation Results

	EMPL	RES_CUS	RESIDENTIAL	BI_RATE	ELECTR	GDP	GDP_GR	INFL	POP	PRI_CON	TOT_EN_CON
EMPL	1.000000	0.953906	0.949308	-0.662555	0.937326	0.979989	0.379168	-0.163452	0.987775	0.963323	0.973591
RES_CUS	0.953906	1.000000	0.980129	-0.572963	0.994608	0.973949	0.316993	-0.162063	0.970685	0.986525	0.994861
RESIDENTIALS	0.949308	0.980129	1.000000	-0.611469	0.954537	0.979106	0.343789	-0.109198	0.969766	0.992349	0.986598
BI_RATE	-0.662555	-0.572963	-0.611469	1.000000	-0.540863	-0.644848	-0.083986	0.283792	-0.693559	-0.611687	-0.613944
ELECTRIFICAT	0.937326	0.994608	0.954537	-0.540863	1.000000	0.953276	0.291541	-0.184724	0.953332	0.966856	0.982408
GDP	0.979989	0.973949	0.979106	-0.644848	0.953276	1.000000	0.361632	-0.139270	0.988973	0.992618	0.990739
GDP_GROWTH	0.379168	0.316993	0.343789	-0.083986	0.291541	0.361632	1.000000	-0.223165	0.332751	0.361836	0.330817
INFLATION	-0.163452	-0.162063	-0.109198	0.283792	-0.184724	-0.139270	-0.223165	1.000000	-0.160146	-0.158930	-0.150918
POPULATION	0.987775	0.970685	0.969766	-0.693559	0.953332	0.988973	0.332751	-0.160146	1.000000	0.978866	0.985972
PRIVATE_CONS	0.963323	0.986525	0.992349	-0.611687	0.966856	0.992618	0.361836	-0.158930	0.978866	1.000000	0.994474
TOTAL_EN_CONS	0.973591	0.994861	0.986598	-0.613944	0.982408	0.990739	0.330817	-0.150918	0.985972	0.994474	1.000000

Estimation Results

Dependent Variable: TOTAL_ENERGY_CONSUMPT
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-5.707133	14.03572	-0.406615	0.6904
BI_RATE	-0.046825	0.036534	-1.281687	0.2208
ELECTRIFICATION_RATIO	0.740182	0.133522	5.543516	0.0001
GDP	0.104364	0.074479	1.401251	0.1829
INFLATION	0.006798	0.014482	0.469427	0.6460
POPULATION	0.734259	0.783484	0.937171	0.3646
PRIVATE_CONSUMPTION	0.187530	0.063815	2.938624	0.0108

R-squared	0.998048	Mean dependent var	17.08156
Adjusted R-squared	0.997211	S.D. dependent var	0.589862
S.E. of regression	0.031149	Akaike info criterion	-3.838870
Sum squared resid	0.013584	Schwarz criterion	-3.490696
Log likelihood	47.30814	F-statistic	1193.011
Durbin-Watson stat	1.892522	Prob(F-statistic)	0.000000

Dependent Variable: TOTAL_ENERGY_CONS
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.339025	1.013886	-0.334382	0.7430
BI_RATE	-0.006906	0.004515	-1.529439	0.1484
ELECTRIFICATION_R	0.158202	0.026525	5.964230	0.0000
GDP	0.152207	0.096107	1.583736	0.1356
INFLATION	0.001049	0.001164	0.901230	0.3827
POPULATION	0.786775	0.839799	0.936861	0.3647
PRIVATE_CONSUMPTION	0.208004	0.079199	2.626346	0.0199

R-squared	0.998151	Mean dependent var	1.232278
Adjusted R-squared	0.997359	S.D. dependent var	0.015124
S.E. of regression	0.000777	Akaike info criterion	-11.22037
Sum squared resid	8.46E-06	Schwarz criterion	-10.87220
Log likelihood	124.8139	F-statistic	1259.716
Durbin-Watson stat	1.965824	Prob(F-statistic)	0.000000

