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Technical Improvement Report on Energy Outlook and Energy Saving Potential in East Asia

Edited by

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This technical improvement report was prepared by the Working Group for Energy Outlook and Energy Saving Potential in East Asia under the Economic Research Institute for ASEAN and East Asia (ERIA) Energy Project. Members of the Working Group, who represent the participating countries of the East Asia Summit (EAS) region, discussed and agreed to certain key assumptions for the modelling approaches to enable harmonization of the forecasting techniques. One of the unique exercise is the setting up scenario of “keeping CO2 emission at 2013 level by 2040”. To achieve this scenario, best energy mix comprising high share of renewable and energy efficiency programmes are displayed. This is purely the excise and, therefore, the projections of energy mix presented here should not be viewed as official national projections of the participating countries

Preface

Due to decision by 9th East Asia Summit (EAS) – Energy Ministers Meeting (EMM), EAS energy outlook is updated every two years. Consequently the working group for Energy Outlook and Saving Potential of EAS countries conducted flowing three studies;

a. Seek for possibility to use their national energy data instead of IEA data
b. Conduct a case study on CO2 mitigation scenario
c. Information sharing on their INDC/NDC

This is the first time that the working group members of Energy Outlook and Saving Potentials of East Asia Summit (EAS) countries agreed to take on a serious look on how to improve data used in the modeling of energy demand model in ASEAN countries. In the past, the outlook relies tremendously on International Energy Agency (IEA) energy data.

However, over years of capacity building on energy outlook modelling supported by Economic Research Institute for ASEAN and East Asia (ERIA), the working group has decided to assess quality of the national energy data combined with APEC's energy database to use for the energy demand modeling in some selected ASEAN countries.

To give aspiration to the COP 21, the working group also set a scenario of keeping CO2 emission frozen at 2013 level up to 2040. In this case, it is very challenging tasks for the some EAS countries to find the best energy mix, while keeping CO2 level from 2013 till 2040. The upscaling renewable energy together with energy efficiency programmes remain the key energy policy towards low carbon economy in EAS countries.

On behalf of working group, I am grateful for their strong commitment of working members to improve the energy demand modelling for EAS countries and for their active participation. I hope the ASEAN countries will eventually have their technical expertise in the energy outlook modeling and their respective energy data quality will eventually be improved.

Mr Shigeru Kimura

Leader of the Working Group

2016

# Acknowledgement

This technical improvement report on energy outlook and energy saving potential for EAS region is a joint effort of Working Group members from the East Asia Summit countries, Economic Research Institute for ASEAN and East Asia (ERIA), and The Institute of Energy Economics, Japan (IEEJ). We would like to acknowledge the support provided by everyone involved. We especially take this opportunity to thank the members of the Working Group, ERIA's energy team, the International Affairs Division of the Agency for Natural Resources and Energy (ANRE) of the Ministry of Economy, Trade and Industry (METI) of Japan, and IEEJ's energy outlook modelling team.

Special acknowledgement also goes to Mr. Shigeru Kimura, Dr. Han Phoumin, and Ms. Cecilya Laksmiwati Malik, for their contributions in technical editing of this report.

This study could not have been realised without the invaluable support and contribution provided by many people (please see details in the List of Project Members and contributing authors).

Special thanks go to Ms. Maria Priscila del Rosario, chief editor and publication director of ERIA, and her team of editors and publishing staff for helping edit the report and prepare it for publication.

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List of Abbreviations and Acronyms

ANRE	Agency for Natural Resources and Energy
APS	Alternative Policy Scenario
ASEAN	Association of Southeast Asian Nations
BAU	Business-as-Usual
BREE	Bureau of Resources and Energy Economics
CCS	Carbon capture and storage
CCT	Clean Coal Technology
CDM	Clean Development Mechanism
CNG	Compressed Natural Gas
CO_2	Carbon dioxide
CONST	Constant Value
CSGDP	GDP of Services Sector
EAS	East Asia Summit
ECTF	Energy Cooperation Task Force
EEC	Energy efficiency and conservation
EMM	EAS Energy Ministers Meeting
ERIA	Economic Research Institute for ASEAN and East Asia
FiT	Feed-in-Tariff
GCV	Gross calorific value
GDP	Gross domestic product
GDP	Gross Domestic Products
GHG	Greenhouse gas
GW	Gigawatt
IEEJ	The Institute for Energy Economics, Japan
INEL	Electricity Demand in the Industrial Sector
INGDP	GDP of Industrial Sector
INLB	Coal and Coke Demand in the Industrial Sector
INNG	Natural Gas Demand in the Industrial Sector
INTTC	Total Energy Demand in the Industrial Sector
IPCC	Intergovernmental Panel for Climate Change
ktoe	Thousand tonnes of oil equivalent

kWh	kilowatt-hour
LDV	Light Duty Vehicles
LEAP	Long-range Energy Alternative Planning System
LEDS	Long-Term Energy Demand System
LET	Low emission technologies
LPG	Liquefied petroleum gas
METI	Ministry of Economy, Trade and Industry
MNGDP	GDP of Manufacturing Sector
Mt C	
Mtoe	Million tonnes of oil equivalent (1 Mtoe = 41.868 PJ)
MW	Megawatts
MWh	Megawatt-hour
NCV	Net Calorific Value
OECD	Organization for Economic Cooperation and Development
OSEL	Electricity Demand in the Others Sector
OSLP	LPG Demand in the Others Sector
OSPP	Total Energy Demand of Petroleum Products in the Others Sector
OSTT	Total Energy Demand in the Others Sector
RPOIL	Relative Price of International Crude Oil
RPRGD	Relative Price of Local Diesel
RPRNG	Relative Price of Local Natural Gas
RPS	Renewable Portfolio Standards
SWG	Sub-Working Group
t C	Tonnes of carbon
toe	Tonnes of oil equivalent
TPES	Total Primary Energy Supply
TRGD	Diesel Demand in the Transport Sector
TRJK	Jet Kerosene Demand in the Transport Sector
TSMG	Motor Gasoline Demand in the Transport Sector
TWh	Terawatt-hour
US$	United States Dollar
WG	Working group

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Executive Summary

The technical improvement report on energy outlook and energy saving potential in East Asia is composed of three main chapters.

The Chapter 1 discussed the national data improvement and use this national data for estimating some ASEAN countries of their demand equations aiming to assess the integrity of their historical national data as a potential database to be used in projecting energy demand. In the past, the EAS energy outlook and saving potential relies greatly on the IEA's historical energy data. However, the working group of this study wants to create its country data by looking into each country data and try to treat the national data based on the practical knowledge of the country experts who involved in the preparation of country energy outlook. To start with, only five countries were chosen to check the historical data correction to use for the energy outlook. The national energy data improvement should be accurate, complete and timely to be used in formulating statistical demand model using regression analysis. The main database file for 1990 to 2013 final energy consumption by major economic sector and subsector and socio economic parameters were established and being exported to the forecasting tool. Assessment on the national energy data was made through applying regression analysis to estimate energy demand functions such as electricity demand in residential sector. At the end, national energy data of two ASEAN countries are assessed very well and these data can be used for energy outlook modelling. But remaining three countries need more efforts to improve their national energy data. In this regard, the working group decided to postpone use of national energy data in future.

The Chapter 2 is the case studies, where the working group set a scenario of keeping CO2 emission frozen at 2013 level up to 2040. In this case, it is very challenging tasks for the some EAS countries to find the best energy mix, while keeping CO2 level from 2013 till 2040. The upscaling renewable energy together with energy efficiency programmes remain the key energy policy towards low carbon economy in EAS countries. The Paris Agreement is a bridge between today's policies and climate-neutrality before the end of the century. However, ERIA's energy outlook and saving potential 2016 showed that although the emission reductions under the APS are significant, CO2 emissions from energy demand in the APS case in 2040 will still be above 2013 levels and more than three times higher than 1990 levels. This chapter 2 explore the possibility of each country scenario in ASEAN plus Australia and China to frozen the CO2 emission from 2013 level till 2040. Since some countries such as Japan, Korea, China and New Zealand will likely foresee the reduction of energy consumption, thus they are not included in this case study.

The scenarios setting for this case study are:

- Apply renewable energy and nuclear power generation aggressively;
- Apply energy efficacy and conservation (EEC) to achieve the maximum energy savings;
- Frozen the CO2 emission from 2013 level till 2040, and how it affect the compositions of energy mix in each country

To achieve this scenario, each country will needs to make a drastic change to their energy mix, with very high ambitious of energy savings from energy efficiency and conservations and high contribution from renewable energy where nuclear option become dispensable. This study surely makes clear that reduction of CO_2 emissions is very difficult for some EAS countries under their expected economic growth.

The Chapter 3 is the review of the countries' nationally intended contributions to COP 21. The review showed how countries lay out targets or programmes aiming at reducing the CO_2 emissions. Some countries have clear policy and targets and some are not. Thus it is very important that countries will need to lay out the road map on how they wish to concretely contribute to the COP 21, through clear actions and programmes with timeframe.

Finally, this technical report is an exercise for the working group to improve their national data, practicing the intellectual scenarios of keeping the CO_2 emission at 2013 level till 2040 and reviewing the countries' NDC commitment. The report will improve the capacity of national experts on the energy outlook, and also help policy to think out the possibility of contributing to COP 21 by cutting back the CO_2 emission, or keeping the emission at 2013 level till 2040.

Chapter 1

Re-estimating Energy Demand Formulas Using ASEAN National Energy Data

This chapter discusses the national data improvement and uses this to estimate demand equations of some ASEAN countries to be able to assess the integrity of their historical national data as potential database to project energy demand. In the past, the East Asia Summit energy outlook and saving potential relied greatly on the International Energy Agency's historical energy data. However, the working group of this study wanted to create its data by looking into each country data as prepared based on the practical knowledge of the experts involved in the preparation of country energy outlook. To start with, five countries were chosen to check the historical data correction for the energy outlook. In formulating statistical demand model using regression analysis, the national energy data improvement should be accurate, complete, and timely. The main database file for the 1990–2013 final energy consumption by major economic sectors and subsectors and the socio-economic parameters were established and exported to the forecasting tool. Assessment on the national energy data was made through regression analysis to estimate energy demand functions such as electricity demand in residential sector. At the end, the national energy data of two ASEAN countries were assessed and used for energy outlook modelling. The remaining three countries, however, need to improve their national energy data. In this regard, the working group deferred the use of their national energy data.

1A. Indonesia’s National Energy Data Estimations

1. Background

Developing the energy outlook and analysis of energy-saving potential in East Asia has always been based on the International Energy Agency’s energy balances for member countries of the Organisation for Economic Co-operation and Development (OECD) and non-OECD countries except that of the Lao PDR which came from its Department of Energy and Mines. The plan for the future is to use the energy statistics of the member countries of the Asia Pacific Economic Cooperation (APEC) instead of the International Energy Agency’s energy statistics. In this regard, for the fiscal year 2016–2017, the Energy Working from the ASEAN countries that are member of APEC (except Brunei Darussalam) was tasked to re-estimate the demand equation using APEC’s energy statistics. The Energy Statistics and Training Office of the Asia Pacific Energy Research Centre provided the historical energy data from 1970 to 2014 (only up to 2013 in the case of some countries). The Microfit software was used in re-estimating the energy demand function.

The Lao PDR was also tasked to re-estimate the energy demand function using its national energy statistics. The remaining ASEAN member countries were tasked to prepare and analyse their historical energy statistics.

The socio-economic data were obtained from the World Bank’s World Development Indicators. Where available, data on transportation, buildings, and industrial production indices were provided by the members of the working group.

The APEC energy statistics of Indonesia were only up to 2013. The final energy demand data provided the fuel consumption in the three main energy sectors: industrial; transport; and others, consisting of residential–commercial, agriculture, and other sectors. This report is the result of the re-estimation of the demand function for Indonesia.

2. Methodology

Indonesia’s energy demand function was estimated using the econometric approach, a top-down approach linking macroeconomic model with energy model. The macroeconomic model estimates macroeconomic activities such as gross domestic product (GDP), income distribution, commodity prices, labour, industrial production, number of vehicles, number of households, number of appliances, floor area of buildings, etc. with a given level of exogenous variables such as crude oil price, world trade, and governmental policies such as fiscal expenditure and interest rate.

Thus, in econometric approach, energy demand is modelled as a function of macroeconomic activities such as income, relative prices among sources of energy, and energy demand at previous period

$$E = f(Y, Pe/CPI) \quad \text{or} \quad E = f(Y, Pe/CPI, E_{-1})$$

where

E: Energy Demand
Y: Income
Pe: Energy Price
CPI: Consumer Price Index
Pe/CPI: Relative price
E_{-1}: Energy Demand at previous period

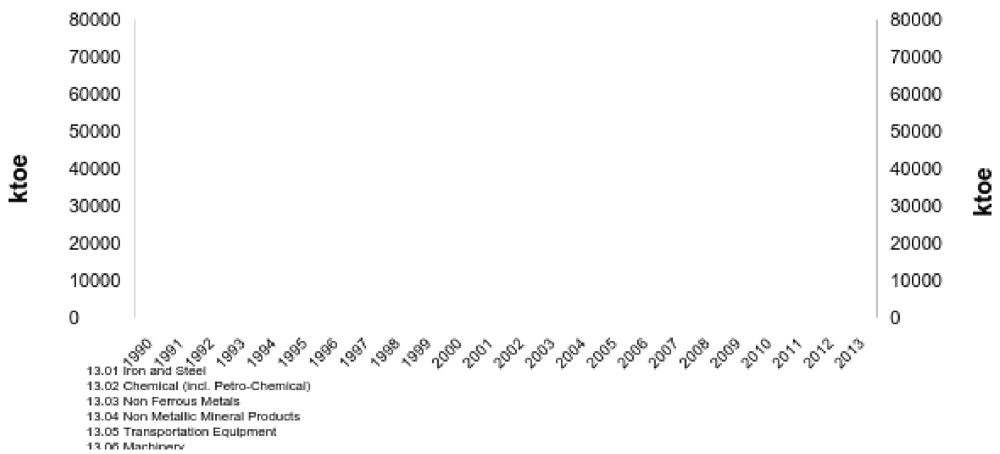
Such relationships among variables are derived by regression analysis using Microfit, a computer programme that offers an extensive choice of data analysis options and is a versatile aid in evaluating and designing advanced univariate and multivariate time series models. It is an interactive, menu-driven programme with a host of facilities for estimating and testing equations, forecasting, data processing, file management, and graphic display.

Not all consumption in each of the sectors or subsectors can be explained by a demand function. In cases where regression analysis is not applicable due to insufficient data or failure to derive a statistically sound equation, it is not necessary to estimate the demand function.

3. Industry Sector

The total final energy demand of the industry sector by subsector is shown in Figure 1A.1. As shown, the consumption data of the sub-sectors prior to 2004 do not add up to the total consumption of the sector. Since 2004, the total subsectors data has been similar to the total industry data. However, majority of the demand is classified as consumption of non-specified industry. Further breakdown will be necessary and the subsectors data since 2004 have irregular trend that need to be further clarified.

Figure 1A.1. Industrial Energy Demand by Sector

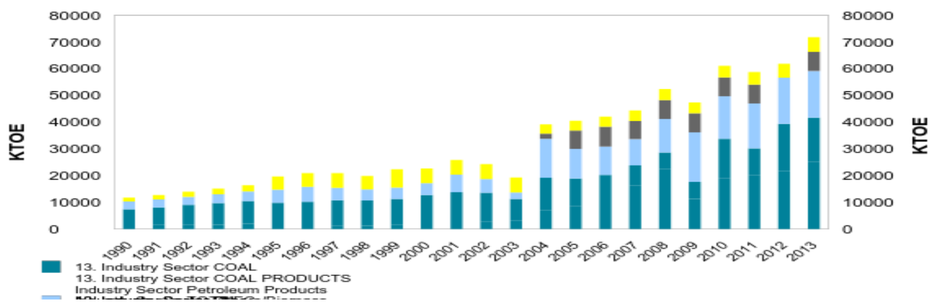


ktoe = kilotonne of oil equivalent.
Source: APEC Energy Statistic of Indonesia.

By type of energy (Figure 1A.2), the total consumption each year since 1990 is the sum of the different types of fuels consumed by the sector, consisting of coal and coal products (briquette), petroleum products, gas, others (fuelwood, other biomass, etc.), and electricity.

Considering the data condition, the re-estimation of the demand function will be done only for total industry and by fuel type wherever possible.

Figure 1A.2. Industrial Energy Demand by Fuel Type



ktoe = kilotonne of oil equivalent.
Source: APEC Energy Statistic of Indonesia.

4. Total Industry Energy Demand (INTT)

Total fuel consumption of industries was re-estimated using the manufacturing GDP (MFFGDP) and consumption of previous year as the independent variables. Imposing price variable resulted in a positive sign in the regression result. Dummy variable was included for 2001 –2004 because without this, the result is statistically not a sound equation.

The result of the regression analysis is shown in Table 1A.1 while the plot of the actual and fitted values is shown in Figure 1A.3. The re-estimated demand equation is:

INTT = -24169.7*CONS + .4366E-4*MFGGDPM + .15377*INTT(-1) + 4546.8*DUM0104

Table 1A.1. Ordinary Least Squares Estimation Total Industry (INTT)

Dependent variable is INTT

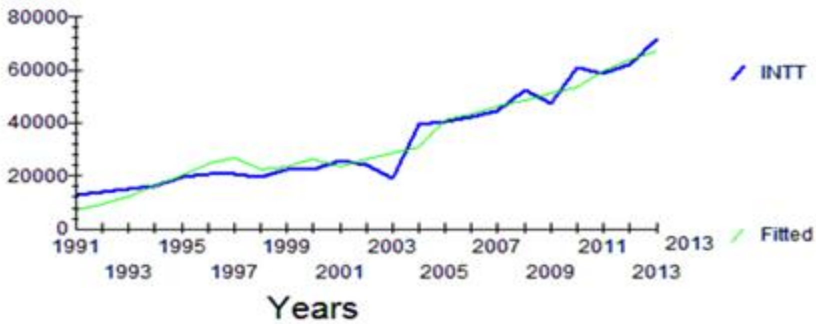
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	-24169.7	8408.8	-2.8743[.010]
MFGGDPM	.4366E-4	.1275E-4	.1275E-4 3.4257[.003]
INTT(-1)	.15377	.26817	.57340[.573]
DUM0104	4546.8	3329.4	1.3657[.188]
R-Squared	.94150	R-Bar-Squared	.93227
S.E. of Regression	4711.6	F-stat. F(3, 19) 101.9352[.000]	
Mean of Dependent Variable	33647.5		
S.D. of Dependent Variable	18103.9		
Residual Sum of Squares	4.22E+08	Equation Log-likelihood	-224.9676
Akaike Info. Criterion	-228.9676	Schwarz Bayesian Criterion	-231.2386
DW-statistic	2.125	Durbin's h-statistic	*NONE*

Source: Microfit regression analysis.

Figure 1A.3. Industrial Energy Demand by Sector

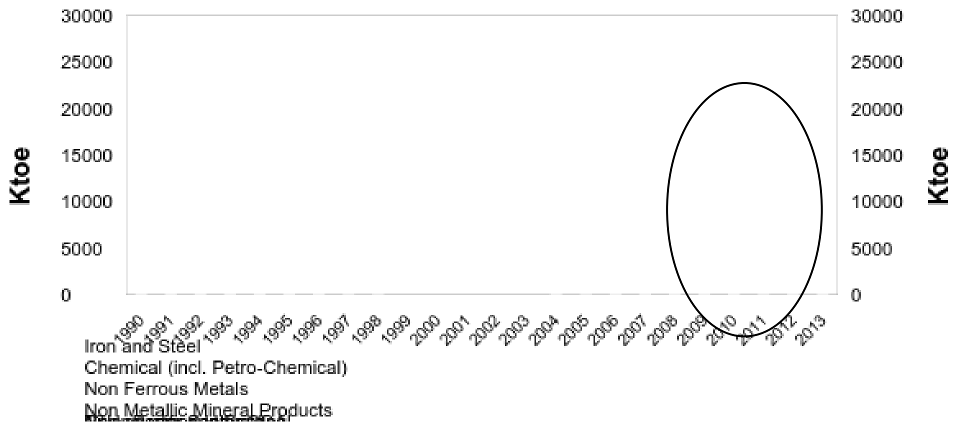
Sou



5. Total Coal Consumption (INCL)

Figure 1A.4 shows the total coal consumption (INCL) of the industrial sector. As before, the total consumption prior to 2004 does not equal the sum of the subsector consumption. Since 2004, coal consumption of the industries has increased significantly. In 2009, coal consumption experienced a steep decline but bounced back in 2010 onwards. Subsector's consumption data of coal is not consistent so it is very difficult to re-estimate the coal demand function by subsector. Thus, the re-estimation was possible only for total coal consumption.

Figure 1A.4. Industrial Coal Consumption



ktoe = kilotonne of oil equivalent.
Source: APEC Energy Statistic of Indonesia.

Re-estimation of the total industrial coal consumption also used the manufacturing GDP (MFFGDP) as the independent variables and the lag variable (previous year consumption). Inclusion of the price variable will also result in a positive sign for the regression result. The regression test was done with and without a dummy variable for 2007–2010. The regression result with the dummy variable is better so that the function to explain the coal consumption in the industrial sector is as follows:

INCL = -7298.7*CONS + .1209E-4*MFGGDPM + .47196*INCL(-1) - 1885.8*DUM0710

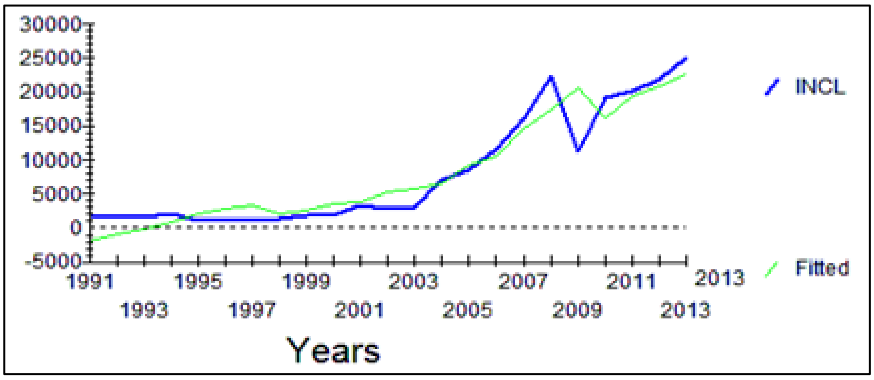
The result of the regression analysis is shown in Table 1A.2 while the plot of the actual and fitted values is shown in Figure 1A.5.