ARIMA Models

Method: Least Squares

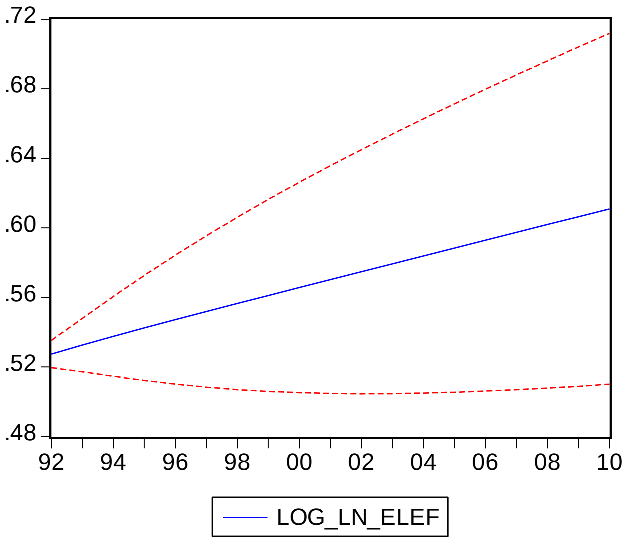
Convergence achieved after 3 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.004515	0.002923	1.544372	0.1409
AR(1)	0.697124	0.180636	3.859282	0.0013

R-squared	0.466985	Mean dependent var	0.005119
Adjusted R-squared	0.435632	S.D. dependent var	0.005057
S.E. of regression	0.003799	Akaike info criterion	-8.208954
Sum squared resid	0.000245	Schwarz criterion	-8.109539
Log likelihood	79.98506	F-statistic	14.89406
Durbin-Watson stat	1.982750	Prob(F-statistic)	0.001258

Inverted AR Roots	.70

D(LOG_LN_ELECTRIFICATION_R) = 0.004514879351 + [AR(1)=0.6971241405]



Forecast: LOG_LN_ELEF
Actual: LOG_LN_ELECTRIFICATION_R
Forecast sample: 1990 2010
Adjusted sample: 1992 2010
Included observations: 19

Root Mean Squared Error	0.022516
Mean Absolute Error	0.020116
Mean Abs. Percent Error	3.396254
Theil Inequality Coefficient	0.019394
Bias Proportion	0.798176
Variance Proportion	0.000076
Covariance Proportion	0.201748

Dependent Variable: BI_RATE

Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.394307	0.015873	24.84080	0.0000

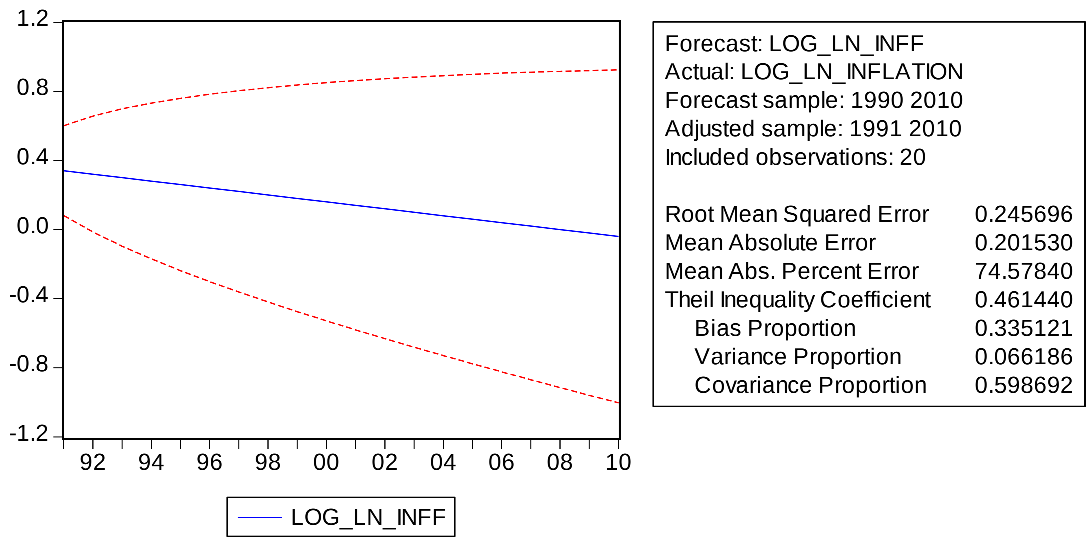
R-squared	0.000000	Mean dependent var	0.394307
Adjusted R-squared	0.000000	S.D. dependent var	0.072741
S.E. of regression	0.072741	Akaike info criterion	-2.357380
Sum squared resid	0.105825	Schwarz criterion	-2.307641
Log likelihood	25.75249	Durbin-Watson stat	0.862596

Dependent Variable: D(INFLATION)
Method: Least Squares
Convergence achieved after 105 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.020024	0.006320	-3.168237	0.0053
MA(1)	-1.820582	0.534403	-3.406760	0.0031

R-squared	0.829282	Mean dependent var	-0.003640
Adjusted R-squared	0.819797	S.D. dependent var	0.304896
S.E. of regression	0.129429	Akaike info criterion	-1.156728
Sum squared resid	0.301534	Schwarz criterion	-1.057155
Log likelihood	13.56728	F-statistic	87.43681
Durbin-Watson stat	2.861821	Prob(F-statistic)	0.000000

Inverted MA Roots	1.82
	Estimated MA process is noninvertible



D(LOG_LN_INFLATION) = -0.02002449863 + [MA(1)=-1.820582086,INITMA=1991]

Dependent Variable: ELECTRIFICATION_R
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.583230	0.007145	81.63172	0.0000

R-squared	0.000000	Mean dependent var	0.583230
Adjusted R-squared	0.000000	S.D. dependent var	0.032741
S.E. of regression	0.032741	Akaike info criterion	-3.953935
Sum squared resid	0.021439	Schwarz criterion	-3.904195
Log likelihood	42.51631	Durbin-Watson stat	0.046332

ARCH/GARCH Model

Dependent Variable: ELECTRIFICATION_R
Method: ML - ARCH
Convergence achieved after 26 iterations
Variance backcast: ON
GARCH = C(2) + C(3)*RESID(-1)^2 + C(4)*GARCH(-1)

	Coefficient	Std. Error	z-Statistic	Prob.
C	0.596791	0.001879	317.6721	0.0000
Variance Equation				
C	1.46E-05	8.82E-06	1.649636	0.0990
RESID(-1)^2	1.757682	0.923721	1.902828	0.0571
GARCH(-1)	-0.621546	0.149115	-4.168225	0.0000

R-squared	-0.180124	Mean dependent var	0.583230
Adjusted R-squared	-0.388381	S.D. dependent var	0.032741
S.E. of regression	0.038578	Akaike info criterion	-5.508915
Sum squared resid	0.025301	Schwarz criterion	-5.309958
Log likelihood	61.84361	Durbin-Watson stat	0.039260

Dependent Variable: TOTAL_ENERGY_CONS
Method: ML - ARCH
Convergence achieved after 7 iterations
Variance backcast: ON
GARCH = C(9) + C(10)*RESID(-1)^2 + C(11)*GARCH(-1) + C(12)
BI_RATE + C(13) ELECTRIFICATION_R

	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.225702	1.053294	-0.214282	0.8303
BI_RATE	-0.006631	0.007345	-0.902698	0.3667
ELECTRIFICATION_R	0.152716	0.032096	4.758166	0.0000
GDP	0.168744	0.125529	1.344257	0.1789
INFLATION	0.001088	0.003850	0.282581	0.7775
POPULATION	0.687059	0.868757	0.790852	0.4290
PRIVATE_CONS	0.204834	0.124833	1.640869	0.1008
AR(1)	0.004999	0.862628	0.005795	0.9954
Variance Equation				
C	9.04E-08	4.74E-06	0.019057	0.9848
RESID(-1)^2	0.149957	1.174349	0.127693	0.8984
GARCH(-1)	0.599990	3.219071	0.186386	0.8521
BI_RATE	7.34E-07	5.20E-06	0.141237	0.8877
ELECTRIFICATION_R	-4.39E-07	6.89E-06	-0.063736	0.9492

R-squared	0.997814	Mean dependent var	1.233702
Adjusted R-squared	0.994068	S.D. dependent var	0.014000
S.E. of regression	0.001078	Akaike info criterion	-10.59006
Sum squared resid	8.14E-06	Schwarz criterion	-9.942829
Log likelihood	118.9006	F-statistic	266.3198
Durbin-Watson stat	2.061551	Prob(F-statistic)	0.000000
Inverted AR Roots	.00		