Table 1A.2. Ordinary Least Squares Estimation for INCL

Dependent variable is INTT			
23 observations used for estimation from 1991 to 2013			
Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	-7298.7	4027.1	-1.8124[.086]
MFGGDPM	.1209W-4	.4192E-5	2.8849[.009]
INTT(-1)	.47196	.19693	2.3966[.027]
DUM0104	-1885.8	1974.9	'.95486[.352]
R-Squared	.88290	R-Bar-Squared	.86441
S.E. of Regression	3089.2	F-stat. F(3, 19)	47.7502[.000]
Mean of Dependent Variable	8151.7	S.D. of Dependent Variable	8389.4
Residual Sum of Squares	1.81E+08	Equation Log-likelihood	-215.2590
Akaike Info. Criterion	-215.2590	Schwarz Bayesian Criterion	-221.5300
DW-statistic	2.2254	Durbin's h-statistic	-1.6446[.100]

Source: Microfit regression analysis.

Figure 1A.5. Plot of Actual and Fitted Values for INCL

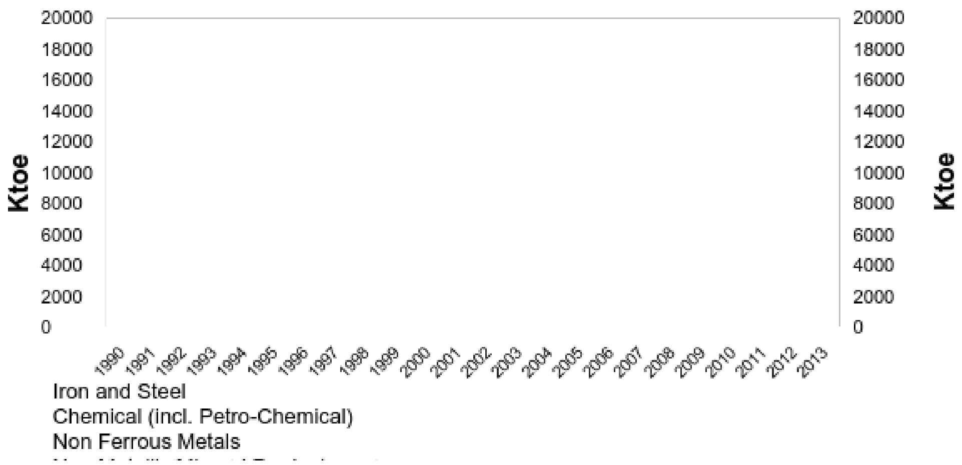


Source: APEC Energy Statistic of Indonesia.

6. Total Petroleum Product Consumption (INPP)

As shown in Figure 1A.6, summation of the industrial subsector consumption of petroleum product prior to 2004 does not equal the total consumption. From 2004 onwards, this has been possible because there was only one subsector for the breakdown of industry in the Indonesian data of APEC, which was the non-specified industries.

Figure 1A.6. Industrial Petroleum Product Consumption (INPP)



ktoe = kilotonne of oil equivalent.

Source: APEC Energy Statistic of Indonesia.

Since the data is not complete to conduct re-estimation of demand function for each of the petroleum products, the estimated function will only be for total petroleum product consumption. As with coal, the independent variable explaining the total petroleum product consumption of industries is the MFFGDP and the lag variable INPP(-1). In the case of petroleum product consumption, the price variable also contributes to the consumption as it results in a negative sign for the regression analysis. The re-estimated demand equation for INPP is:

INPP = 2775.6*CONS + .8315E-5*MFGGDPM - .71444*RPOIL + .27885*INPP(-1)

The result of the regression analysis is shown in Table 1A.3 while the plot of the actual and fitted values is shown in Figure 1A.7.

Table 1A.3. Ordinary Least Squares Estimation for INPP

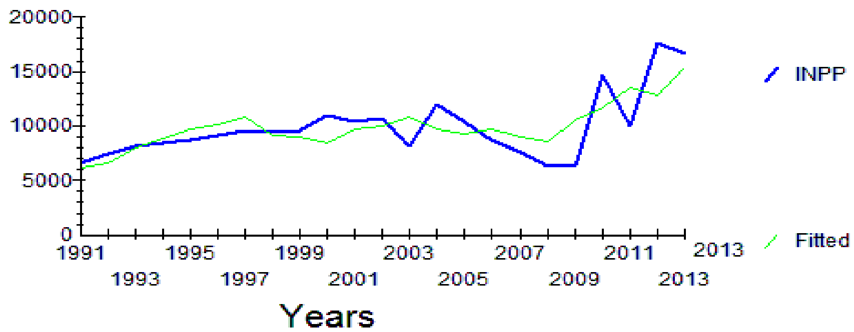
Dependent variable is INTT
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	2775.6	1983.1	1.3996[.178]
MFGGDPM	8.32E-06	2.84E-06	2.9283[.009]
INTT(-1)	.71444	.35838	1.9935[.061]
DUM0104	.27885	.21329	1.3074[.207]

R-Squared	.48642	R-Bar-Squared	.40533
S.E. of Regression	2280.5	F-stat. F(3, 19)	5.9984[.005]
Mean of Dependent Variable	9904.9	S.D. of Dependent Variable	2957.2
Residual Sum of Squares	9.88E+07	Equation Log-likelihood	208.2776
Akaike Info. Criterion	212.2776	Schwarz Bayesian Criterion	214.5486
DW-statistic	2.3736	Durbin's h-statistic	*NONE*

Source: Microfit regression analysis.

Figure 1A.7. Plot of Actual and Fitted Valued for INPP



Source: Microfit regression analysis.

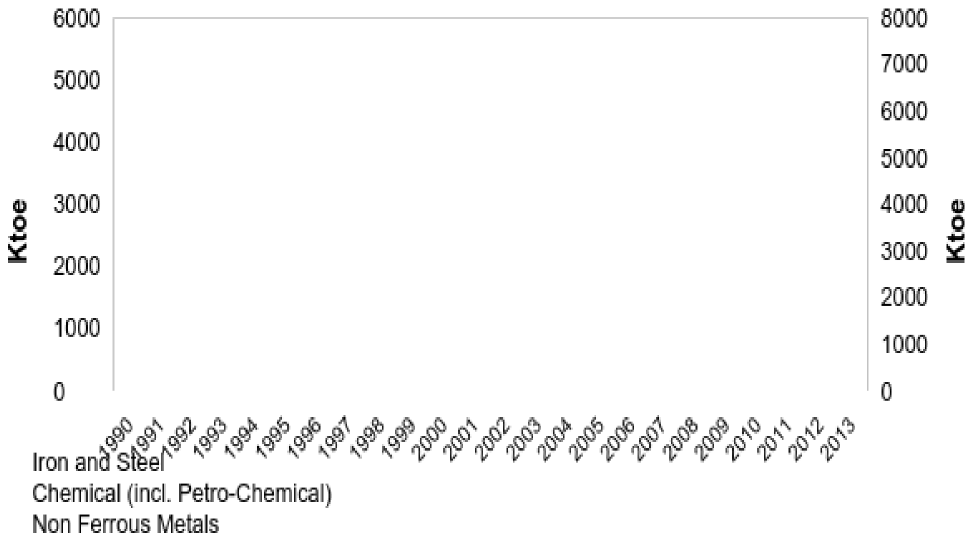
7. Total Electricity Consumption of Industries (INEL)

The subsector data of electricity consumption is not reliable and needs further clarification (Figure 1A.8). As such it is not possible to estimate the demand function for electricity in each subsector.

In the case of total electricity consumption, the data for 1994–2004 showed irregularity. There was no explanation for this irregularity. Although a dummy variable is not appropriate for smoothing unexplained irregularity of data, the result of the regression analysis shows a better fit than that without the dummy. The re-estimated demand equation for INEL from the regression analysis is:

INEL = 1390.9*CONS + .1976E-5*MFGGDPM - .095445*RPOIL + .45469*INEL(-1) - 975.4261*DUM9404

Figure 1A.8. Power Generation by Type of Fuel (TWh)



ktoe = kilotonne of oil equivalent, TWh = terawatt hour.

Source: Author’s calculations.

The result of the regression analysis is shown in Table 1A.4 while the plot of the actual and fitted values is shown in Figure 1A.9.

Table 1A.4. Ordinary Least Squares Estimation for INEL

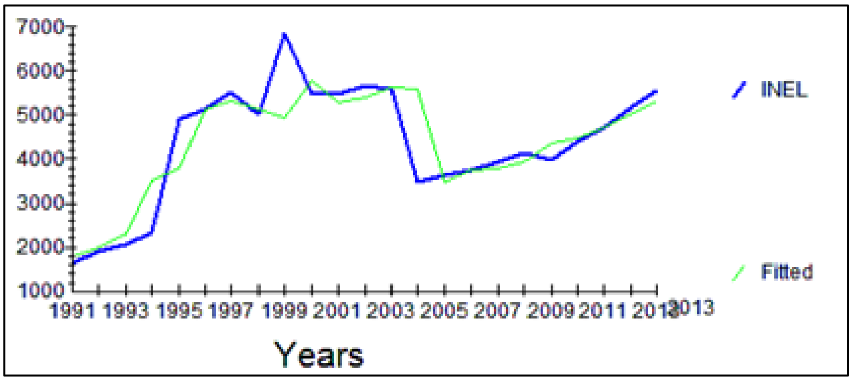
Dependent variable is INTT

23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	1390.9	706.8747	1.9677[.065]
MFGGDPM	.1976E-5	.1029E-5	1.9208[.071]
RPOIL	-.095445	.14716	-.64857[.525]
INEL(-1)	.45469	.22146	2.0531[.055]
DUM9404	-975.4261	712.3919	-1.3692[.188]
R-Squared	.72534	R-Bar-Squared	.66431
S.E. of Regression	796.5824	F-stat. F(3, 19)	11.8841[.000]
Mean of Dependent Variable	4362.3	S.D. of Dependent Variable	1374.9
Residual Sum of Squares	1.14E+07	Equation Log-likelihood	-183.4643
Akaike Info. Criterion	-188.4643	Schwarz Bayesian Criterion	-191.3030
DW-statistic	2.3656	Durbin's h-statistic	*NONE*

Source: Microfit regression analysis.

Figure 1A.9. Plot of Actual and Fitted Valued for INEL

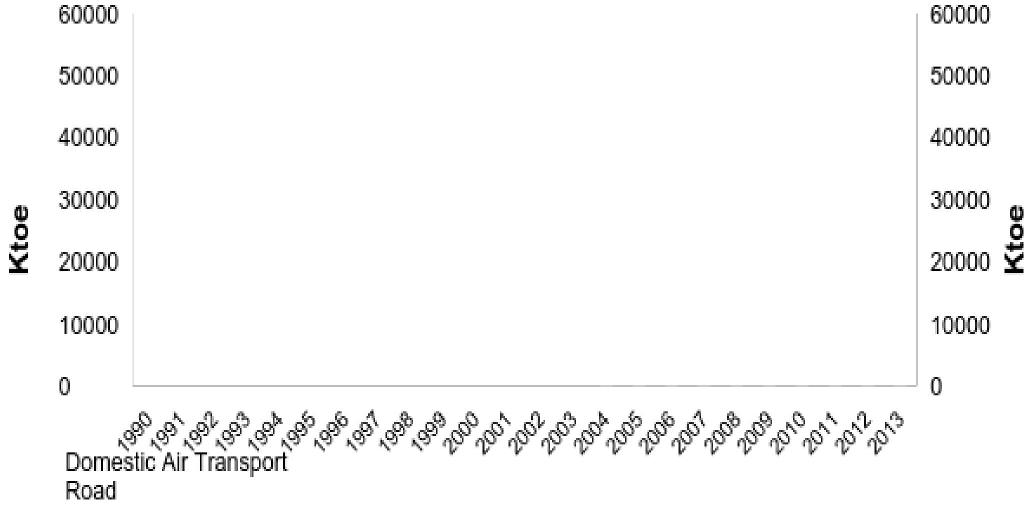


Source: Microfit regression analysis.

11. Transport Sector

The total energy demand of the transport sector by subsector is shown in Figure 1A.10. The data by subsectors are available only since 2004. However, as shown, the subsector data are inconsistent and need to be verified further.

Figure 1A.10. Transport Sector Final Energy Demand by Subsector

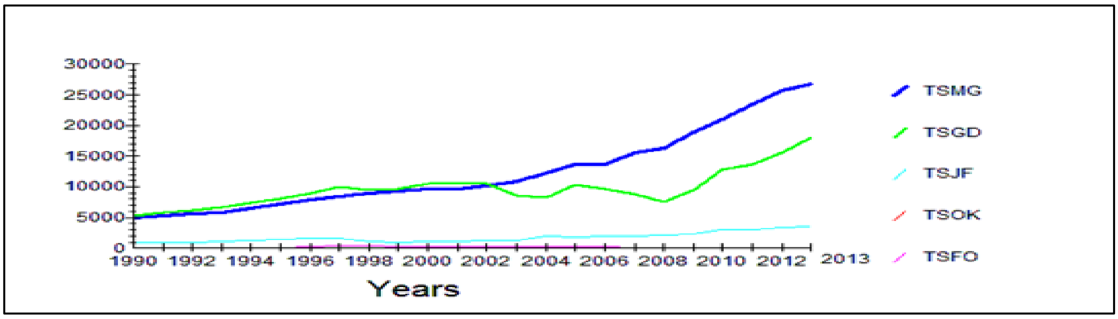


ktoe = kilotonne of oil equivalent.

Source: APEC Energy Statistic of Indonesia.

The majority of the fuel consumed by the transport sector are petroleum products (Figure 1A.11) consisting of motor gasoline, gas/diesel oil, jet fuel, kerosene, and fuel oil. Motor gasoline is used by the road sector while jet fuel is for aviation purposes. Gas/diesel oil can be used in the road, rail, and inland waterways. Fuel oil is consumed in inland waterways.

Figure 1A.11. Transport Sector Petroleum Product Consumption (Ktoe)



ktoe = kilotonne of oil equivalent.

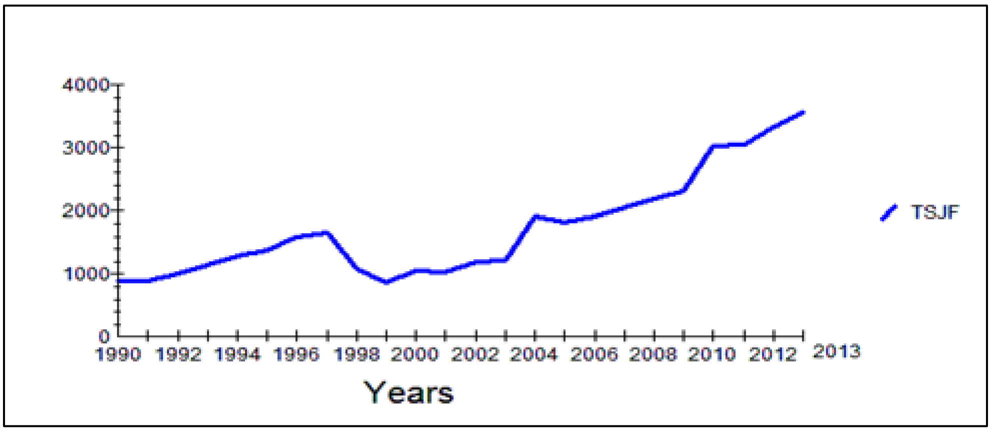
Source: APEC Energy Statistic of Indonesia.

The regression analysis will be done to estimate the demand function for the jet fuel, the petroleum product for road transport, and the fuel oil.

12. Total Jet Fuel (TSJET)

The jet fuel (TSJF) data for the transport sector is shown in Figure 1A.12. The data shows an increasing trend and that the function could be estimated linearly.

Figure 1A.12. Total Jet Fuel (TSJF) Consumption (Ktoe)

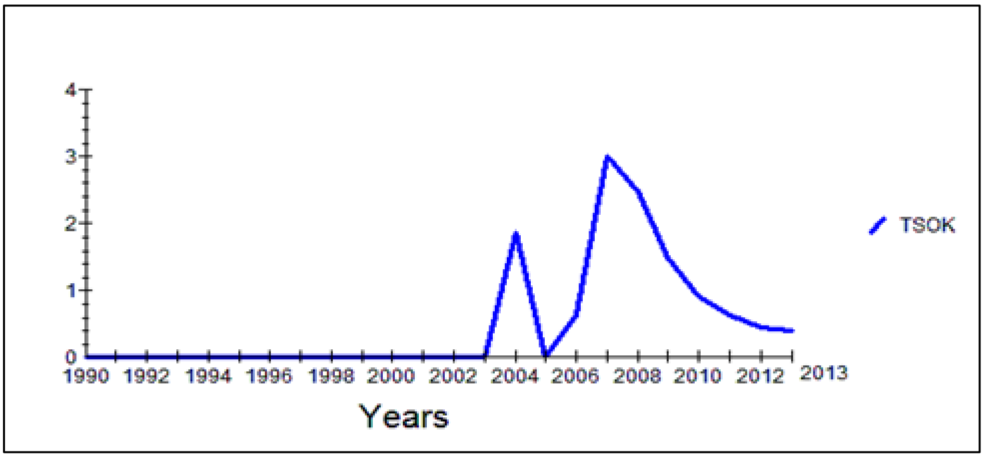


ktoe = kilotonne of oil equivalent.

Source: APEC Energy Statistic of Indonesia.

The APEC energy data for the transport sector, however, also includes kerosene data (TSOK) as shown in Figure 1A.13. Since kerosene is not commonly consumed by the transport sector, it is assumed that this is some inconsistent data.

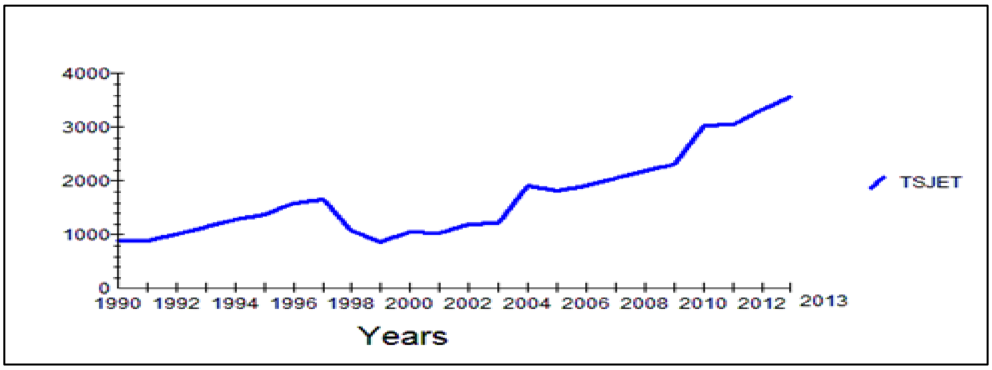
Figure 1A.13. Transport Sector Kerosene (TSOK) Consumption (Ktoe)



Source: APEC Energy Statistic of Indonesia

Considering that jet kerosene has similar specification for kerosene, the kerosene data is assumed to be part of the aviation fuel. Thus, total jet fuel (TSJET) will be the sum of TSJF and TSOK (Figure 1A.14).

Figure 1A.14. Total Jet Fuel (TSJET) Consumption (Ktoe)



ktoe = kilotonne of oil equivalent.

Source: APEC Energy Statistic of Indonesia.

The re-estimated demand equation for TSJET from the regression analysis is:

TSJET = -677.5099*CONS + .4632E-6*GDPMIL - .058392*RPOIL + .31410*TSJET(-1)

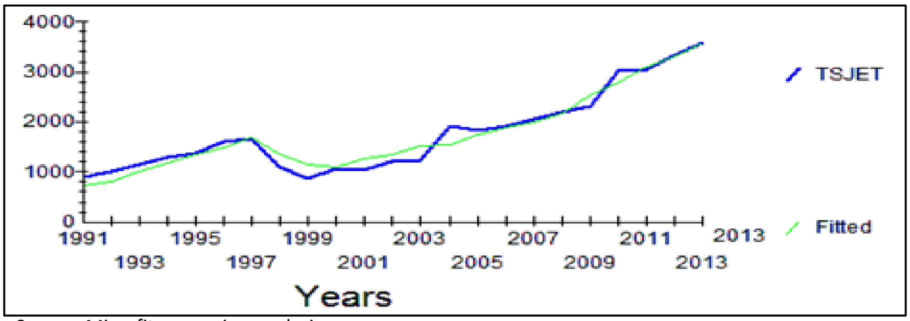
The result of the regression analysis is shown in Table 1A.5 while the plot of the actual and fitted values is shown in Figure 1A.15.

Table 1A.5. Ordinary Least Squares Estimation for TSJET

```
*******************************************************************************
 Dependent variable is TSJET
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                    -677.5099          189.3916             -3.5773[.002]
 GDPMIL                   .4632E-6          .1036E-6              4.4716[.000]
 RPOIL                   -.058392           .027203              -2.1465[.045]
 TSJET(-1)                 .31410           .17675                1.7771[.092]
*******************************************************************************
 R-Squared                       .95376   R-Bar-Squared                   .94646
 S.E. of Regression            188.8635   F-stat.    F( 3, 19)    130.6399[.000]
 Mean of Dependent Variable      1765.6   S.D. of Dependent Variable    816.2348
 Residual Sum of Squares       677719.0   Equation Log-likelihood      -150.9820
 Akaike Info. Criterion       -154.9820   Schwarz Bayesian Criterion   -157.2530
 DW-statistic                    1.6757   Durbin's h-statistic       1.4658[.143]
*******************************************************************************
```

Source: Microfit regression analysis.

Figure 1A.15. Plot of Actual and Fitted Values for TSJET

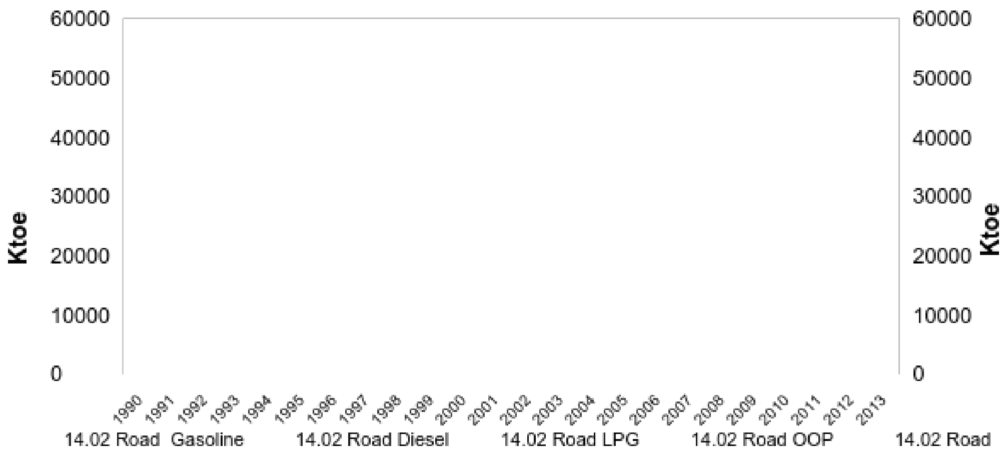


Source: Microfit regression analysis.

13. Road Transport

The road sector consumed majority of the petroleum product consumption of the transport sector. There was no data on road consumption prior to 2004 (Figure 1A.16). In 2004, the data shows only for motor gasoline, while the total consumption of the road sector is not available.

Figure 1A.16. Road Sector Petroleum Product Consumption (RDPP)



ktoe = kilotonne of oil equivalent.
Source: APEC Energy Statistic of Indonesia.

The total consumption of the road sector equals the sum of the different fuels since 2005. However, in 2012 and 2013, the sum of the fuels was lower than the total. In addition, data of the gas/diesel oil is only available from 2010 onwards and that there is other petroleum product (OOP) data which also needs to be clarified. The irregularity of the data by fuel type makes it difficult to estimate the demand function for each of the petroleum product in the road transport.

Considering the data limitation, a demand function analysis was still conducted for total petroleum product consumption of the road transport. The regression analysis shows a better result if the period is from 1991 as compared from 2005. The re-estimated demand equation for RDPP from the regression analysis is:

RDPP = -13144.7*CONS + .3582E-5*GDPMIL - .14432*RPOIL + .81835*RDPP(-1)

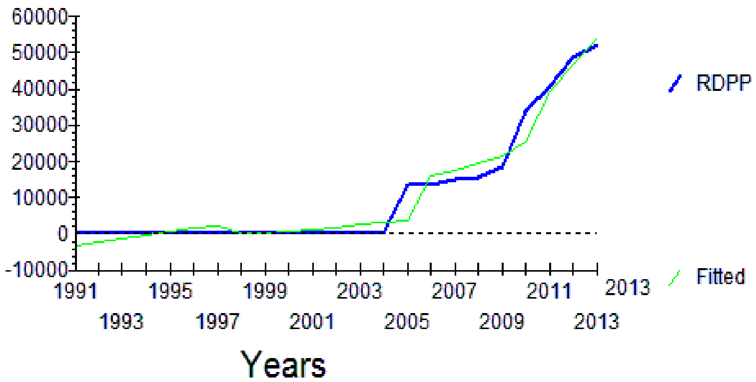
The result of the regression analysis is shown in Table 1A.6 while the plot of the actual and fitted values is shown in Figure 1A.17.

Table 1A.6. Ordinary Least Squares Estimation for RDPP

```
*******************************************************************************
 Dependent variable is RDPP
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                     -13144.7            5896.6             -2.2292[.038]
 GDPMIL                   .3582E-5           .1739E-5             2.0602[.053]
 RPOIL                    -.14432             .54429             -.26515[.794]
 RDPP(-1)                  .81835             .14256              5.7406[.000]
*******************************************************************************
 R-Squared                     .95735   R-Bar-Squared                   .95062
 S.E. of Regression            3769.0   F-stat.    F( 3, 19)    142.1645[.000]
 Mean of Dependent Variable   10956.5   S.D. of Dependent Variable     16960.4
 Residual Sum of Squares     2.70E+08   Equation Log-likelihood      -219.8335
 Akaike Info. Criterion     -223.8335   Schwarz Bayesian Criterion   -226.1045
 DW-statistic                  2.0417   Durbin's h-statistic      -.13709[.891]
 *******************************************************************************
```

Source: Microfit regression analysis

Figure 1A.17. Plot of Actual and Fitted Values for RDPP



Source: Microfit regression analysis.

14. Road Motor Gasoline (RDMG)

The road sector motor gasoline consumption has been analysed as a function of GDP, domestic relative price of gasoline, and previous year consumption. The re-estimated demand equation for RDMG from the regression analysis is:

RDMG = -3370.5*CONS + .3795E-5*GDPMIL - 112.9137*RPPREM + .18479*RDMG(-1)

The result of the regression analysis is shown in Table 1-4.7 while the plot of the actual and fitted values is shown in Figure 1A.18.

Table 1A.7. Ordinary Least Squares Estimation for RDMG

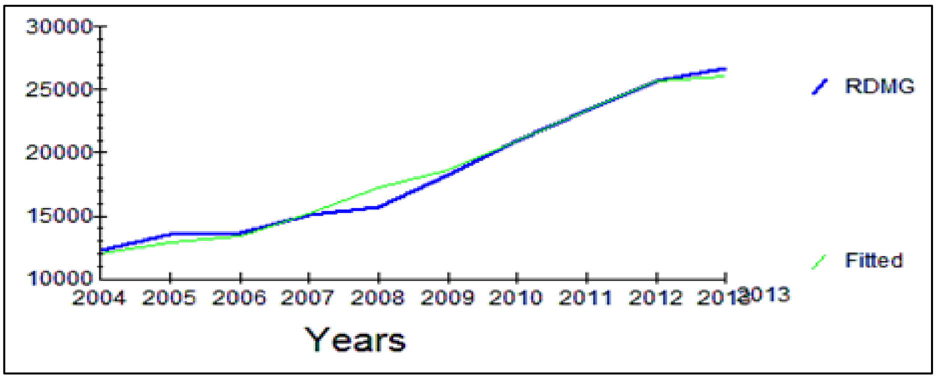
Dependent variable is RDMG
10 observations used for estimation from 2004 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	-3370.5	5827.5	-.57838[.584]
GDPMIL	.3795E-5	.9451E-6	4.0159[.007]
RPPREM	-112.9137	55.2232	-2.0447[.087]
RDMG(-1)	.18479	.16017	1.1537[.292]

R-Squared	.98550	R-Bar-Squared	.97826
S.E. of Regression	783.7370	F-stat. F(3, 6)	135.9718[.000]
Mean of Dependent Variable	18550.0	S.D. of Dependent Variable	5315.0
Residual Sum of Squares	3685463	Equation Log-likelihood	-78.2760
Akaike Info. Criterion	-82.2760	Schwarz Bayesian Criterion	-82.8812
DW-statistic	1.2535	Durbin's h-statistic	1.3689[.171]

Source: Microfit regression analysis.

Figure 1A.18. Plot of Actual and Fitted Values for RDMG



Source: Microfit regression analysis.

15. Road Diesel Transport (RDGD)

As with motor gasoline, the road sector motor gas/diesel consumption has been analysed as a function of GDP, domestic relative price of gas/diesel oil, and previous year consumption. The re-estimated demand equation for RDGD from the regression analysis is:

RDGD = -12737.1*CONS + .4483E-5*GDPMIL - 371.6183*RPDSLS + .43108*RDMG(-1)

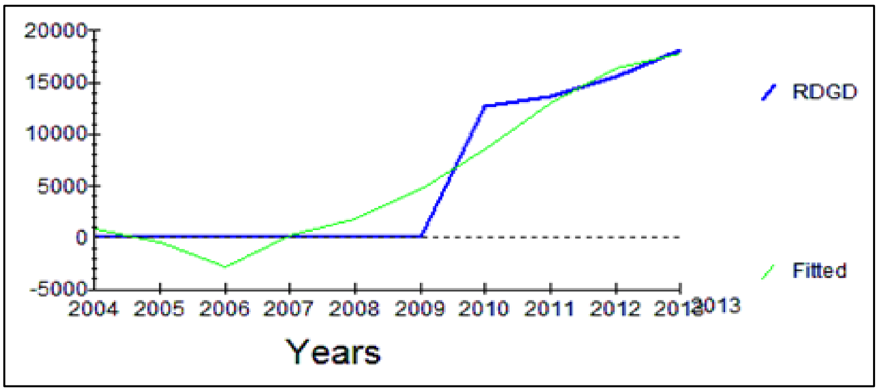
The result of the regression analysis is shown in Table 1-4.8 while the plot of the actual and fitted values is shown in Figure 1A.19.

Table 1A.8. Ordinary Least Squares Estimation for RDGD

```
*******************************************************************************
 Dependent variable is RDGD
 10 observations used for estimation from 2004 to 2013
*******************************************************************************
 Regressor              Coefficient        Standard Error         T-Ratio[Prob]
 CONS                     -23995.0             9816.3             -2.4444[.050]
 GDPMIL                   .6424E-5            .2006E-5             3.2020[.019]
 RPDSLS                  -254.7739            134.8292            -1.8896[.108]
 RDGD(-1)                  .087633             .32024              .27364[.794]
*******************************************************************************
 R-Squared                      .90763   R-Bar-Squared                   .86145
 S.E. of Regression             2928.8   F-stat.    F( 3, 6)     19.6530[.002]
 Mean of Dependent Variable     6000.0   S.D. of Dependent Variable      7868.5
 Residual Sum of Squares      5.15E+07   Equation Log-likelihood       -91.4588
 Akaike Info. Criterion       -95.4588   Schwarz Bayesian Criterion    -96.0640
 DW-statistic                   2.3243   Durbin's h-statistic            *NONE*
*******************************************************************************
```

Source: Microfit regression analysis.

Figure 1A.19. Plot of Actual and Fitted Valued for RDGD



Source: Microfit regression analysis.

16. Transport Fuel Oil

The transport sector fuel oil consumption has been analysed as a function of GDP, relative price of crude oil, and previous year consumption. The re-estimated demand equation for TSFO from the regression analysis is:

TSFO = 96.5251*CONS + .1138E-7*GDPMIL - .017440*RPOIL + .76634*TSFO(-1)

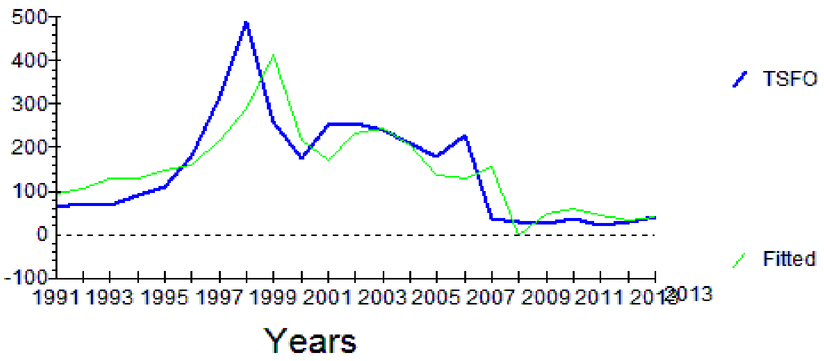
The result of the regression analysis is shown in Table 1-4.9 while the plot of the actual and fitted values is shown in Figure 1A.20.

Table 1A.9. Ordinary Least Squares Estimation for TSFO

```
*******************************************************************************
 Dependent variable is TSFO
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient        Standard Error         T-Ratio[Prob]
 CONS                       96.5251             77.5171            1.2452[.228]
 GDPMIL                   .1138E-7            .2163E-7             .52626[.605]
 RPOIL                    -.017440             .011672            -1.4942[.152]
 TSFO(-1)                   .76634              .16278             4.7078[.000]
*******************************************************************************
 R-Squared                    .63262   R-Bar-Squared                     .57462
 S.E. of Regression          78.6495   F-stat.    F( 3, 19)        10.9060[.000]
 Mean of Dependent Variable 147.8957   S.D. of Dependent Variable      120.5883
 Residual Sum of Squares    117529.1   Equation Log-likelihood        -130.8335
 Akaike Info. Criterion    -134.8335   Schwarz Bayesian Criterion     -137.1045
 DW-statistic                 2.1285   Durbin's h-statistic         -.49287[.622]
*******************************************************************************
```

Source: Microfit regression analysis.

Figure 1A.20. Plot of Actual and Fitted Values for TSFO



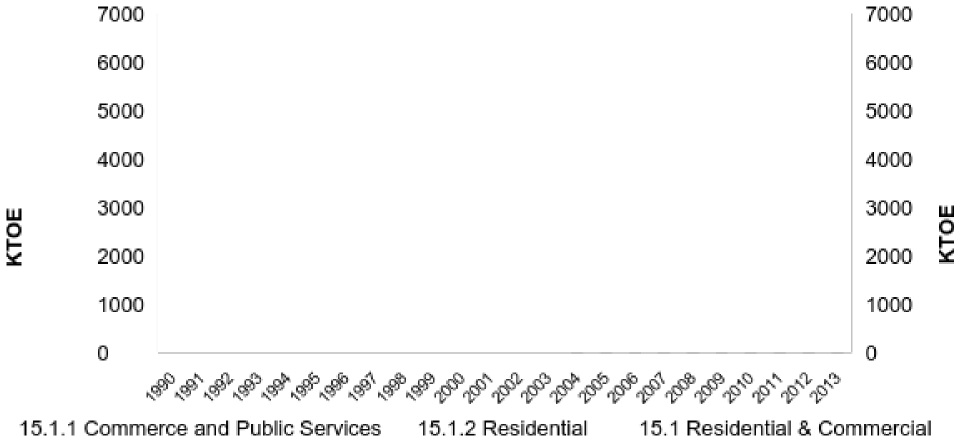
Source: Microfit regression analysis.

17. Residential and Commercial Sector

By type of fuel, the residential and commercial (ResCom) sector consumption covers LPG, electricity, biomass (fuelwood and charcoal), coal product (briquette), and gas/diesel. As with the industry and transport sector, the subsector consumption is not complete and unreliable.

For example, for the LPG consumption of the ResCom sector shown in Figure 1-4.21, the subsector data is available only from 2004 and only for commercial sector. In 2005, the data is only for the residential sector. From 2007 onward, both subsector data are available, but the commercial sector data is significantly lower than 2004. Under this data condition, it would be better to estimate total sector LPG consumption rather than the subsector consumption.

Figure 1A.21. Residential and Commercial (ResCom) Sector LPG Consumption (RECSLP)

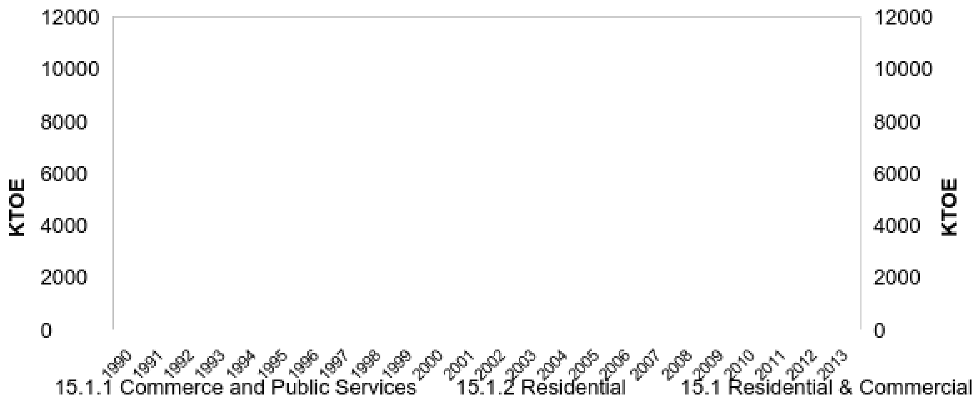


ktoe = kilotonne of oil equivalent.

Source: APEC Energy Statistic of Indonesia.

In the case of electricity consumption (Figure 1A.22), the sum of the subsectors is similar to the total consumption data although only from 2004 onward. Prior to 2004, the available data is only for total consumption. It is possible to estimate demand function for electricity consumption in each of the subsectors, but the regression analysis would be best if done for total ResCom consumption of electricity.

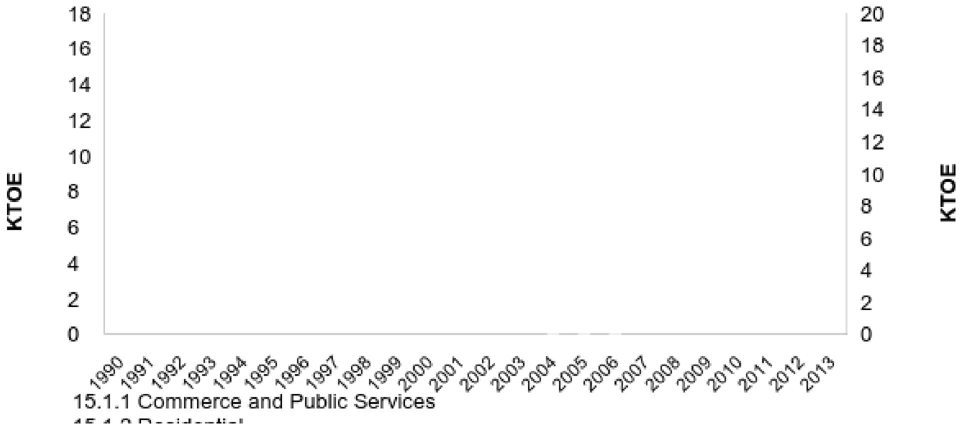
Figure 1A.22. Residential and Commercial (ResCom) Electricity Consumption (RECSEL)



ktoe = kilotonne of oil equivalent.
Source: APEC Energy Statistic of Indonesia.

The coal product consumed by the ResCom sector is actually briquette. Thus, the data shown in Figure 1A.23 is the briquette consumption (RECSCL). The data, however, needs to be clarified and revised because it seems there are missing data in 2001 and 2007 onwards. The subsector data seems also to be incorrect. Under this condition, no estimation of the demand function will be done.

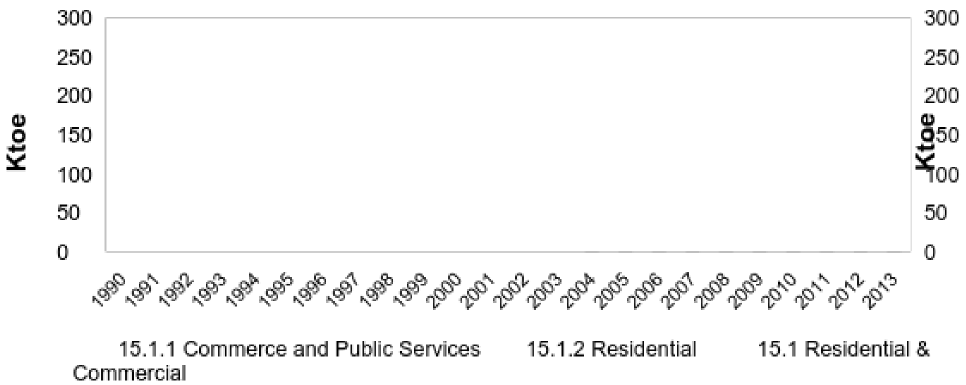
Figure 1A.23. Coal Product Consumption by Sector (CS)



ktoe = kilotonne of oil equivalent.
Source: APEC Energy Statistic of Indonesia.

Similarly, for natural gas consumption of the ResCom sector, the data available in the APEC statistic is unreliable. No explanation for the reason why the data is as it is. Therefore, no demand function was estimated for natural gas consumption in the ResCom sector (see Figure 1A.24).

Figure 1A.24. Natural Gas Consumption by Sector (Ktoe)

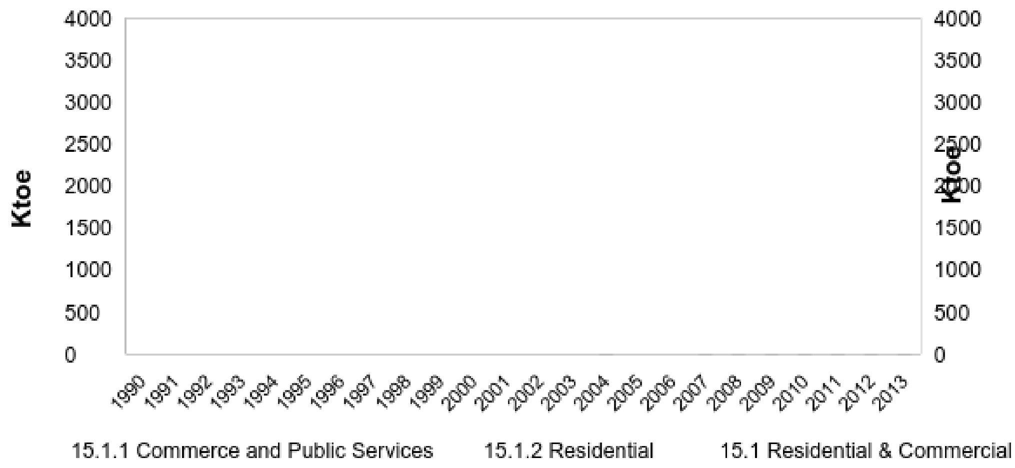


ktoe = kilotonne of oil equivalent.
Source: APEC Energy Statistic of Indonesia.

18. Total LPG consumption (RECSOILP)

The ResCom consumption of oil covers not only LPG but kerosene and gas/diesel oil as well. Kerosene consumption is decreasing in line with the government programme to switch to LPG. The gas/diesel oil consumption data for ResCom is not reliable (Figure 1A.25), making it difficult to estimate the demand function. As a result, the demand equation will be estimated only for total LPG consumption of the ResCom sector.

Figure 1A.25. Residential and Commercial (ResCom) Sector Gas/Diesel Oil Consumption (Ktoe)



ktoe = kilotonne of oil equivalent.
Source: APEC Energy Statistic of Indonesia.

The total LPG consumption of the ResCom sector has been analysed as a function of GDP, relative price of oil, and previous year consumption. The re-estimated demand equation for RECSLP from the regression analysis is:

RECSLP = -2707.0*CONS - .11164*RPOIL + .6136E-6*GDPMIL + .74018*RECSLP(-1) + 1087.2*DUM01

The result of the regression analysis is shown in Table 1A.10 while the plot of the actual and fitted values is shown in Figure 1A.26.