AMDI and LMDI Output for R2-residential sub-sector

Year	Arithmetic Mean Divisia												
	Additive							Multiplicative					
	ΔlnE_{tot}	ΔlnE_{act}	ΔlnE_{str1}	ΔlnE_{str2}	ΔlnE_{str3}	ΔlnE_{int}	ΔlnE_{res}	D_{tot}	D_{act}	D_{str1}	D_{str2}	D_{str3}	D_{int}	D_{res}
2000-2001	0,1078	0,0138	0,0028	0,0006	0,0013	-0,0080	0,0973	1,1138	1,0091	1,0028	1,0006	1,0013	0,9920	1,1074
2001-2002	0,0293	0,0108	0,0012	0,0004	0,0037	-0,0092	0,0224	1,0297	1,0055	1,0012	1,0004	1,0037	0,9908	1,0281
2002-2003	0,1005	0,0092	0,0016	0,0015	0,0004	-0,0035	0,0913	1,1057	1,0056	1,0016	1,0015	1,0004	0,9965	1,0995
2003-2004	0,1113	0,0082	0,0023	-0,0006	-0,0012	-0,0017	0,1042	1,1177	1,0077	1,0023	0,9994	0,9988	0,9983	1,1105
2004-2005	0,0927	0,0129	0,0034	0,0003	-0,0022	-0,0073	0,0856	1,0971	1,0115	1,0034	1,0003	0,9978	0,9927	1,0910
2005-2006	0,0758	0,0037	0,0018	0,0060	-0,0165	0,0010	0,0798	1,0787	1,0125	1,0018	1,0060	0,9836	1,0010	1,0737
2006-2007	0,1373	0,0134	0,0028	0,0017	-0,0009	-0,0046	0,1249	1,1472	1,0098	1,0028	1,0017	0,9991	0,9954	1,1372
2007-2008	0,0741	0,0150	0,0031	0,0017	-0,0047	-0,0101	0,0691	1,0769	1,0150	1,0031	1,0017	0,9953	0,9900	1,0716
2008-2009	0,1112	0,0131	0,0039	0,0012	-0,0003	-0,0057	0,0990	1,1176	1,0084	1,0039	1,0012	0,9997	0,9944	1,1093
2009-2010	0,1026	0,0097	0,0003	0,0006	0,0100	-0,0027	0,0845	1,1080	0,9987	1,0003	1,0006	1,0101	0,9973	1,1002
Total	0,9425	0,1098	0,0234	0,0135	-0,0104	-0,0519	0,8581	10,9926	10,0837	10,0234	10,0135	9,9899	9,9483	10,9286

Log-Mean Divisia											
Additive						Multiplicative					
ΔE_{tot}	ΔE_{act}	ΔE_{str1}	ΔE_{str2}	ΔE_{str3}	ΔE_{int}	D_{tot}	D_{act}	D_{str1}	D_{str2}	D_{str3}	D_{int}
183.776,88	288.838,10	90.354,47	18.997,92	40.981,89	-255.395,50	1,1138	1,1846	1,0544	1,0112	1,0243	0,8609
53.441,54	184.885,96	40.046,03	14.348,11	124.878,72	-310.717,28	1,0297	1,1066	1,0222	1,0079	1,0708	0,8435
195.813,71	195.055,36	57.207,34	51.903,10	14.803,78	-123.155,88	1,1057	1,1053	1,0298	1,0270	1,0076	0,9387
240.994,61	284.039,82	87.128,32	-22.172,79	-43.980,29	-64.020,45	1,1177	1,1401	1,0410	0,9898	0,9799	0,9709
222.309,25	453.983,43	134.352,39	13.856,05	-88.015,58	-291.867,04	1,0971	1,2084	1,0576	1,0058	0,9640	0,8854
197.646,48	525.354,23	77.834,66	254.892,31	-701.952,38	41.517,66	1,0787	1,2231	1,0303	1,1026	0,7641	1,0160
398.790,02	441.819,32	129.051,88	79.445,32	-40.234,83	-211.291,67	1,1472	1,1644	1,0454	1,0277	0,9862	0,9298
238.994,69	726.335,89	152.021,80	82.408,18	-230.574,21	-491.196,97	1,0769	1,2525	1,0483	1,0259	0,9310	0,8587
393.683,17	440.112,92	203.271,66	61.034,26	-13.755,04	-296.980,63	1,1176	1,1324	1,0591	1,0174	0,9961	0,9195
403.992,46	-72.886,14	19.201,43	35.913,66	575.368,15	-153.604,64	1,1080	0,9817	1,0049	1,0092	1,1573	0,9618
2.529.442,81	3.467.538,91	990.469,97	590.626,13	-362.479,80	-2.156.712,41	10,9926	11,4991	10,3931	10,2245	9,8814	9,1853