Table 1A.10. Ordinary Least Squares Estimation for RECSLP

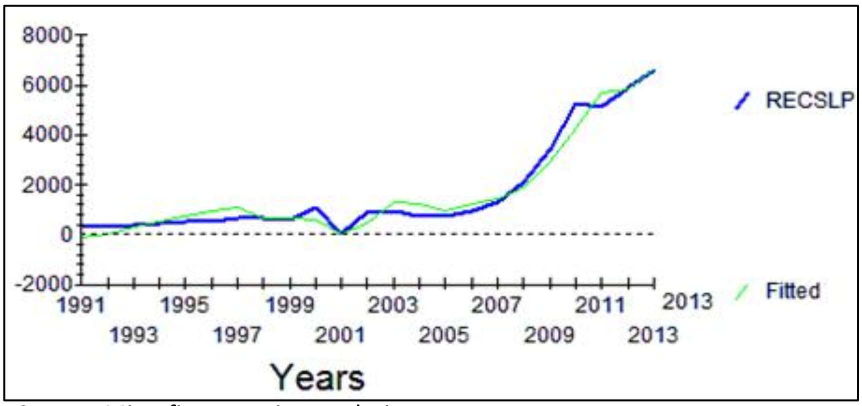
Dependent variable is RECSLP
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	-2707.0	674.3900	-4.0139[.001]
RPOIL	-.11164	.071735	-1.5563[.137]
GDPMIL	.6136E-6	.2229E-6	2.7523[.013]
RECSLP(-1)	.74018	.13736	5.3888[.000]
DUM01	1087.2	450.9640	2.4108[.027]

R-Squared	.96279	R-Bar-Squared	.95452
S.E. of Regression	430.1381	F-stat. F(4, 18)	116.4411[.000]
Mean of Dependent Variable	1708.1	S.D. of Dependent Variable	2017.0
Residual Sum of Squares	3330338	Equation Log-likelihood	-169.2911
Akaike Info. Criterion	-174.2911	Schwarz Bayesian Criterion	-177.1299
DW-statistic	1.6535	Durbin's h-statistic	1.1042[.270]

Source: Microfit regression analysis.

Figure 1A.26: Plot of Actual and Fitted Valued for RECSOILC

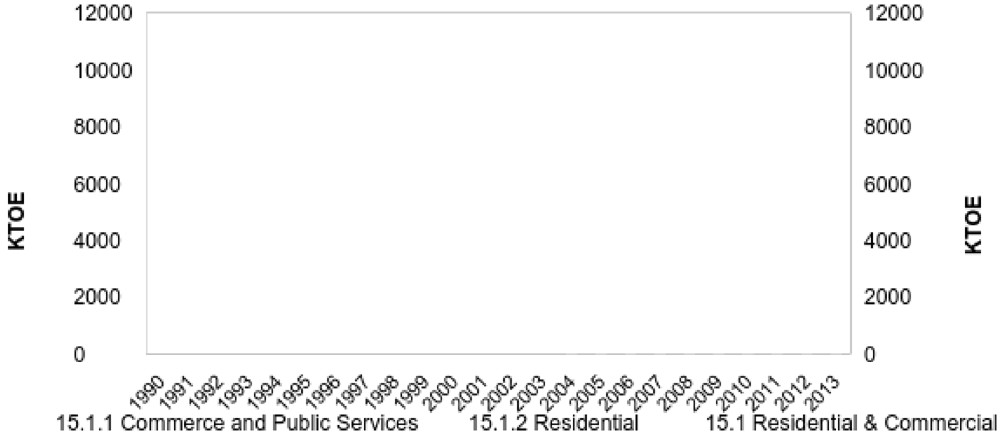


Source: Microfit regression analysis.

19. Total electricity consumption (RECSEL)

Demand function for electricity consumption will be estimated for total ResCom sector. It is not broken down by subsector (Figure 1A.27).

Figure 1A.27. Total Electricity Consumption by Sector (Ktoe)



ktoe = kilotonne of oil equivalent.
Source: APEC Energy Statistic of Indonesia.

The re-estimated demand equation for RECSEL from the regression analysis is:

RECSEL = -653.9821*CONS + .4125E-6*GDPMIL - 25.8784*RPELCC + .83281*RECSEL(-1)

The result of the regression analysis is shown in Table 1A.11 while the plot of the actual and fitted values is shown in Figure 1A.28.

Table 1A.11. Ordinary Least Squares Estimation for RECSEL

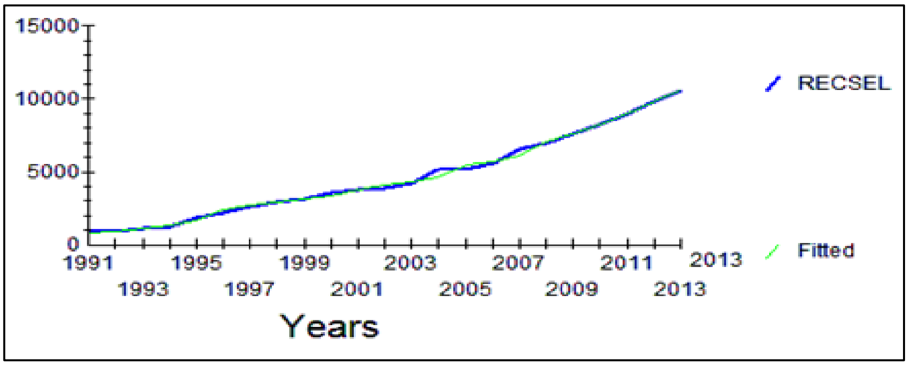
Dependent variable is RECSEL
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	-653.9821	426.9971	-1.5316[.142]
GDPMIL	.4125E-6	.1631E-6	2.5294[.020]
RPELCC	-25.8784	24.2586	-1.0668[.299]
RECSEL(-1)	.83281	.095520	8.7187[.000]

R-Squared	.99627	R-Bar-Squared	.99568
S.E. of Regression	193.3224	F-stat. F(3, 19)	1693.0[.000]
Mean of Dependent Variable	4654.2	S.D. of Dependent Variable	2942.8
Residual Sum of Squares	710097.6	Equation Log-likelihood	-151.5187
Akaike Info. Criterion	-155.5187	Schwarz Bayesian Criterion	-157.7897
DW-statistic	2.7034	Durbin's h-statistic	-1.8974[.058]

Source: Microfit regression analysis.

Figure 1A.28. Plot of Actual and Fitted Valued for RECSEL



Source: Microfit regression analysis.

20. Conclusion and Recommendation

The re-estimation of the demand function using APEC data is not as sound as with the energy statistics of the International Energy Agency. The Indonesian data in the APEC energy statistics still need to be analysed in detail due to data irregularity and inconsistency. Nevertheless, some demand equations have been re-estimated for each of the demand sector.

In the industrial sector, re-estimation has been done for total final energy consumption (INTT), total coal consumption (INCL), total petroleum product consumption (INPP), and total electricity consumption (INEL). In the transport sector, the re-estimated demand function is for total aviation fuel (TSJET) consisting of jet fuel (TSJF) and kerosene (TSOK), total petroleum product of road transport (RDPP), total motor gasoline and gas/diesel oil consumption of road transport (RDMG and RDGD), and total fuel oil consumption (TSFO). In the residential and commercial sector, the demand equation has been re-estimated only for the LPG and electricity consumption of total residential and commercial sector (RECSLP and RECSEL).

A better APEC energy statistics of Indonesia can be developed by further communication with Pusdatin (the Centre of Data and Information) of the Ministry of Energy and Mineral Resources of Indonesia which supplies data.

1B. Malaysia's National Energy Data Estimations

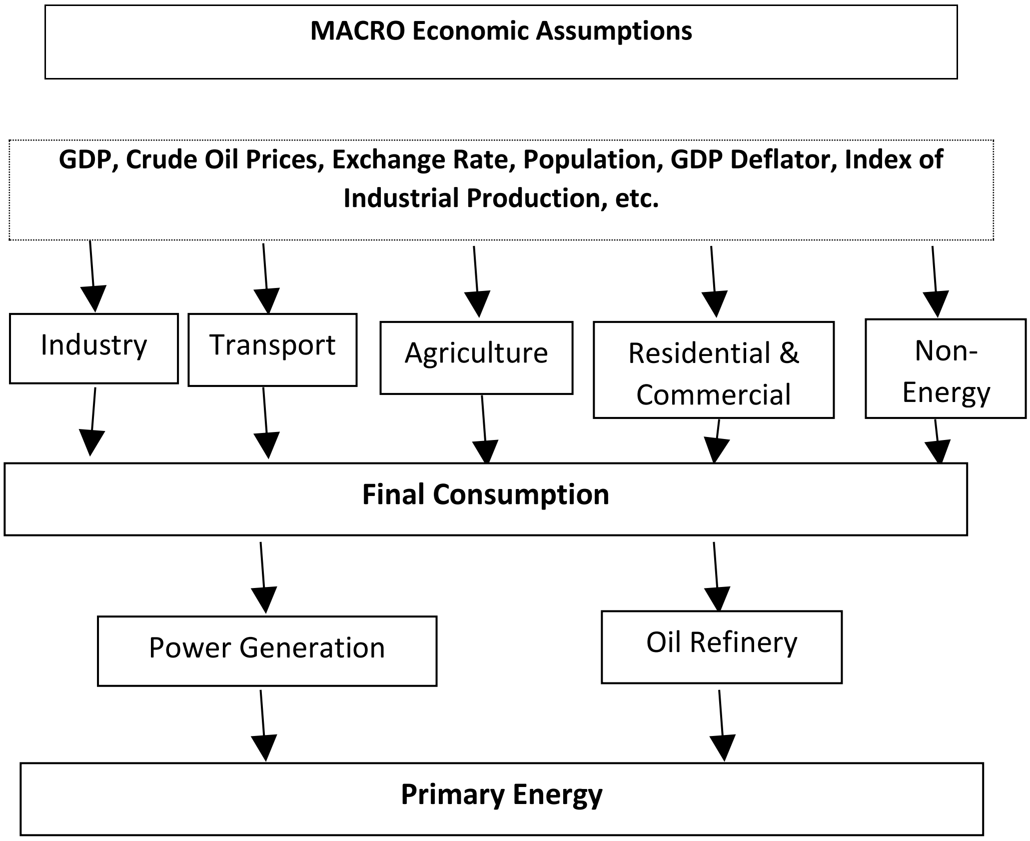
1. Introduction

Malaysia's energy demand projections up to 2040 were estimated using the econometric approach. Historical energy demand data were taken from the National Energy Balance of the Energy Commission of Malaysia. The economic indicators used in energy modelling such as gross domestic products (GDP) were taken from the World Bank's World Development Indicators. Energy modelling involved the estimation of final energy consumption and the corresponding primary energy requirements or supply. Figure 1B.1 shows the model structure from final energy demand projection and estimation of transformation inputs to arrive at the primary energy requirements.

The econometric approach was used in forecasting Malaysia's final energy demand. The historical correlation between energy demand as well as macroeconomic and activity indicators were derived by regression analysis using Microfit, an interactive software for microcomputers designed especially for the econometric modelling of time series data. It has powerful features for data processing, file management, graphic display, estimation, hypothesis testing, and forecasting under a variety of univariate and multivariate model specifications.

The future energy demand for various energy sources were estimated using assumed values of the macroeconomic and activity indicators. Future values of these indicators were also derived using historical data depending on their sufficiency for such analysis. In the model structure, energy demand was modelled as a function of activity such as income, industrial production, number of vehicles, number of households, number of appliances, floor area of buildings, etc. In the residential sector, for example, the demand for electricity could be a function of number of households, disposable income, and penetration rate of electrical appliances. In the commercial sector, energy consumption could be driven by building floor areas, private consumption, and other factors that encourage commercial activities. However, due to unavailable information on the activity indicators, macroeconomic data, i.e. GDP, was the best variable to search for the relationship with the energy demand trend. The GDP information was broken down into industry GDP, commercial GDP, agriculture GDP, and manufacturing GDP. These macroeconomic indicators were mainly used to generate the model equations. In some cases, where regression analysis was not applicable due to insufficiency of data or failure to derive a statistically sound equation, other methods such as share of percentage approach were used. Figure 1B.1 describes the flow of modelling structure of the energy demand outlook.

Figure 1B.1. Modelling Structure



GDP = gross domestic product.
Source: Author's llustration.

2. Industry Sector

Total Industry Sector

(INTTC): 1105.5*CONST + 27.4371*MNGDP -986.1141*RPOIL + 0.76655*INTTC (-1)

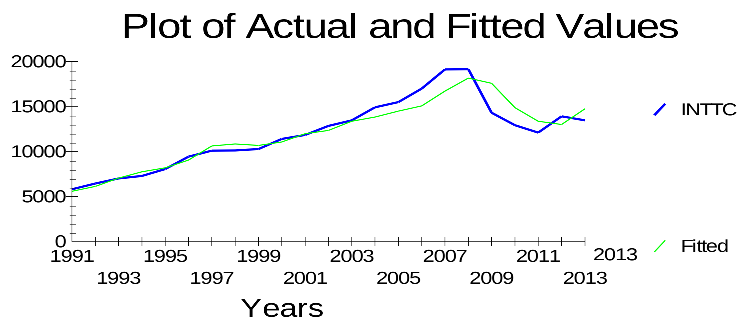
Average Annual Growth Rate (2013–2040): 3.16 %

Table 1B.1. Coefficient Estimates of Total Industry Sector

```
                    Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is INTTC
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONST                      1105.5            948.1395            1.1660[.258]
 MNGDP                     27.4371             16.6577            1.6471[.116]
 RPOIL                   -986.1141            851.0325           -1.1587[.261]
 INTTC(-1)                  .76655              .13197            5.8087[.000]
*******************************************************************************
 R-Squared                     .89417   R-Bar-Squared                   .87746
 S.E. of Regression            1316.1   F-stat.    F(  3,  19)   53.5127[.000]
 Mean of Dependent Variable   12023.5   S.D. of Dependent Variable      3759.6
 Residual Sum of Squares     3.29E+07   Equation Log-likelihood      -195.6336
 Akaike Info. Criterion     -199.6336   Schwarz Bayesian Criterion   -201.9046
 DW-statistic                  1.1141   Durbin's h-statistic      2.7436[.006]
*******************************************************************************
```

Source: Microfit result.

Figure 1B.2. Plot of actual and fitted values of total industry sector



3. Coal Demand in Industry Sector

INLB = -5.5412 + 4.0091*MNGDP + 0.52011*INLB (-1)

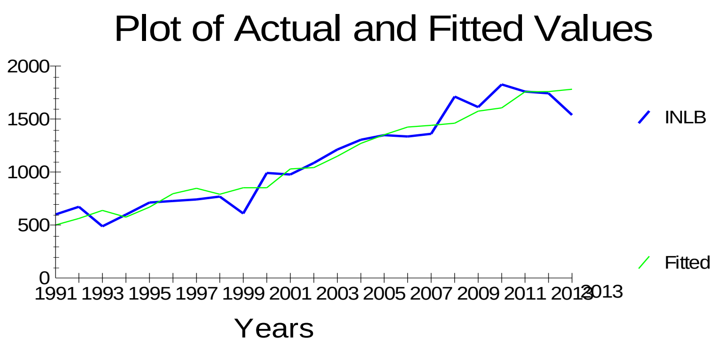
Average Annual Growth Rate (2013–2040): 2.87 %

Table 1B.2. Coefficient Estimates of Coal Demand in Industry Sector

```
                      Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is INLB
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONST                     -5.5412            87.0944           -.063623[.950]
 MNGDP                      4.0091             1.6053             2.4974[.021]
 INLB(-1)                   .52011             .17588             2.9572[.008]
*******************************************************************************
 R-Squared                     .92121   R-Bar-Squared                   .91333
 S.E. of Regression          130.1585   F-stat.    F(  2,  20)  116.9119[.000]
 Mean of Dependent Variable    1118.2   S.D. of Dependent Variable    442.1069
 Residual Sum of Squares     338824.6   Equation Log-likelihood      -143.0096
 Akaike Info. Criterion     -146.0096   Schwarz Bayesian Criterion   -147.7129
 DW-statistic                  1.9475   Durbin's h-statistic       .23458[.815]
*******************************************************************************
```

Source: Microfit result.

Figure 1B.3. Plot of actual and fitted values of coal demand



4. Natural Gas Demand in Industry Sector

INNG = -507.5752 + 5.5600*INGDP -2519.1*RPRNG + 0.80290*INNG (-1)

Table 1B.3. Coefficient Estimates of Gas Demand in Industry Sector

Ordinary Least Squares Estimation

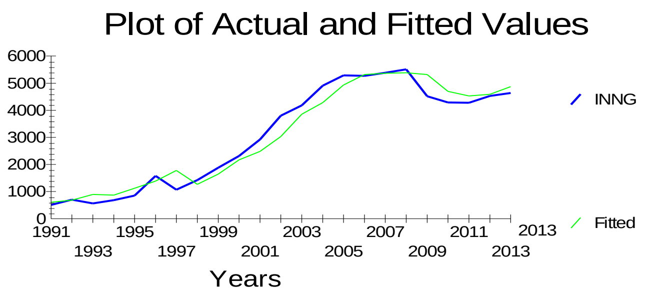
Dependent variable is INNG
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONST	-507.5752	594.2775	-.85410[.404]
INGDP	5.5600	3.8590	1.4408[.166]
RPRNG	-2519.1	3160.2	-.79714[.435]
INNG(-1)	.80290	.11943	6.7229[.000]

R-Squared	.95728	R-Bar-Squared	.95054
S.E. of Regression	412.8358	F-stat. F(3, 19)	141.9263[.000]
Mean of Dependent Variable	3090.0	S.D. of Dependent Variable	1856.3
Residual Sum of Squares	3238234	Equation Log-likelihood	-168.9686
Akaike Info. Criterion	-172.9686	Schwarz Bayesian Criterion	-175.2396
DW-statistic	1.1700	Durbin's h-statistic	2.4279[.015]

Source: Microfit result.

Figure 1B.4. Plot of actual and fitted values of gas demand



5. Electricity Demand in Industry Sector

INEL = 18.0327 + 9.4470*MNGDP -169.9169*RPOIL + 0.68847*INEL (-1)

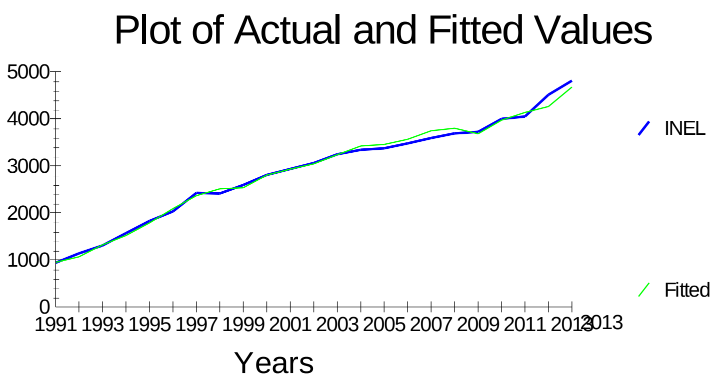
Average Annual Growth Rate (2013–2040): 3.20 %

Table 1B.4. Coefficient Estimates of Electricity Demand

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is INEL
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONST                      18.0327              74.7523           .24123[.812]
 MNGDP                       9.4470               2.7083           3.4882[.002]
 RPOIL                    -169.9169              66.3959          -2.5591[.019]
 INEL(-1)                    .68847              .099358           6.9292[.000]
*******************************************************************************
 R-Squared                       .99290   R-Bar-Squared                   .99178
 S.E. of Regression             96.9606   F-stat.    F(  3,  19)  885.5087[.000]
 Mean of Dependent Variable      2904.0   S.D. of Dependent Variable      1069.3
 Residual Sum of Squares       178625.8   Equation Log-likelihood      -135.6475
 Akaike Info. Criterion       -139.6475   Schwarz Bayesian Criterion   -141.9185
 DW-statistic                    1.5416   Durbin's h-statistic      1.2503[.211]
*******************************************************************************
```

Source: Microfit result.

Figure 1B.5. Plot of actual and fitted values of electricity demand



6. Transport Sector

Jet Kerosene Demand in Transport Sector

TRJK = -87.3853 + 2.2125*GDP -165.5858*RPOIL + 0.51359*TRJK (-1)

Average Annual Growth Rate (2013–2040): 3.55 %

Table 1B.5. Coefficient Estimates of Jet Kerosene Demand

Ordinary Least Squares Estimation

Dependent variable is TRJK

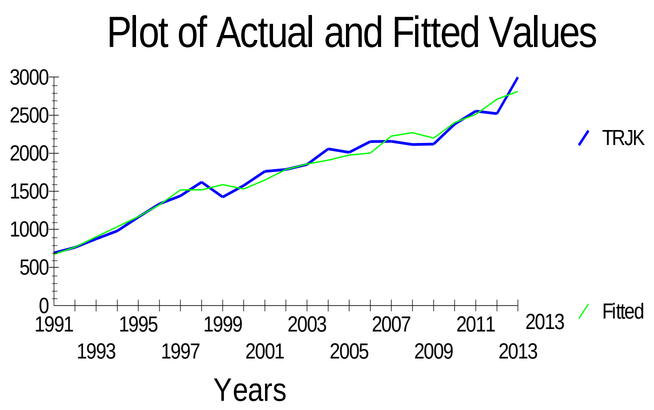
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONST	-87.3853	81.9289	-1.0666[.300]
GDP	2.2125	.57156	3.8709[.001]
RPOIL	-165.5858	70.8858	-2.3360[.031]
TRJK(-1)	.51359	.15524	3.3083[.004]

R-Squared	.97357	R-Bar-Squared	.96940
S.E. of Regression	106.7293	F-stat. F(3, 19)	233.2949[.000]
Mean of Dependent Variable	1752.8	S.D. of Dependent Variable	610.1014
Residual Sum of Squares	216431.8	Equation Log-likelihood	-137.8553
Akaike Info. Criterion	-141.8553	Schwarz Bayesian Criterion	-144.1262
DW-statistic	2.2660	Durbin's h-statistic	-.95532[.339]

Source: Microfit result.

Figure 1B.6. Plot of actual and fitted values of jet kerosene demand



Motor Gasoline Demand in Transport Sector

TSMG = -246.4996 + 10.8371*GDP -989.7284*RPOIL + 0.39919*TSMG (-1)

Average Annual Growth Rate (2013–2040): 3.51 %

Table 1B.6. Coefficient Estimates of Motor Gasoline Demand

Ordinary Least Squares Estimation

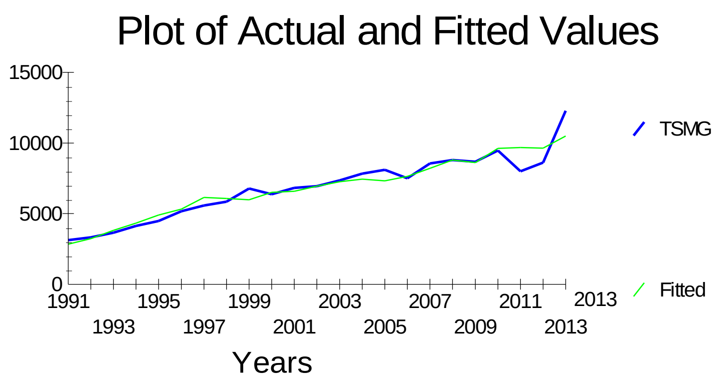
Dependent variable is TSMG
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONST	-246.4996	556.3996	-.44303[.663]
GDP	10.8371	2.7401	3.9551[.001]
RPOIL	-989.7284	469.3141	-2.1089[.048]
TSMG(-1)	.39919	.20797	1.9195[.070]

R-Squared	.91353	R-Bar-Squared	.89987
S.E. of Regression	705.3982	F-stat. F(3, 19)	66.9081[.000]
Mean of Dependent Variable	6841.3	S.D. of Dependent Variable	2229.3
Residual Sum of Squares	9454146	Equation Log-likelihood	-181.2900
Akaike Info. Criterion	-185.2900	Schwarz Bayesian Criterion	-187.5610
DW-statistic	1.5664	Durbin's h-statistic	14.3911[.000]

Source: Microfit result.

Figure 1B.7. Plot of actual and fitted value of motor gasoline demand



Diesel Demand in Transport Sector

TRGD = -90.1833 + 17.8414*MNGDP -5900.6*RPRGD + 0.43692*TRGD (-1)

Average Annual Growth Rate (2013–2040): 2.82 %

Table 1B.7. Coefficient Estimates of Diesel Demand

Ordinary Least Squares Estimation

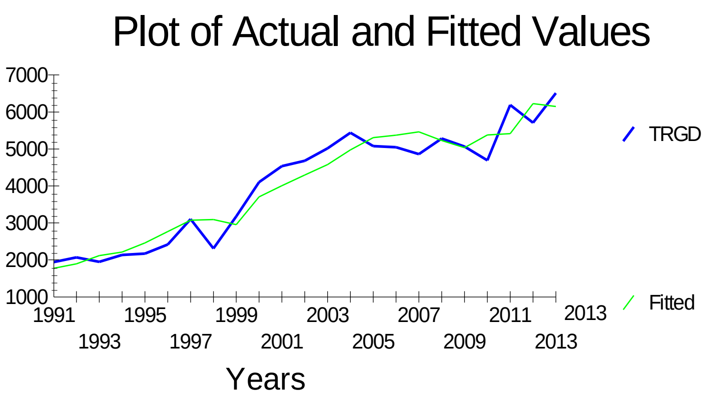
Dependent variable is TRGD
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONST	-90.1833	342.9761	-.26294[.795]
MNGDP	17.8414	5.9019	3.0230[.007]
RPRGD	-5900.6	9136.7	-.64581[.526]
TRGD(-1)	.43692	.18056	2.4197[.026]

R-Squared	.92074	R-Bar-Squared	.90823
S.E. of Regression	456.1234	F-stat. F(3, 19)	73.5773[.000]
Mean of Dependent Variable	4064.0	S.D. of Dependent Variable	1505.7
Residual Sum of Squares	3952923	Equation Log-likelihood	-171.2620
Akaike Info. Criterion	-175.2620	Schwarz Bayesian Criterion	-177.5330
DW-statistic	2.0617	Durbin's h-statistic	-.29569[.767]

Source: Microfit result.

Figure 1B.8. Plot of actual and fitted value of diesele demand



7. Others Sector

Total Energy Demand in Others Sector

OSTT = 220.6223 + 17.5420*CSGDP -43.6012*RRPOIL + 0.025252*OSTT (-1)

Average Annual Growth Rate (2013–2040): 3.52 %

Table 1B.8. Coefficient Estimates of Others Sector Demand

Ordinary Least Squares Estimation

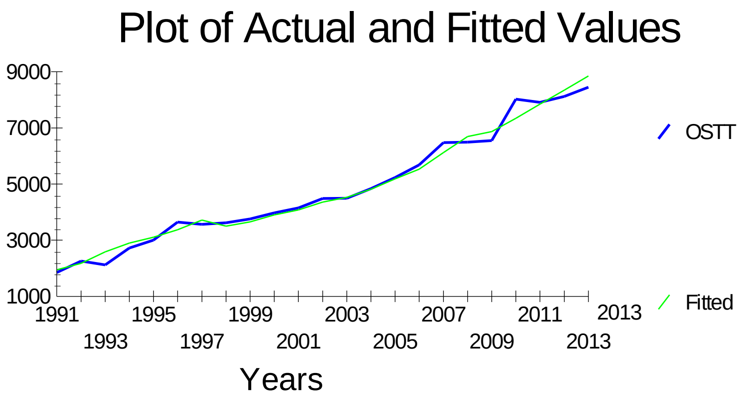
Dependent variable is OSTT
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONST	220.6223	146.3524	1.5075[.148]
CSGDP	17.5420	4.2622	4.1158[.001]
RRPOIL	-43.6012	172.8712	-.25222[.804]
OSTT(-1)	.025252	.23431	.10778[.915]

R-Squared	.98444	R-Bar-Squared	.98198
S.E. of Regression	272.3962	F-stat. F(3, 19)	400.6784[.000]
Mean of Dependent Variable	4844.1	S.D. of Dependent Variable	2029.3
Residual Sum of Squares	1409794	Equation Log-likelihood	-159.4054
Akaike Info. Criterion	-163.4054	Schwarz Bayesian Criterion	-165.6764
DW-statistic	1.9510	Durbin's h-statistic	*NONE*

Source: Microfit result.

Figure 1B.9. Plot of actual and fitted values of other sectors demand



Total Energy Demand of Petroleum Products in Others Sector

OSPP = 610.1269 + 6.6199*CSGDP -265.9463*RRPOIL -.036547*OSPP (-1)

Average Annual Growth Rate (2013–2040): 3.32 %

Table 1B.9. Coefficient Estimates of Petroleum Products in Others Sector Demand

Ordinary Least Squares Estimation

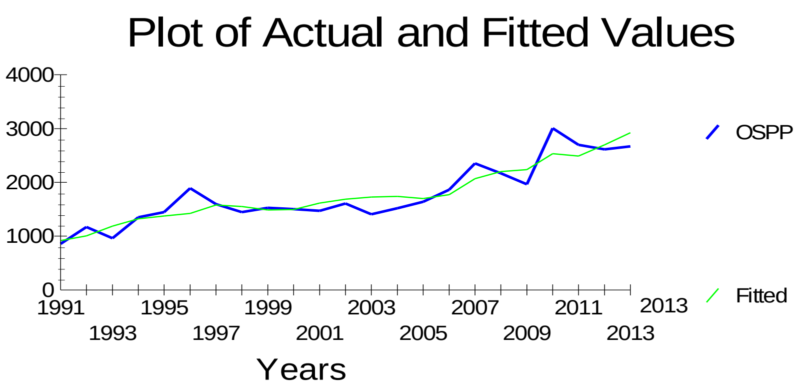
Dependent variable is OSPP
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONST	610.1269	167.0910	3.6515[.002]
CSGDP	6.6199	1.8272	3.6230[.002]
RRPOIL	-265.9463	157.3498	-1.6902[.107]
OSPP(-1)	-.036547	.22554	-.16204[.873]

R-Squared	.86097	R-Bar-Squared	.83901
S.E. of Regression	229.5971	F-stat. F(3, 19)	39.2189[.000]
Mean of Dependent Variable	1770.6	S.D. of Dependent Variable	572.2302
Residual Sum of Squares	1001582	Equation Log-likelihood	-155.4740
Akaike Info. Criterion	-159.4740	Schwarz Bayesian Criterion	-161.7449
DW-statistic	1.7418	Durbin's h-statistic	*NONE*

Source: Microfit result.

Figure 1B.10. Plot of actual and fitted value of petorleum products in other sectors demand



LPG Demand in the Others Sector

OSLP = 871.4548 + .82150*CSGDP -24571.4*RPRLP + 0.45162*OSLP (-1)

Average Annual Growth Rate (2013–2040): 2.04 %

Table 1B.10. Coefficient Estimates of LPG Demand

Ordinary Least Squares Estimation

Dependent variable is OSLP

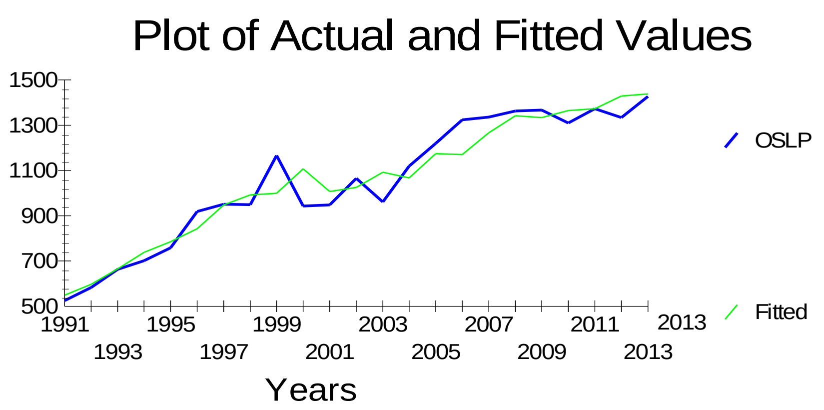
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONST	871.4548	437.5028	1.9919[.061]
CSGDP	.82150	.39657	2.0715[.052]
RPRLP	-24571.4	15925.7	-1.5429[.139]
OSLP(-1)	.45162	.20244	2.2308[.038]

R-Squared	.92173	R-Bar-Squared	.90937
S.E. of Regression	84.0227	F-stat. F(3, 19)	74.5861[.000]
Mean of Dependent Variable	1056.7	S.D. of Dependent Variable	279.1079
Residual Sum of Squares	134136.4	Equation Log-likelihood	-132.3534
Akaike Info. Criterion	-136.3534	Schwarz Bayesian Criterion	-138.6244
DW-statistic	2.2691	Durbin's h-statistic	-2.6934[.007]

Source: Microfit result.

Figure 1B.11. Plot of actual and fitted value of LPG demand



Electricity Demand in the Others Sector

OSEL = 298.2890 + 1.2677*CSGDP -732.9436*RPREL + .93157*OSEL (-1)

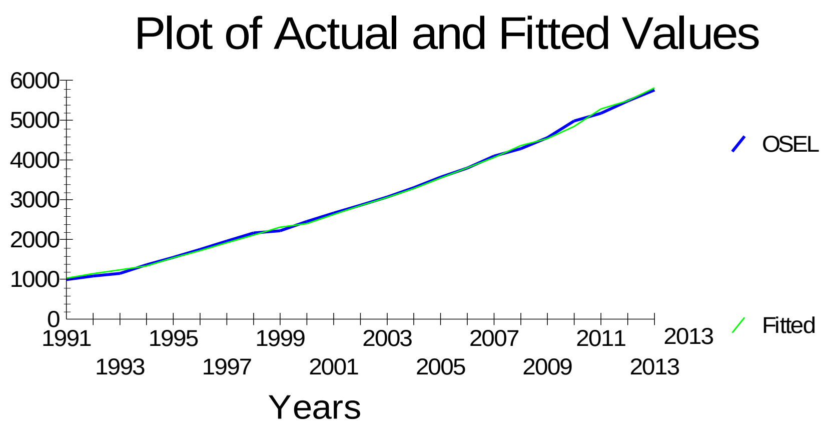
Average Annual Growth Rate (2013–2040): 3.91 %

Table 1B.11. Coefficient Estimates of Electricity Demand in Other Sectors

```
                                 Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is OSEL
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONST                    298.2890           217.5719             1.3710[.186]
 CSGDP                      1.2677             .99305             1.2765[.217]
 RPREL                   -732.9436           675.1614            -1.0856[.291]
 OSEL(-1)                   .93157            .081069            11.4910[.000]
*******************************************************************************
 R-Squared                     .99849   R-Bar-Squared                   .99825
 S.E. of Regression           62.4854   F-stat.    F(  3,  19)    4174.6[.000]
 Mean of Dependent Variable    3054.0   S.D. of Dependent Variable      1492.0
 Residual Sum of Squares      74184.2   Equation Log-likelihood       -125.5419
 Akaike Info. Criterion     -129.5419   Schwarz Bayesian Criterion    -131.8129
 DW-statistic                  2.2865   Durbin's h-statistic       -.74565[.456]
*******************************************************************************
```

Source: Microfit result.

Figure 1B.12. Plot of actual and fitted value of electricity demand in other sectors



Conclusions

By using national energy data from 1990 to 2013, major energy demand functions can be generated using the Microfit software. However, due to non-linear historical energy data for some parameters, the software was unable to generate satisfactory outcome. To overcome this problem, other methodologies, such as fuel share proportion or targeted growth rate, can be applied. Further improvement of historical data needs to be done to ensure that the time series data provide a good trend without any outliers.

In this exercise, other parameters, such as energy prices, were also chosen to determine the energy demand for the future. However, current information or data on future energy prices data are very limited due to uncertain economic situation. Information on short-term periods (less than 5 years) might be available but might be very hard to predict for long-term periods (until 2040).

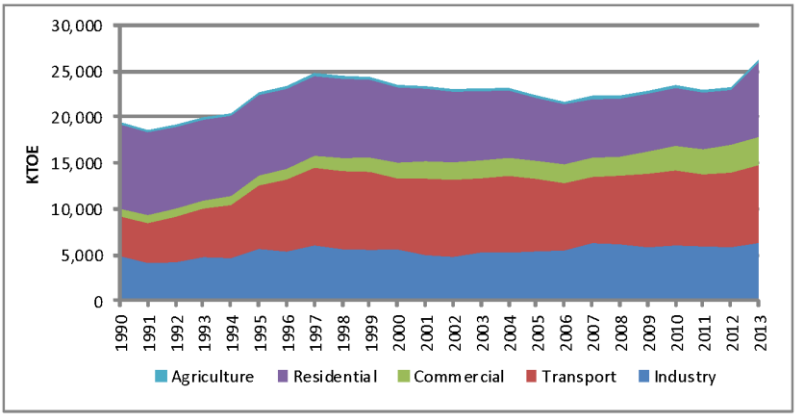
Overall, some improvements need to be considered for the future development of the demand functions for Malaysia, mainly issues on historical energy time series data and other useful parameters for analysis.

1C. National Energy Data Estimations of the Philippines

1. Introduction

Based on the energy database of the Asia-Pacific Economic Cooperation, the total final energy consumption (TFEC) of the Philippines was 26.3 metric tonnes of oil equivalent (Mtoe) in 2013, growing by 1.3% from its 1990 level of 19.5 Mtoe (see Figures 1C.1 and 1C.2). The residential sector recorded the highest level of energy demand with an annual average share of 35.4% to TFEC. In terms of rate of increase, however, the sector's share in the demand mix was decreasing to a rate of 0.5% per year of the demand level during the period. On the other hand, the transport and industry sectors, with considerably significant annual average shares of 32.2% and 24%, respectively, to the demand mix, registered yearly increase of 3% and 1.1%, respectively. Nevertheless, the fact that the main driver of growth in the country was the services sector, which is composed of essentially lesser energy-intensive establishments, commercial sectors grew the highest at 5.8% per year with an annual average share of 7.8%.

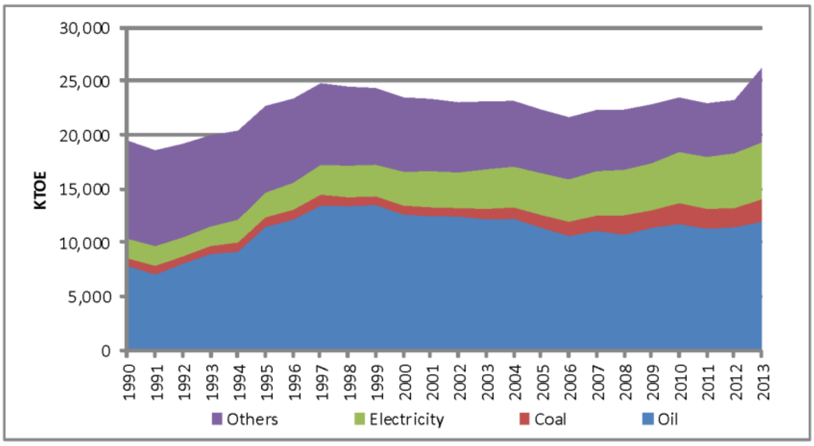
Figure 1C.1. Total Final Energy Consumption by Sector, 1990–2013



ktoe = kilotonne of oil equivalent.
Source: Department of Energy, Philippines.

In terms of TFEC by fuel, oil dominated the demand mix during the period with an annual average share of 49.3%. Likewise, biomass has a significant share in the demand mix with an annual average share of around 30% to TFEC. However, its share to the demand mix was decreasing as its energy demand level declined at a rate of 1.2% per year. Meanwhile, the demand levels of electricity and coal grew the fastest at 4.7% and 4.9%, respectively, with annual average shares of 14.7% and 5.1%, respectively, to TFEC.

Figure 1C.2. Total Final Energy Consumption by Fuel, 1990–2013



ktoe = kilotonne of oil equivalent.

Source: Department of Energy, Philippines.

2. Estimation of Energy Demand Equation by Sector

In simulating the dataset to formulate the demand equation by fuel for each sector, linear regression was applied for the sample data covering the period 1990–2013. The Microfit forecasting tool was used to estimate the demand model for each fuel by sector.

Industry demand model

The fuels utilised in the industry sector include coal, electricity, diesel oil, fuel oil, liquefied petroleum gas (LPG), kerosene, biomass, and natural gas (Table 1C.1).

Table 1C.1. Industry Demand Mix, 2013

Coal	33.1%
Kerosene	0.2%
Diesel	10.4%
Fuel Oil	7.9%
LPG	1.8%
Biomass	17.3%
Electricity	28.2%
Natural Gas	1.0%
Total Demand	6.3 Mtoe

LPG = liquefied petroleum gas, Mtoe = million tonne of oil equivalent.
Source: Department of Energy, Philippines.

The following are the variables used to define the demand model for each fuel utilised in the industry sector:

1) Coal (CL):

1.1 Non-metallic minerals (NM): NMCL constant BNMMFGVA RCOILPR

Coal is mostly utilised in cement production which is within the non-metallic minerals subsector of the manufacturing sector. The explanatory variables used in the equation are GVA of the manufacturing sector and ratio of coal and crude oil prices.

1.2 Coal demand in industry (IN): INCL constant LINGDP INCL(-1)

Total coal demand of industry was defined as the function of industry GVA in logarithm and its previous year's total demand. This equation has been formulated just to cover coal consumptions in other subsectors of manufacturing other than in non-metallic mineral subsector, which are insignificant in terms of demand level.

2) Electricity (EL): INEL constant LBINGDP

Total electricity consumption's explanatory variable identified as industry GVA in billion and logarithm.

3) Diesel (GD):

3.1 Diesel for mining and construction: OTHGD CONSTANT LOTINGDP OTHGD(-1)

OTHGD is the diesel oil demand in the mining and construction subsectors of the industry sector. Diesel oil in these subsectors was significant in terms of its level of consumption. Its explanatory variables identified as mining and construction GVA in logarithm and its previous year's demand level.

3.2 Diesel demand in industry (INGD): INGD CONSTANT LINGDP DUM939578

Total diesel oil demand equation was also derived to cover the diesel oil utilisation in the manufacturing subsector, which was defined as a function of industry GVA in logarithm.

4) Fuel oil (INFO): INFO CONSTANT RPOIL INFO(-1) DUM935770

The total fuel oil consumption was equated with the crude oil price and its previous year's demand level.

5) Petroleum products: INPP CONSTANT RPOIL INPP(-1) DUM935778

The total petroleum products demand equation was derived with its relationship with the price of crude oil and its previous year's demand level. Its equation was derived to estimate the percentage shares of LPG and kerosene consumption as the difference of the total petroleum products consumption and diesel plus fuel oil consumption, which are small portion of the industry demand mix.

6) LPG and kerosene:

LPG and kerosene will be projected with their percentage shares in the total petroleum products demand (not fit for linear regression).

7) Other (biomass) and natural gas:

Biomass and natural gas will be projected using energy intensity (not fit for linear regression)

3. Transport demand model

The transport sector is comprised of road transport (including rail), air transport, and water transport. The derivation of demand equation for transport sector was formulated by mode of transport as follows:

Road transport (RD)

1) Motor gasoline (MG): RDMG constant RRPOILJ RNOMGVE90 RDMg(-1)

The motor gasoline demand equation was derived from the relationship of motor gasoline with the relative growth rate of crude oil (1990=1) and relative growth rate of number of gasoline motor vehicles (1990=1).

2) Diesel (GD): RDGD constant RRPOILJ RNODSLVE

The diesel oil demand equation was also derived from the relationship of diesel oil with the relative growth rate of crude oil (1990=1) and relative growth rate of number of diesel motor vehicles (1990=1).

3) LPG and natural gas

LPG and natural gas will be projected based on the number of their demand technology. LPG consumption in road transport is very small and started being utilised only in 2000 while the current demand for natural gas is negligible.

4) Electricity (EL): RAEL constant TRDGVA RAEL(-1) DUM2003

Electricity consumption demand equation was derived from the relationship of electricity used in rail (RA) transport with the transport GVA and its previous year's demand level.

Air transport (DA)

Air transport demand: DAPP constant TGDPCAP DUM989078

Jet fuel equation was derived with its relationship with GDP per capita in thousand units.

Water transport (IW)

1) Fuel oil: IWFO constant LGDP RPOIL DUM0937

Fuel oil for inland waterways was defined as a function of GDP in logarithm and price of crude oil.

2) Diesel: IWGD constant LGDP RPOIL IWGD(-1)

Diesel oil was defined as a function of GDP in logarithm, price of crude oil, and its previous year's demand level.

3) Motor gasoline: IWMG constant LCSGDP RPOIL IWMG(-1)

Motor gasoline consumption for inland waterways was defined as a function of services sector GVA, price of crude oil, and its previous year's demand level.

4. Other sectors demand model

Other sectors include commercial, residential, and agriculture sectors. The formulation of demand equation for other sectors was disaggregated based on the specified sectors as follows:

Commercial (CS)

1) LPG: CSLP constant LCSGDP RPOIL CSLP(-1)

LPG demand equation was derived from its relationship with commercial sector GVA in logarithm, price of crude oil, and its previous year's demand level.

2) Diesel: CSGD constant MCSGDP RDSLPR CSGD(-1)

Diesel oil used variables such as commercial sector GVA, diesel oil price, and its previous year's demand level.

3) Electricity: CSEL constant LBCSGDP CSEL(-1)

Electricity for commercial sector was defined as being correlated with commercial GVA in logarithm and its previous year's demand level.

4) Biomass and fuel oil: Projection using energy intensity (no regression)

Biomass and fuel oil as part of the demand mix of commercial sector will be projected using energy intensity (not fit for linear regression).

Residential (RE)

1) LPG: RELP constant LHEXP RPOIL RELP(-1)

LPG demand equation was derived using variables such as household final consumption expenditure in log, crude oil price, and its previous year's demand level.

2) Kerosene (OK): REOK constant R2KERPR REOK(-1)

Kerosene demand equation was derived using variables such as local price of kerosene and its previous year's demand level.

3) Electricity: REEL constant LBHEXP R2REELPR

Electricity was defined as a function of household final consumption expenditure in billion and log and local electricity price in residential sector.

4) Others (biomass): REOTH constant BPOPR REOTH(-1)

Biomass demand equation was derived using population of rural areas in billion and its previous year's demand level.

Agriculture (AG)

1) Diesel: TAGGD constant RPOIL TAGGD(-1) DUM07

Diesel oil consumption in agriculture sector was defined as a function of crude oil price and its previous year's demand level.

2) Other petroleum products: OTAGPP constant RPOIL DUM978347

The petroleum products demand equation was formulated to get the percentage shares of motor gasoline, fuel oil, and kerosene as the difference of the total petroleum products and diesel oil demand in the agriculture demand mix.

3) Motor gasoline, fuel oil, and kerosene:

Motor gasoline, fuel oil, and kerosene consumption in agriculture will be projected using their proportion to the total petroleum products consumption.

4) Electricity: TAGEL constant laggdp tagel(-1)

Electricity demand equation in agriculture was derived from its relationship with agriculture GVA in log and its previous year's demand level.

5. Data and Estimations of Regression Results

Final energy consumption

Table 1C.2. Final Energy Consumption by Sector, 1990–2013, ktoe

	Industry	Transport	Commercial	Residential	Agriculture	Total
1990	4,896	4,290	841	9,164	283	19,474
1991	4,118	4,341	877	8,995	261	18,592
1992	4,206	4,943	887	8,863	291	19,191
1993	4,764	5,275	875	8,773	300	19,987
1994	4,658	5,760	992	8,720	275	20,404
1995	5,659	6,897	1,078	8,753	319	22,706
1996	5,375	7,823	1,169	8,675	337	23,378
1997	6,044	8,431	1,308	8,647	376	24,806
1998	5,628	8,486	1,427	8,599	350	24,489
1999	5,568	8,464	1,555	8,449	331	24,366
2000	5,611	7,695	1,726	8,172	298	23,502
2001	4,987	8,310	1,898	7,880	281	23,355
2002	4,792	8,372	1,917	7,661	298	23,040
2003	5,278	8,054	1,956	7,519	318	23,126
2004	5,257	8,334	1,969	7,301	311	23,171
2005	5,402	7,867	1,962	6,820	308	22,359
2006	5,492	7,314	2,053	6,526	277	21,661
2007	6,296	7,172	2,105	6,340	411	22,324
2008	6,173	7,452	2,055	6,311	364	22,355
2009	5,840	7,990	2,419	6,280	326	22,856
2010	6,049	8,142	2,668	6,285	343	23,488
2011	5,927	7,828	2,743	6,162	301	22,961
2012	5,845	8,108	3,028	5,956	319	23,256
2013	6,299	8,466	3,056	8,098	358	26,276

ktoe = kilotonne of oil equivalent.
Source: Department of Energy, Philippines.

Table 1C.3. Final Energy Consumption by Fuel, 1990–2013, ktoe

	Oil	Coal	Electricity	Others	Total
1990	7,833	696	1,824	9,121	19,474
1991	7,026	816	1,839	8,910	18,592
1992	8,041	676	1,775	8,699	19,191
1993	8,927	748	1,824	8,488	19,987
1994	9,146	866	2,115	8,277	20,404
1995	11,458	894	2,287	8,067	22,706
1996	12,128	911	2,515	7,825	23,378
1997	13,437	1,010	2,777	7,583	24,806
1998	13,380	833	2,936	7,341	24,489
1999	13,488	809	2,936	7,133	24,366
2000	12,592	840	3,144	6,926	23,502
2001	12,451	818	3,366	6,721	23,355
2002	12,418	782	3,322	6,518	23,040
2003	12,162	974	3,674	6,316	23,126
2004	12,210	1,055	3,791	6,116	23,171
2005	11,374	1,184	3,884	5,917	22,359
2006	10,616	1,324	3,928	5,793	21,661
2007	11,082	1,419	4,129	5,694	22,324
2008	10,733	1,798	4,232	5,593	22,355
2009	11,373	1,624	4,377	5,481	22,856
2010	11,727	1,933	4,753	5,075	23,488
2011	11,296	1,838	4,824	5,002	22,961
2012	11,422	1,784	5,092	4,957	23,256
2013	11,935	2,082	5,295	6,964	26,276

ktoe = kilotonne of oil equivalent.
Source: Department of Energy, Philippines.

6. Industry demand model

1) Coal

1.1 Non-metallic minerals:

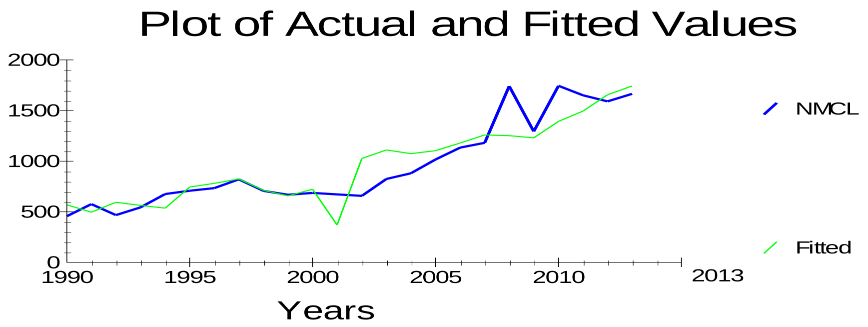
NMCL constant BNMMFGVA RCOILPR

Table 1C.4. Coefficient Estimates of Non-metallic Mineral Demand in Industry