AMDI and LMDI Output for R3-residential sub-sector

Year	Arithmetic Mean Divisia												
	Additive							Multiplicative					
	ΔlnE_{tot}	ΔlnE_{act}	ΔlnE_{str1}	ΔlnE_{str2}	ΔlnE_{str3}	ΔlnE_{int}	ΔlnE_{res}	D_{tot}	D_{act}	D_{str1}	D_{str2}	D_{str3}	D_{int}	D_{res}
2000-2001	0,0870	0,0066	0,0008	0,0003	0,0007	-0,0041	0,0828	1,0909	1,0048	1,0008	1,0003	1,0007	0,9959	1,0883
2001-2002	0,0282	0,0055	0,0004	0,0002	0,0019	-0,0047	0,0248	1,0286	1,0029	1,0004	1,0002	1,0019	0,9953	1,0278
2002-2003	0,0736	0,0048	0,0009	0,0008	0,0002	-0,0027	0,0695	1,0764	1,0029	1,0009	1,0008	1,0002	0,9973	1,0741
2003-2004	0,1542	0,0046	0,0016	-0,0003	-0,0006	0,0000	0,1489	1,1667	1,0040	1,0016	0,9997	0,9994	1,0000	1,1613
2004-2005	0,1043	0,0079	0,0028	0,0002	-0,0012	-0,0046	0,0991	1,1100	1,0061	1,0028	1,0002	0,9988	0,9954	1,1063
2005-2006	0,0983	0,0024	0,0014	0,0033	-0,0090	0,0009	0,0994	1,1033	1,0067	1,0014	1,0033	0,9911	1,0009	1,0997
2006-2007	0,1251	0,0076	0,0019	0,0010	-0,0005	-0,0033	0,1184	1,1333	1,0053	1,0019	1,0010	0,9995	0,9967	1,1284
2007-2008	0,0602	0,0074	0,0010	0,0009	-0,0025	-0,0052	0,0587	1,0621	1,0080	1,0010	1,0009	0,9975	0,9948	1,0598
2008-2009	0,0644	0,0058	0,0010	0,0006	-0,0001	-0,0036	0,0606	1,0665	1,0044	1,0010	1,0006	0,9999	0,9964	1,0641
2009-2010	0,1219	0,0127	0,0079	0,0003	0,0052	-0,0084	0,1043	1,1297	0,9993	1,0079	1,0003	1,0052	0,9916	1,1248
Total	0,9173	0,0653	0,0197	0,0072	-0,0059	-0,0356	0,8666	10,9674	10,0444	10,0198	10,0072	9,9941	9,9645	10,9345

Log-Mean Divisia											
Additive						Multiplicative					
ΔE_{tot}	ΔE_{act}	ΔE_{str1}	ΔE_{str2}	ΔE_{str3}	ΔE_{int}	D_{tot}	D_{act}	D_{str1}	D_{str2}	D_{str3}	D_{int}
78.190,33	152.208,52	25.420,75	10.011,30	21.596,15	-131.046,40	1,0909	1,1846	1,0287	1,0112	1,0243	0,8643
26.849,27	96.387,61	14.847,98	7.480,18	65.103,71	-156.970,21	1,0286	1,1066	1,0157	1,0079	1,0708	0,8479
73.681,05	100.256,66	33.002,43	26.677,72	7.609,01	-93.864,76	1,0764	1,1053	1,0335	1,0270	1,0076	0,9105
173.150,63	147.264,70	58.970,47	-11.495,81	-22.802,24	1.213,52	1,1667	1,1401	1,0539	0,9898	0,9799	1,0011
133.261,79	241.791,79	112.852,11	7.379,74	-46.877,14	-181.884,71	1,1100	1,2084	1,0924	1,0058	0,9640	0,8673
139.012,79	284.651,75	59.567,19	138.107,85	-380.337,61	37.023,61	1,1033	1,2231	1,0430	1,1026	0,7641	1,0265
197.783,03	240.560,13	85.199,13	43.256,09	-21.906,91	-149.325,40	1,1333	1,1644	1,0554	1,0277	0,9862	0,9099
104.417,20	390.367,16	47.755,67	44.290,04	-123.921,45	-254.074,21	1,0621	1,2525	1,0279	1,0259	0,9310	0,8637
118.759,07	229.404,00	51.770,98	31.813,44	-7.169,66	-187.059,69	1,0665	1,1324	1,0285	1,0174	0,9961	0,9036
247.019,72	-37.491,94	451.671,46	18.473,65	295.963,91	-481.597,37	1,1297	0,9817	1,2497	1,0092	1,1573	0,7884
1.292.124,88	1.845.400,37	941.058,18	315.994,18	-212.742,24	-1.597.585,61	10,9674	11,4991	10,6288	10,2245	9,8814	8,9832