```
                       Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is NMCL
 24 observations used for estimation from 1990 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                 730.6747          171.4776               4.2611[.000]
 BNMMFGVA                  29.7715            5.3153               5.6011[.000]
 RCOILPR                   -1370.5          223.1813              -6.1406[.000]
*******************************************************************************
 R-Squared                     .80531   R-Bar-Squared                   .78677
 S.E. of Regression          198.5057   F-stat.    F( 2, 21)    43.4322[.000]
 Mean of Dependent Variable  962.1444   S.D. of Dependent Variable    429.8807
 Residual Sum of Squares     827494.9   Equation Log-likelihood      -159.4318
 Akaike Info. Criterion     -162.4318   Schwarz Bayesian Criterion   -164.1989
 DW-statistic                  1.7217
**************************************************************
```

Source: Author's calculations.

Figure 1C.3. Plot of Actual and Fitted Values of Non-metallic Mineral Demand in Industry



Source: Author's calculations.

NMCL = 730.6747*CONSTANT + 29.7715*BNMMFGVA -1370.5*RCOILPR

1.2 Coal industry

INCL constant BINGDP INCL(-1)

Table 1C.5. Coefficient Estimates of Coal Demand in Industry

Ordinary Least Squares Estimation

Dependent variable is INCL

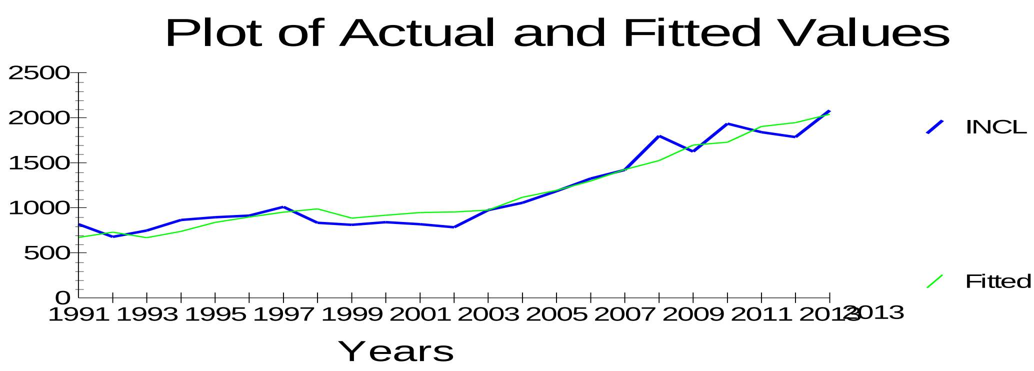
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONSTANT	-271.5342	114.1237	-2.3793[.027]
BINGDP	.63547	.18277	3.4769[.002]
INCL(-1)	.50380	.16312	3.0884[.006]

R-Squared	.93351	R-Bar-Squared	.92686
S.E. of Regression	121.1182	F-stat. F(2, 20)	140.3907[.000]
Mean of Dependent Variable	1174.8	S.D. of Dependent Variable	447.8409
Residual Sum of Squares	293392.5	Equation Log-likelihood	-141.3540
Akaike Info. Criterion	-144.3540	Schwarz Bayesian Criterion	-146.0572
DW-statistic	1.9066	Durbin's h-statistic	.35953[.719]

Source: Author's calculations.

Figure 1C.4. Plot of Actual and Fitted Values of Coal Demand in Industry



INCL = -271.5342*CONSTANT + 0.63547*BINGDP + 0.50380*INCL(-1)

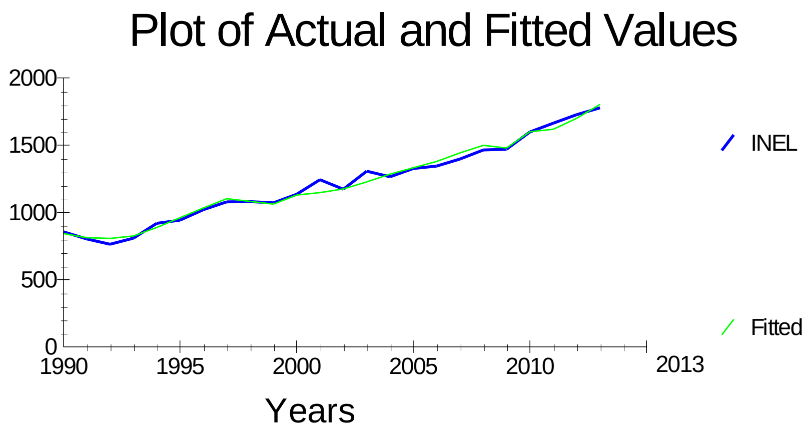
2) Electricity

INEL constant LBINGDP

Table 1C.6. Coefficient Estimates of Electricity Demand in Industry

```
                         Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is INEL
 24 observations used for estimation from 1990 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                 -6985.9            206.1562            -33.8866[.000]
 LBINGDP                   1140.6             28.6448             39.8176[.000]
*******************************************************************************
 R-Squared                    .98631   R-Bar-Squared                    .98569
 S.E. of Regression          35.8191   F-stat.    F(  1,  22)     1585.4[.000]
 Mean of Dependent Variable   1217.6   S.D. of Dependent Variable     299.4462
 Residual Sum of Squares     28226.2   Equation Log-likelihood       -118.8940
 Akaike Info. Criterion     -120.8940   Schwarz Bayesian Criterion    -122.0720
 DW-statistic                 1.7414
*******************************************************************************
```

Figure 1C.5. Plot of Actual and Fitted Values of Electricity Demand in Industry



INEL = -6985.9*CONSTANT + 1140.6*LBINGDP

3) Diesel

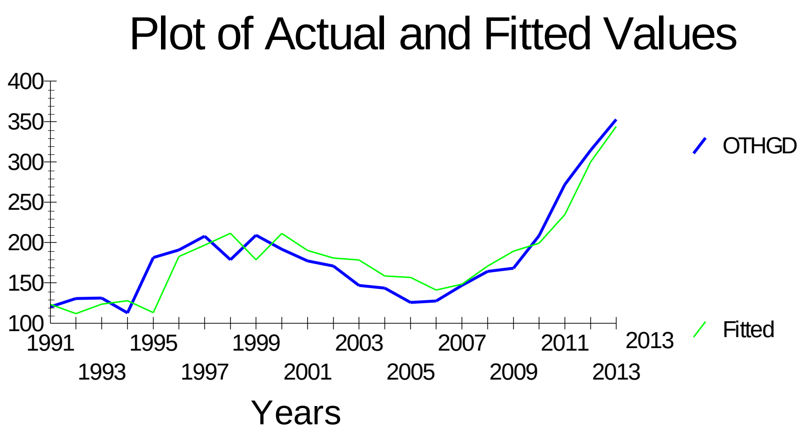
3.1 Diesel for mining and construction sector

OTHGD CONSTANT LOTINGDP OTHGD(-1)

Table 1C.7. Coefficient Estimates of Diesel for Mining and Construction Demand

```
Ordinary Least Squares Estimation
*******************************************************************************
Dependent variable is OTHGD
23 observations used for estimation from 1991 to 2013
*******************************************************************************
Regressor               Coefficient        Standard Error          T-Ratio[Prob]
CONSTANT                  -1337.9            608.6225              -2.1983[.040]
LOTINGDP                  50.8158             23.2980               2.1811[.041]
OTHGD(-1)                  .94589              .13607               6.9518[.000]
*******************************************************************************
R-Squared                     .84398   R-Bar-Squared                       .82838
S.E. of Regression           25.2109   F-stat.     F( 2, 20)     54.0953[.000]
Mean of Dependent Variable  181.4092   S.D. of Dependent Variable         60.8561
Residual Sum of Squares      12711.7   Equation Log-likelihood          -105.2556
Akaike Info. Criterion     -108.2556   Schwarz Bayesian Criterion       -109.9589
DW-statistic                  1.8898   Durbin's h-statistic           .34859[.727]
*******************************************************************************
```

Figure 1C.6. Plot of Actual and Fitted Values of Diesel for Mining and Construction Demand



OTHGD = -1337.9*CONSTANT + 50.8158*LOTINGDP + .94589*OTHGD(-1)

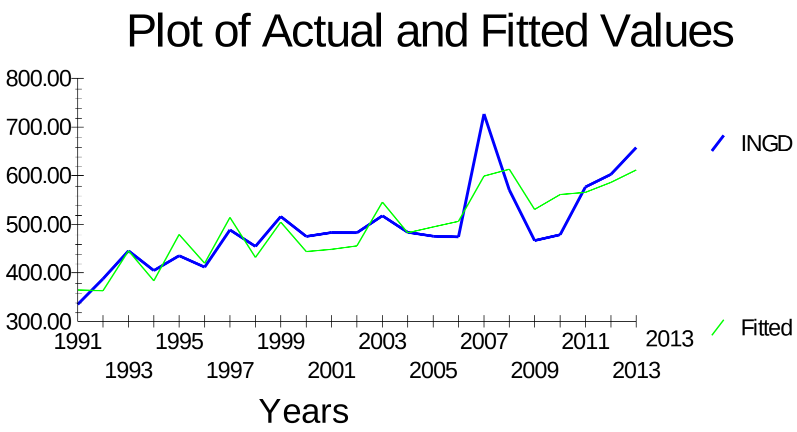
3.2 Diesel demand in industry

INGD CONSTANT LINGDP DUM939578

Table 1C.8. Coefficient Estimates of Diesel Demand in Industry

```
             Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is INGD
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                 -7389.8             1075.6             -6.8706[.000]
 LINGDP                   284.1724           38.5950              7.3629[.000]
 DUM939578                -77.3006           21.0673             -3.6692[.002]
*******************************************************************************
 R-Squared                     .75047   R-Bar-Squared                   .72552
 S.E. of Regression           45.7941   F-stat.    F( 2, 20)    30.0759[.000]
 Mean of Dependent Variable  493.3329   S.D. of Dependent Variable     87.4087
 Residual Sum of Squares      41942.0   Equation Log-likelihood      -118.9839
 Akaike Info. Criterion     -121.9839   Schwarz Bayesian Criterion   -123.6871
 DW-statistic                  1.9550
*******************************************************************************
```

Figure 1C.7. Plot of Actual and Fitted Values of Diesel Demand in Industry



INGD = -7389.8*CONSTANT + 284.1724*LINGDP -77.3006*DUM939578

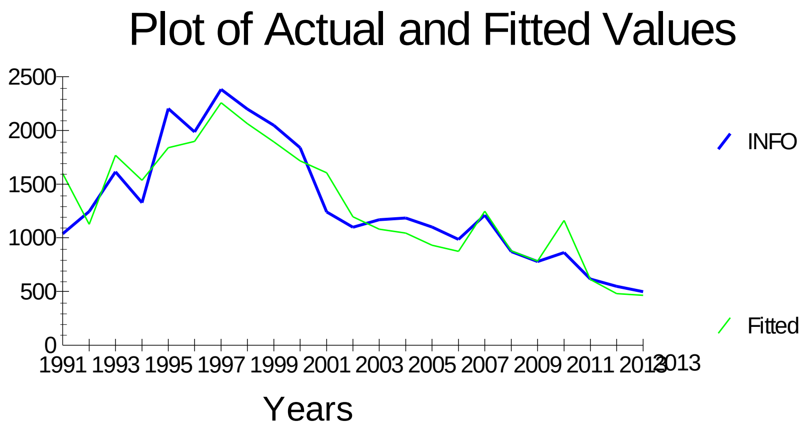
4) Fuel oil

INFO CONSTANT RPOIL INFO(-1) DUM935770

Table 1C.9. Coefficient Estimates of Fuel Oil Demand in Industry

```
                       Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is INFO
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                   1140.9            307.7944            3.7065[.001]
 RPOIL                    -19.8698              8.9321           -2.2245[.038]
 INFO(-1)                   .63875              .13994            4.5644[.000]
 DUM935770               -483.5952            116.5109           -4.1506[.001]
*******************************************************************************
 R-Squared                     .86595   R-Bar-Squared                    .84479
 S.E. of Regression          219.6716   F-stat.    F( 3, 19)    40.9131[.000]
 Mean of Dependent Variable    1306.4   S.D. of Dependent Variable     557.5808
 Residual Sum of Squares     916856.4   Equation Log-likelihood       -154.4575
 Akaike Info. Criterion     -158.4575   Schwarz Bayesian Criterion    -160.7285
 DW-statistic                  1.6433   Durbin's h-statistic       1.1536[.249]
*******************************************************************************
```

Figure 1C.8. Plot of Actual and Fitted Values of Fuel Oil Demand in Industry



INFO = 1140.9*CONSTANT -19.8698*RPOIL + .63875*INFO(-1) -483.5952*DUM935770

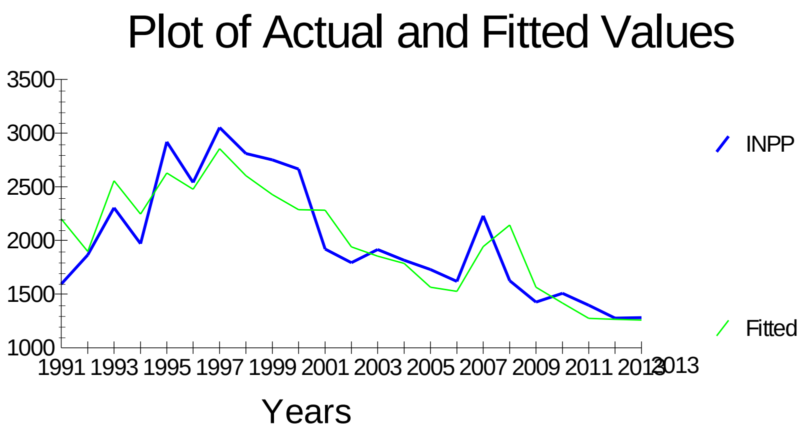
5) Petroleum products

INPP CONSTANT RPOIL INPP(-1) DUM935778

Table 1C.10. Coefficient Estimates of Petroleum Products Demand in Industry

```
                      Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is INPP
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                   2043.8           463.6495             4.4081[.000]
 RPOIL                    -28.9752            10.0196            -2.8919[.009]
 INPP(-1)                   .40690             .15800             2.5752[.019]
 DUM935778               -512.6589           143.3941            -3.5752[.002]
*******************************************************************************
 R-Squared                     .77237   R-Bar-Squared                   .73643
 S.E. of Regression          282.5306   F-stat.    F( 3, 19)   21.4894[.000]
 Mean of Dependent Variable    1999.5   S.D. of Dependent Variable    550.3191
 Residual Sum of Squares      1516647   Equation Log-likelihood      -160.2455
 Akaike Info. Criterion     -164.2455   Schwarz Bayesian Criterion   -166.5165
 DW-statistic                  1.5512   Durbin's h-statistic       1.6491[.099]
*******************************************************************************
```

Figure 1C.9. Plot of Actual and Fitted Values of Petroleum Products Demand in Industry



INPP = 2043.8*CONSTANT -28.9752*RPOIL + .40690*INPP(-1) -512.6589*DUM935778

Transport demand model

1) Road Transport

1.1 Motor gasoline

RDMG constant RRPOILJ RNOMGVE90 RDMg(-1)

Table 1C.11. Coefficient Estimates of Motor Gasoline Demand in Transport

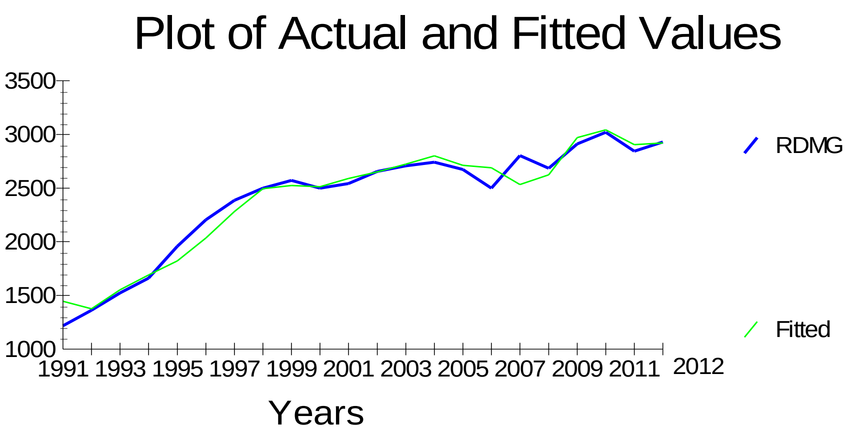
Ordinary Least Squares Estimation

Dependent variable is RDMG
22 observations used for estimation from 1991 to 2012

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONSTANT	433.7545	133.7149	3.2439[.005]
RRPOILJ	-285.7495	79.2469	-3.6058[.002]
RNOMGVE90	494.1055	137.3021	3.5987[.002]
RDMG(-1)	.51980	.13246	3.9241[.001]

R-Squared	.95816	R-Bar-Squared	.95118
S.E. of Regression	116.3466	F-stat. F(3, 18)	137.3897[.000]
Mean of Dependent Variable	2404.4	S.D. of Dependent Variable	526.5792
Residual Sum of Squares	243657.6	Equation Log-likelihood	-133.6539
Akaike Info. Criterion	-137.6539	Schwarz Bayesian Criterion	-139.8360
DW-statistic	1.6514	Durbin's h-statistic	1.0433[.297]

Figure 1C.10. Plot of Actual and Fitted Values of Motor Gasoline Demand in Transport



RDMG =433.7545*CONSTANT -285.7495*RRPOILJ + 494.1055*RNOMGVE90 + .51980*RDMG(-1)

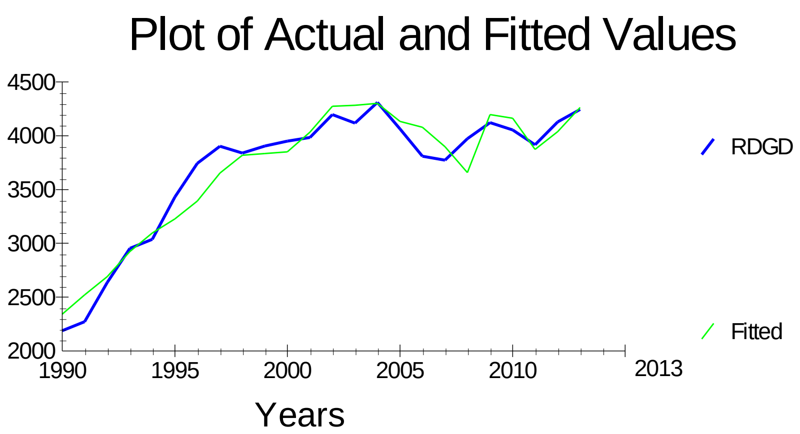
1.2 Diesel

RDGD constant RRPOILJ RNODSLVE

Table 1C.12. Coefficient Estimates of Diesel Demand in Transport

```
                      Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is RDGD
 24 observations used for estimation from 1990 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                  1604.5            128.5955            12.4772[.000]
 RRPOILJ                -343.4349             42.1219            -8.1534[.000]
 RNODSLVE                  1079.4             72.5288            14.8826[.000]
*******************************************************************************
 R-Squared                     .93167   R-Bar-Squared                   .92516
 S.E. of Regression          167.5537   F-stat.    F( 2, 21)  143.1707[.000]
 Mean of Dependent Variable    3689.4   S.D. of Dependent Variable    612.4921
 Residual Sum of Squares     589558.9   Equation Log-likelihood      -155.3634
 Akaike Info. Criterion     -158.3634   Schwarz Bayesian Criterion   -160.1305
 DW-statistic                  1.2356
*******************************************************************************
```

Figure 1C.11. Plot of Actual and Fitted Values of Diesel Demand in Transport



RDGD = 1604.5*CONSTANT -343.4349*RRPOILJ + 1079.4*RNODSLVE

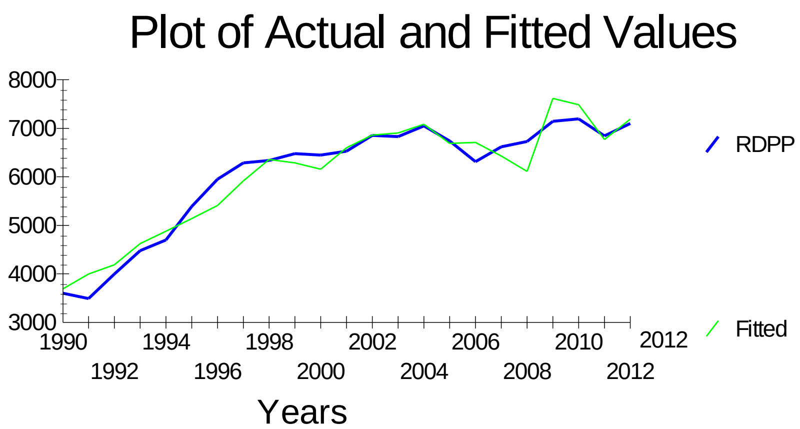
1.3 Road transport total

RDPP constant RRPOILJ RNOTOOVE

Table 1C.13. Coefficient Estimates of Road Transport Total

```
                         Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is RDPP
 23 observations used for estimation from 1990 to 2012
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                   2621.6            209.9990            12.4838[.000]
 RRPOILJ                   -1033.4            112.8145            -9.1606[.000]
 RNOTOOVE                   2102.7            147.1657            14.2882[.000]
*******************************************************************************
 R-Squared                     .93750   R-Bar-Squared                    .93125
 S.E. of Regression          306.4042   F-stat.    F( 2, 20)  150.0002[.000]
 Mean of Dependent Variable    6047.0   S.D. of Dependent Variable       1168.6
 Residual Sum of Squares      1877671   Equation Log-likelihood       -162.7011
 Akaike Info. Criterion     -165.7011   Schwarz Bayesian Criterion    -167.4044
 DW-statistic                  1.6201
*******************************************************************************
```

Figure 1C.12. Plot of Actual and Fitted Values of Road Transport Total



RDPP = 2621.6*CONSTANT -1033.4*RRPOILJ + 2102.7*RNOTOOVE

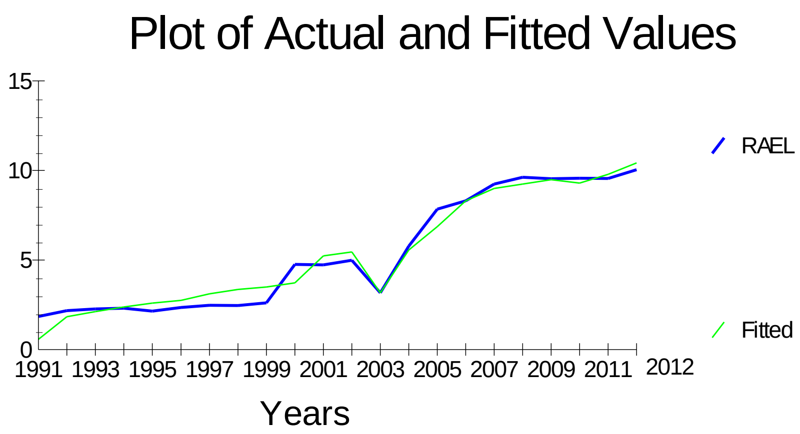
1.4 Rail: Electricity

RAEL constant TRDGVA RAEL(-1) DUM2003

Table 1C.14. Coefficient Estimates of Electricity in Rail Transport

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is RAEL
 22 observations used for estimation from 1991 to 2012
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                  -6.7225             1.4360             -4.6814[.000]
 TRDGVA                    62.5306            15.4766              4.0403[.001]
 RAEL(-1)                   .60962            .094718              6.4362[.000]
 DUM2003                    3.0153             .66363              4.5436[.000]
*******************************************************************************
 R-Squared                     .96655   R-Bar-Squared                   .96097
 S.E. of Regression            .63033   F-stat.    F( 3, 18)  173.3573[.000]
 Mean of Dependent Variable    5.3504   S.D. of Dependent Variable      3.1906
 Residual Sum of Squares       7.1516   Equation Log-likelihood       -18.8559
 Akaike Info. Criterion      -22.8559   Schwarz Bayesian Criterion    -25.0380
 DW-statistic                  1.3356   Durbin's h-statistic       1.7391[.082]
*******************************************************************************
```

Figure 1C.13. Plot of Actual and Fitted Values of Electricity in Rail Transport



RAEL = -6.7225*CONSTANT + 62.5306*TRDGVA + .60962*RAEL(-1) +3.0153*DUM2003

2) Air transport

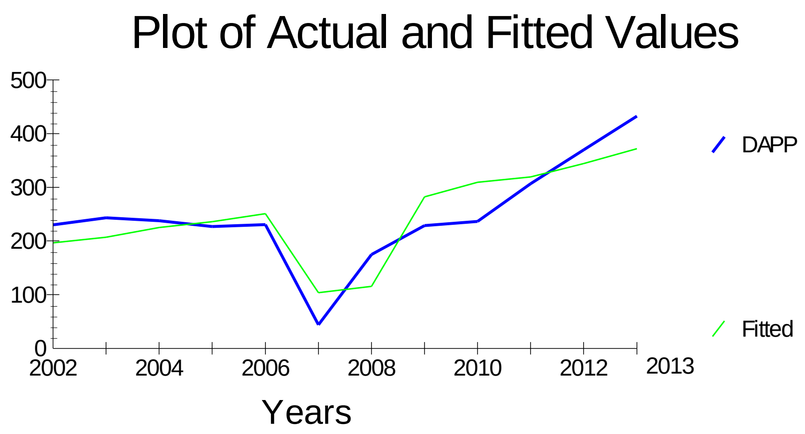
2.1 Air transport demand (jet fuel)

DAPP constant TGDPCAP DUM989078

Table 1C.15. Coefficient Estimates of Jet Fuel

```
                      Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is DAPP
 12 observations used for estimation from 2002 to 2013
*******************************************************************************
 Regressor              Coefficient        Standard Error         T-Ratio[Prob]
 CONSTANT                -343.5947            130.9274             -2.6243[.028]
 TGDPCAP                    7.9071              2.1992              3.5955[.006]
 DUM989078                168.4262             39.0732              4.3105[.002]
*******************************************************************************
 R-Squared                      .77354   R-Bar-Squared                   .72321
 S.E. of Regression            50.4271   F-stat.     F( 2, 9)    15.3709[.001]
 Mean of Dependent Variable   246.7468   S.D. of Dependent Variable      95.8499
 Residual Sum of Squares       22886.0   Equation Log-likelihood        -62.3475
 Akaike Info. Criterion       -65.3475   Schwarz Bayesian Criterion     -66.0749
 DW-statistic                   1.5879
*******************************************************************************
```

Figure 1C.14. Plot of Actual and Fitted Values of Jet Fuel



DAPP = -343.5947*CONSTANT +7.9071*TGDPCAP +168.4262*DUM989078

3) Water transport

3.1 Fuel oil

IWFO constant LGDP RPOIL DUM0937

Table 1C.16. Coefficient Estimates of Fuel Oil in Water Transport

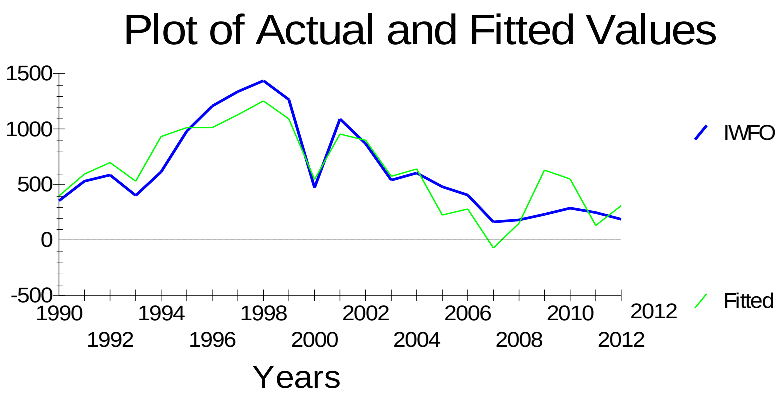
Ordinary Least Squares Estimation

Dependent variable is IWFO
23 observations used for estimation from 1990 to 2012

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONSTANT	-33808.1	9569.8	-3.5328[.002]
LGDP	1221.1	335.9026	3.6352[.002]
RPOIL	-75.3265	11.4034	-6.6056[.000]
DUM0937	295.0693	105.9703	2.7845[.012]

R-Squared	.80290	R-Bar-Squared	.77178
S.E. of Regression	192.3839	F-stat. F(3, 19)	25.7988[.000]
Mean of Dependent Variable	627.4025	S.D. of Dependent Variable	402.7060
Residual Sum of Squares	703219.9	Equation Log-likelihood	-151.4068
Akaike Info. Criterion	-155.4068	Schwarz Bayesian Criterion	-157.6778
DW-statistic	1.2301		

Figure 1C.15. Plot of Actual and Fitted Values of Fuel Oil in Water Transport



IWFO = -33808.1*CONSTANT + 1221.1*LGDP -75.3265*RPOIL + 295.0693*DUM0937

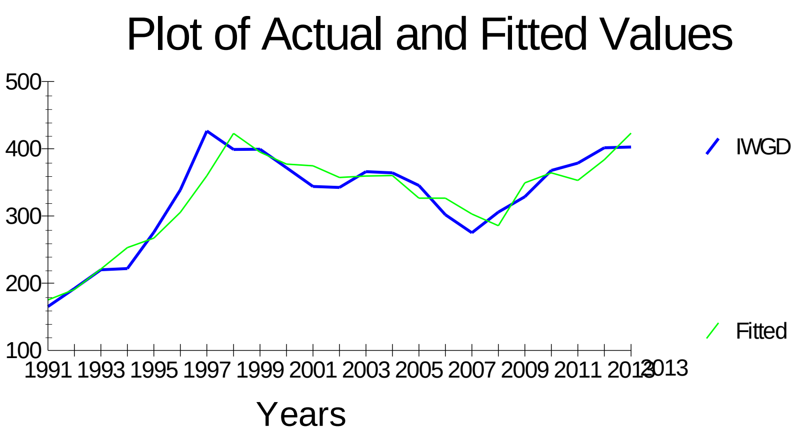
3.2 Diesel

IWGD constant LGDP RPOIL IWGD(-1)

Table 1C.17. Coefficient Estimates of Diesel in Water Transport

```
                       Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is IWGD
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                 -6504.7             2070.8              -3.1411[.005]
 LGDP                    232.8977            73.4121               3.1725[.005]
 RPOIL                    -6.9632             2.1778              -3.1974[.005]
 IWGD(-1)                  .59340             .10939               5.4246[.000]
*******************************************************************************
 R-Squared                     .89115   R-Bar-Squared                    .87397
 S.E. of Regression           25.6908   F-stat.     F( 3, 19)    51.8528[.000]
 Mean of Dependent Variable  327.5296   S.D. of Dependent Variable      72.3663
 Residual Sum of Squares      12540.3   Equation Log-likelihood       -105.0995
 Akaike Info. Criterion     -109.0995   Schwarz Bayesian Criterion    -111.3705
 DW-statistic                  1.8800   Durbin's h-statistic       .33800[.735]
*******************************************************************************
```

Figure 1C.16. Plot of Actual and Fitted Values of Diesel in Water Transport



IWGD = -6504.7*CONSTANT + 232.8977*LGDP -6.9632*RPOIL + .59340*IWGD(-1)

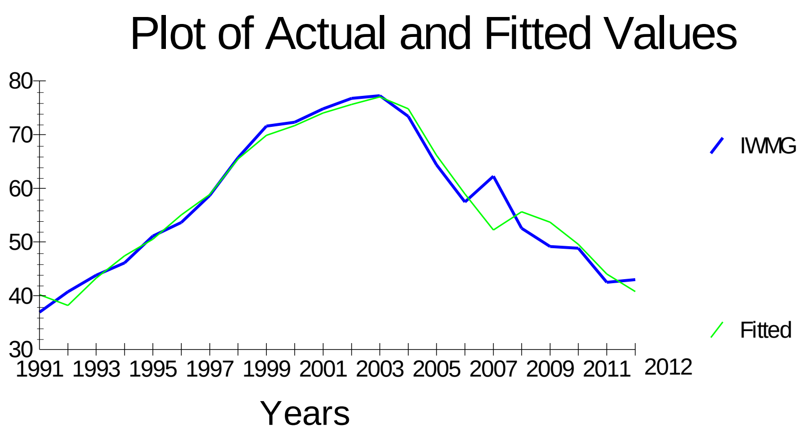
3.3 Motor gasoline

IWMG constant LCSGDP RPOIL IWMG(-1)

Table 1C.18. Coefficient Estimates of Motor Gasoline in Water Transport

```
                      Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is IWMG
 22 observations used for estimation from 1991 to 2012
*******************************************************************************
 Regressor                  Coefficient        Standard Error         T-Ratio[Prob]
 CONSTANT                    -458.7576            165.0077            -2.7802[.012]
 LCSGDP                        16.9625              5.9733             2.8397[.011]
 RPOIL                         -.99224              .22169            -4.4758[.000]
 IWMG(-1)                       .89065             .055098            16.1648[.000]
*******************************************************************************
 R-Squared                         .95159   R-Bar-Squared                    .94352
 S.E. of Regression                3.0909   F-stat.     F( 3, 18)  117.9448[.000]
 Mean of Dependent Variable       57.4055   S.D. of Dependent Variable      13.0064
 Residual Sum of Squares         171.9705   Equation Log-likelihood        -53.8357
 Akaike Info. Criterion          -57.8357   Schwarz Bayesian Criterion     -60.0178
 DW-statistic                      2.2789   Durbin's h-statistic      -.67703[.498]
*******************************************************************************
```

Figure 1C.17. Plot of Actual and Fitted Values of Motor Gasoline in Water Transport



IWMG =-458.7576*CONSTANT +16.9625*LCSGDP -.99224*RPOIL +.89065*IWMG(-1)

B.3 Other sector demand model

Commercial sector demand model

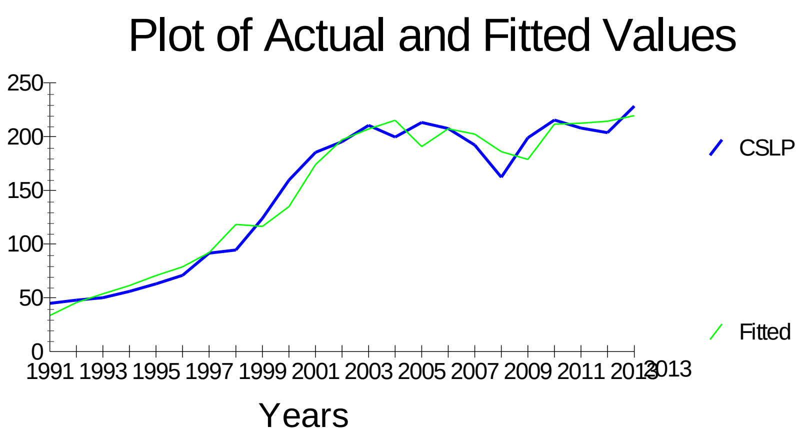
1) LPG

CSLP constant LCSGDP RPOIL CSLP(-1)

Table 1C.19. Coefficient Estimates of LPG in Commercial Sector

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is CSLP
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                  -1008.6            389.1156            -2.5921[.018]
 LCSGDP                    73.7462             27.9569             2.6379[.016]
 RPOIL                     -2.9345              .94410            -3.1083[.006]
 CSLP(-1)                   .93630             .095899             9.7634[.000]
*******************************************************************************
 R-Squared                     .96249   R-Bar-Squared                    .95657
 S.E. of Regression           13.9914   F-stat.    F( 3, 19)  162.5206[.000]
 Mean of Dependent Variable  148.7138   S.D. of Dependent Variable      67.1376
 Residual Sum of Squares       3719.4   Equation Log-likelihood        -91.1226
 Akaike Info. Criterion      -95.1226   Schwarz Bayesian Criterion     -97.3936
 DW-statistic                  2.0588   Durbin's h-statistic      -.15880[.874]
*******************************************************************************
```

Figure 1C.18. Plot of Actual and Fitted Values of LPG in Commercial Sector



CSLP = -1008.6*CONSTANT + 73.7462*LCSGDP -2.9345*RPOIL + .93630*CSLP(-1)

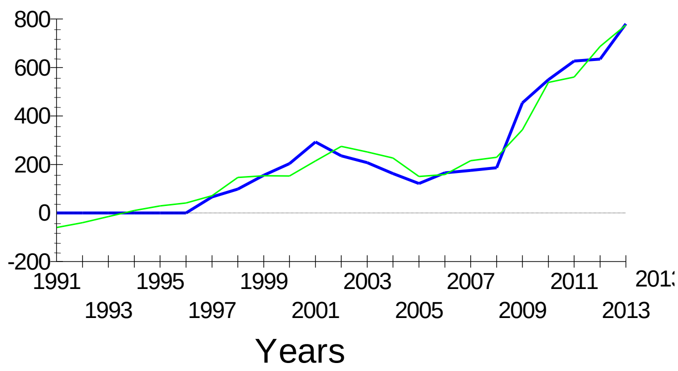
2) Diesel

CSGD constant MCSGDP RPOIL CSGD(-1)

Table 1C.20. Coefficient Estimates of Diesel in Commercial Sector

```
             Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is CSGD
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                -262.7964            67.2700            -3.9066[.001]
 MCSGDP                   259.9314            59.8464             4.3433[.000]
 RPOIL                    -13.1069             3.7415            -3.5031[.002]
 CSGD(-1)                   .63577             .13134             4.8407[.000]
*******************************************************************************
 R-Squared                    .95687   R-Bar-Squared                    .95007
 S.E. of Regression          51.5839   F-stat.    F( 3, 19)  140.5256[.000]
 Mean of Dependent Variable 222.4543   S.D. of Dependent Variable     230.8415
 Residual Sum of Squares     50557.1   Equation Log-likelihood       -121.1323
 Akaike Info. Criterion    -125.1323   Schwarz Bayesian Criterion    -127.4033
 DW-statistic                 1.6488   Durbin's h-statistic       1.0843[.278]
*******************************************************************************
```

Figure 1C.19. Plot of Actual and Fitted Values of Diesel in Commercial Sector



CSGD =-262.7964*CONSTANT + 259.9314*MCSGDP -13.1069*RPOIL +.63577*CSGD(-1)

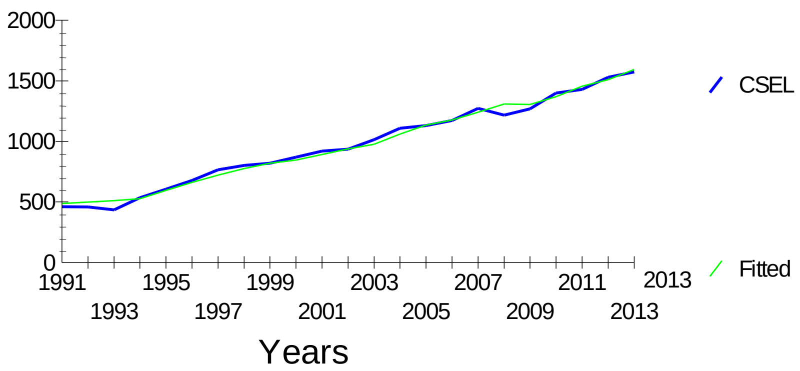
3) Electricity

CSEL constant LBCSGDP CSEL(-1)

Table 1C.21. Coefficient Estimates of Electricity in Commercial Sector

```
                      Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is CSEL
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor                  Coefficient        Standard Error         T-Ratio[Prob]
 CONSTANT                       -3991.6                1383.4          -2.8853[.009]
 LBCSGDP                       594.5959              204.3727           2.9094[.009]
 CSEL(-1)                        .44499                .19831           2.2439[.036]
*******************************************************************************
 R-Squared                          .98907   R-Bar-Squared                    .98797
 S.E. of Regression                38.5880   F-stat.    F( 2, 20)  904.5527[.000]
 Mean of Dependent Variable       973.7839   S.D. of Dependent Variable     351.8522
 Residual Sum of Squares           29780.7   Equation Log-likelihood       -115.0460
 Akaike Info. Criterion          -118.0460   Schwarz Bayesian Criterion    -119.7492
 DW-statistic                       1.5973   Durbin's h-statistic       3.1258[.002]
*******************************************************************************
```

Figure 1C.20. Plot of Actual and Fitted Values of Electricity in Commercial Sector



CSEL = -3991.6*CONSTANT + 594.5959*LBCSGDP + .44499*CSEL(-1**)**

Residential sector demand model

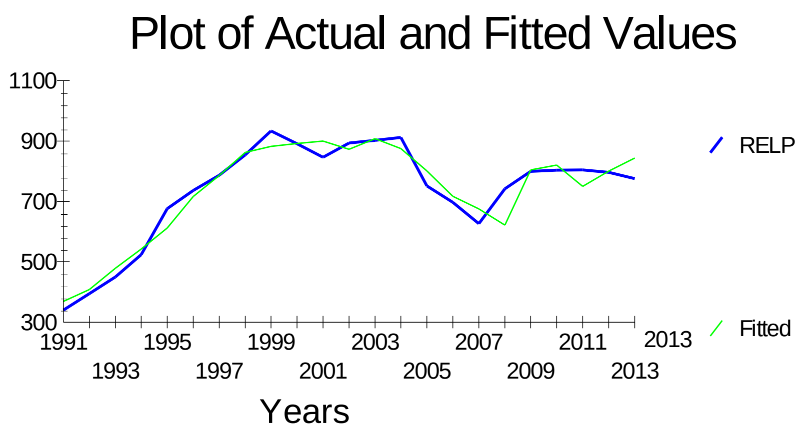
1) LPG

RELP constant LHEXP RPOIL RELP(-1)

Table 1C.22. Coefficient Estimates of LPG in Residential Sector

```
                    Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is RELP
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                 -12791.2             3792.3           -3.3730[.003]
 LHEXP                    465.0721           136.2398            3.4136[.003]
 RPOIL                    -16.0292             4.0443           -3.9634[.001]
 RELP(-1)                   .63293            .092144            6.8690[.000]
*******************************************************************************
 R-Squared                     .93135   R-Bar-Squared                   .92052
 S.E. of Regression           46.9958   F-stat.    F( 3, 19)   85.9279[.000]
 Mean of Dependent Variable  736.2255   S.D. of Dependent Variable    166.6931
 Residual Sum of Squares      41963.4   Equation Log-likelihood      -118.9898
 Akaike Info. Criterion     -122.9898   Schwarz Bayesian Criterion   -125.2608
 DW-statistic                  2.2307   Durbin's h-statistic      -.61673[.537]
*******************************************************************************
```

Figure 1C.21. Plot of Actual and Fitted Values of LPG in Residential Sector



RELP = -12791.2*CONSTANT + 465.0721*LHEXP -16.0292*RPOIL + .63293*RELP(-1)

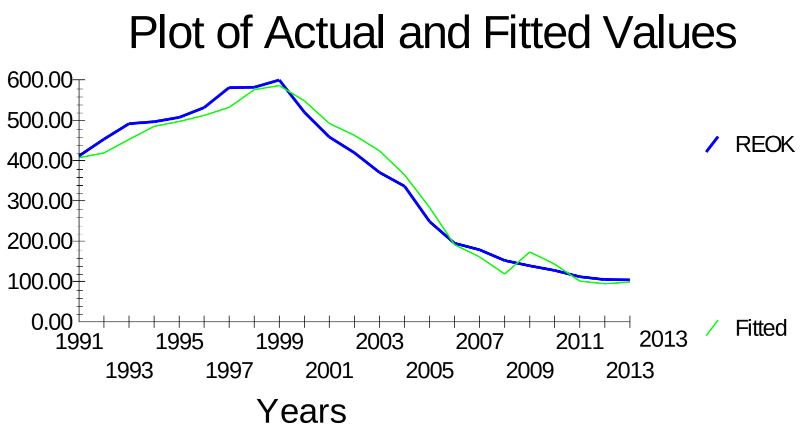
2) Kerosene

REOK constant R2KERPR REOK(-1)

Table 1C.23. Coefficient Estimates of Kerosene in Residential Sector

```
                        Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is REOK
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor               Coefficient        Standard Error          T-Ratio[Prob]
 CONSTANT                  335.6263             100.3275              3.3453[.003]
 R2KERPR                   -1023.6              283.1607             -3.6148[.002]
 REOK(-1)                   .55251               .13559               4.0749[.001]
*******************************************************************************
 R-Squared                         .97460   R-Bar-Squared                    .97206
 S.E. of Regression               29.8784   F-stat.    F( 2, 20)   383.7111[.000]
 Mean of Dependent Variable      352.8924   S.D. of Dependent Variable     178.7514
 Residual Sum of Squares          17854.4   Equation Log-likelihood       -109.1624
 Akaike Info. Criterion         -112.1624   Schwarz Bayesian Criterion    -113.8657
 DW-statistic                      .84749   Durbin's h-statistic       3.6377[.000]
*******************************************************************************
```

Figure 1C.22. Plot of Actual and Fitted Values of Kerosene in Residential Sector



REOK = 335.6263*CONSTANT -1023.6*R2KERPR + .55251*REOK(-1)

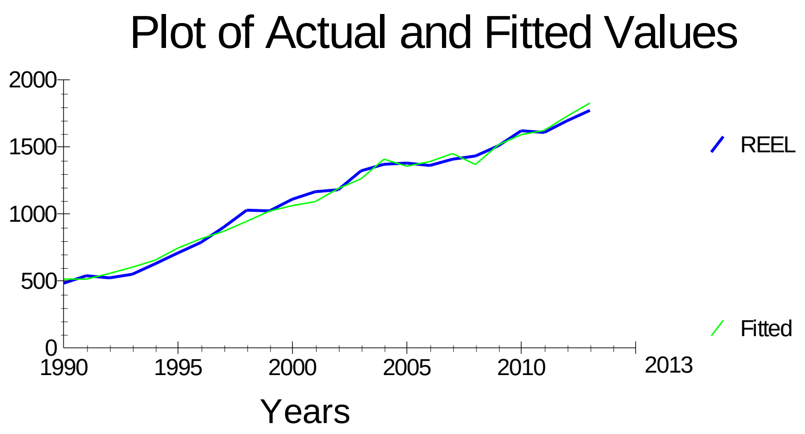
3) Electricity

REEL constant LBHEXP R2REELPR

Table 1C.24. Coefficient Estimates of Electricity in Residential Sector

```
                    Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is REEL
 24 observations used for estimation from 1990 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                 -9987.0            270.3355            -36.9429[.000]
 LBHEXP                    1454.5             39.8506             36.4982[.000]
 R2REELPR                 -7975.9              1526.3             -5.2255[.000]
*******************************************************************************
 R-Squared                    .98925   R-Bar-Squared                   .98823
 S.E. of Regression          44.2744   F-stat.    F( 2, 21)   966.2599[.000]
 Mean of Dependent Variable   1128.4   S.D. of Dependent Variable    408.0348
 Residual Sum of Squares     41164.6   Equation Log-likelihood       -123.4219
 Akaike Info. Criterion     -126.4219  Schwarz Bayesian Criterion    -128.1890
 DW-statistic                 1.7034
*******************************************************************************
```

Figure 1C.23. Plot of Actual and Fitted Values of Electricity in Residential Sector



REEL = -9987.0*CONSTANT + 1454.5*LBHEXP -7975.9*R2REELPR

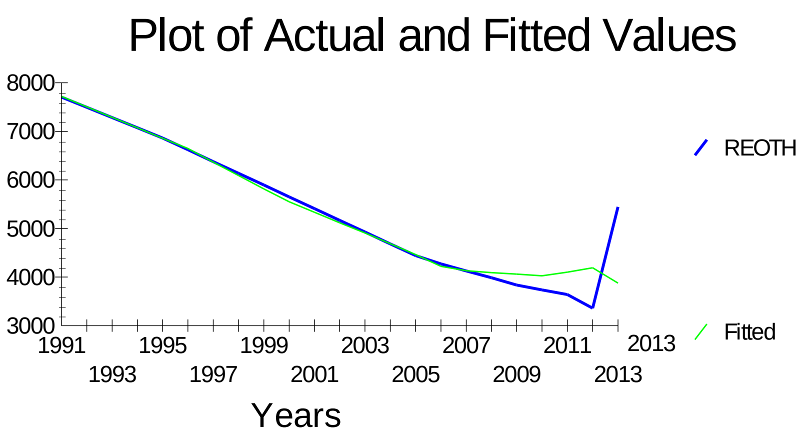
4) Others (biomass)

REOTH constant MPOPR REOTH(-1)

Table 1C.25. Coefficient Estimates of Biomass in Residential Sector

```
                    Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is REOTH
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                 -19278.0             8942.8             -2.1557[.043]
 MPOPR                    291.2535           131.2575              2.2189[.038]
 REOTH(-1)                  2.2082             .60150              3.6711[.002]
*******************************************************************************
 R-Squared                      .91282   R-Bar-Squared                   .90410
 S.E. of Regression           420.6040   F-stat.    F( 2, 20)  104.7040[.000]
 Mean of Dependent Variable     5397.1   S.D. of Dependent Variable      1358.2
 Residual Sum of Squares       3538154   Equation Log-likelihood      -169.9872
 Akaike Info. Criterion      -172.9872   Schwarz Bayesian Criterion   -174.6905
 DW-statistic                   1.6807   Durbin's h-statistic            *NONE*
*******************************************************************************
```

Figure 1C.24. Plot of Actual and Fitted Values of Biomass in Residential Sector



REOTH = -19278.0*CONSTANT + 291.2535*MPOPR + 2.2082*REOTH(-1)

Agriculture demand model

1) Total diesel demand

TAGGD constant RPOIL TAGGD(-1) DUM07

Table 1C.26. Coefficient Estimates of Diesel Demand in Agricultural Sector

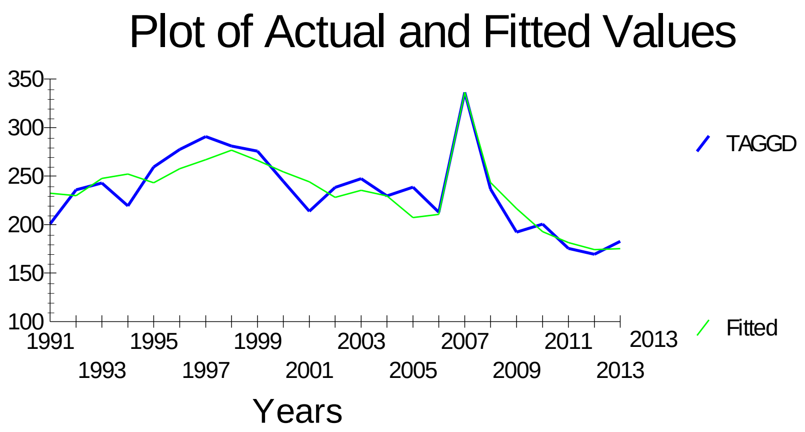
Ordinary Least Squares Estimation

Dependent variable is TAGGD
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONSTANT	310.1387	35.5129	8.7331[.000]
RPOIL	-2.3767	.51289	-4.6340[.000]
TAGGD(-1)	.41622	.10829	3.8435[.001]
DUM07	-140.6408	19.6104	-7.1717[.000]

R-Squared	.81787	R-Bar-Squared	.78911
S.E. of Regression	18.5351	F-stat. F(3, 19)	28.4398[.000]
Mean of Dependent Variable	234.7599	S.D. of Dependent Variable	40.3613
Residual Sum of Squares	6527.4	Equation Log-likelihood	-97.5907
Akaike Info. Criterion	-101.5907	Schwarz Bayesian Criterion	-103.8617
DW-statistic	1.7363	Durbin's h-statistic	.74003[.459]

Figure 1C.25. Plot of Actual and Fitted Values of Diesel Demand in Agricultural Sector



TAGGD = 310.1387*CONSTANT -2.3767*RPOIL +.41622*TAGGD(-1) -140.6408*DUM07

2) Total petroleum products demand

Table 1C.27. Coefficient Estimates of Petroleum Products Demand in Agricultural Sector

Ordinary Least Squares Estimation

Dependent variable is TAGGD
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONSTANT	292.6657	35.5636	8.2294[.000]
RDSLPR	-170.0127	40.4258	-4.2055[.000]
TAGGD(-1)	.48173	.10996	4.3809[.000]
DUM07	-141.0179	20.6702	-6.8223[.000]

R-Squared	.79907	R-Bar-Squared	.76734
S.E. of Regression	19.4682	F-stat. F(3, 19)	25.1861[.000]
Mean of Dependent Variable	234.7599	S.D. of Dependent Variable	40.3613
Residual Sum of Squares	7201.2	Equation Log-likelihood	-98.7205
Akaike Info. Criterion	-102.7205	Schwarz Bayesian Criterion	-104.9915
DW-statistic	1.5131	Durbin's h-statistic	1.3740[.169]

3) Other petroleum products

OTAGPP constant RPOIL DUM978347

Table 1C.28. Coefficient Estimates of Other Petroleum Products Demand in Agricultural Sector

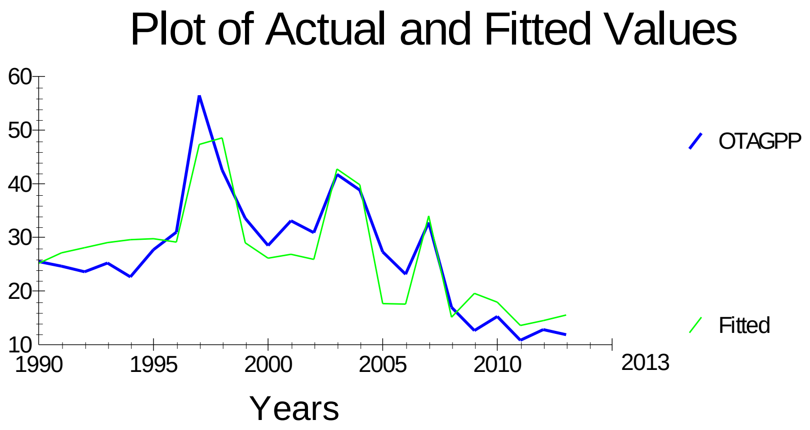
Ordinary Least Squares Estimation

Dependent variable is OTAGPP
24 observations used for estimation from 1990 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONSTANT	52.7772	2.8628	18.4354[.000]
RPOIL	-.71568	.12594	-5.6827[.000]
DUM978347	-17.7046	2.5114	-7.0496[.000]

R-Squared	.81659	R-Bar-Squared	.79912
S.E. of Regression	4.9572	F-stat. F(2, 21)	46.7479[.000]
Mean of Dependent Variable	27.0524	S.D. of Dependent Variable	11.0604
Residual Sum of Squares	516.0563	Equation Log-likelihood	-70.8725
Akaike Info. Criterion	-73.8725	Schwarz Bayesian Criterion	-75.6396
DW-statistic	1.5459		

Figure 1C.26. Plot of Actual and Fitted Values of Other Petroleum Products Demand in Agricultural Sector



OTAGPP = 52.7772*CONSTANT -.71568*RPOIL -17.7046*DUM978347

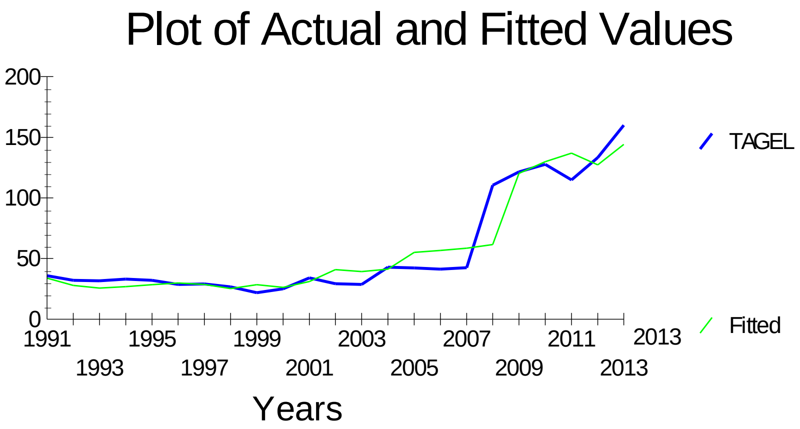
4) Electricity

TAGEL constant laggdp tagel(-1)

Table 1C.29. Coefficient Estimates of Electricity Demand in Agricultural Sector

```
                        Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is TAGEL
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                  -1587.0            623.1709           -2.5467[.019]
 LAGGDP                    59.1806             23.2243            2.5482[.019]
 TAGEL(-1)                  .87320              .11529            7.5742[.000]
*******************************************************************************
 R-Squared                    .89976   R-Bar-Squared                     .88974
 S.E. of Regression          14.5869   F-stat.     F( 2, 20)   89.7601[.000]
 Mean of Dependent Variable  57.5314   S.D. of Dependent Variable       43.9283
 Residual Sum of Squares      4255.5   Equation Log-likelihood         -92.6712
 Akaike Info. Criterion     -95.6712   Schwarz Bayesian Criterion      -97.3744
 DW-statistic                 2.0083   Durbin's h-statistic       -.023745[.981]
*******************************************************************************
```

Figure 1C.27. Plot of Actual and Fitted Values of Electricity Demand in Agricultural Sector



TAGEL = -1587.0*CONSTANT + 59.1806*LAGGDP + .87320*TAGEL(-1)

Conclusion

The national energy data of the Philippines used in estimating the demand equation and as established by the Asia Pacific Energy Research Centre through its Asia-Pacific Economic Cooperation's energy database is comparable with the International Energy Agency's database in terms of its reliability and responsiveness in formulating statistical demand model using regression analysis to project final energy consumption by sector. The annual historical data of most dominant fuels by sector have a good linear trend in which regression analysis through ordinary least squares is applicable. It is assumed there are no significant differences between the use of the International Energy Agency's energy database and the Asia-Pacific Economic Cooperation's energy database in formulating energy demand equations through linear regression analysis for the Philippines.

References

Economic Research Institute for ASEAN and East Asia, 'Energy Supply and Demand Outlook Report FY 2015-206 – Philippines'.

Philippine Statistical Authority, 'Chapter 3. Economic Account', *2015 Philippine Statistical Yearbook.*

Department of Energy, 'Energy Supply and Demand Situation FY 2014 – Philippines'

1D.Thailand's National Energy Data Estimations

The national energy statistics in Thailand are compiled mainly and separately by the Department of Alternative Energy Department and Efficiency (DEDE) and the Energy Policy and Planning Office under the Ministry of Energy. DEDE provides detailed statistics while the Energy Policy and Planning Office focuses more on energy policy. Thus, to make more detailed energy model outlook, divided into subsectors, the data in Thailand's time series will rely on DEDE's data. For example, DEDE's time series data in industrial sector can be broken down into smaller industrial types, such as non-metallic, paper and pulp, and food and tobacco, in every energy type of use.

Characteristic of Data

This study uses DEDE data series to make the estimates for the energy outlook modelling, which is input into LEAP Application. The energy consumption statistics by sector, by subsector, and by energy type have been collected since 1970 but only up to 2015.

Using National Energy Data to Make Energy Model

Econometric equations use statistical data to estimate the results as compared to the actual figures and to see how the data will fit the estimations as forecast. The transport, industry, and others sectors and subsectors use national energy data for estimations. The industrial sector has 11 subsectors: iron and steel, chemical and petrochemical, non-metallic products, machinery, mining and quarrying, food and tobacco, paper, pulp and printing, wood and wood products, construction, textile and leather, and non-specified products. The transport sector has four subsectors: road, water, rail, and aviation. The others sector covers residential, commercial, agricultural, non-specific, and non-energy sectors.

$$Q = f(GDP, P)$$

The consumption of each energy type in subsector relates to income as represented by GDP and energy price. The demand function is applied to estimate the future consumption. For example, food and tobacco consume electricity in their production process. Their electricity consumption will depend upon their production and sales, which are finally derived from the growth of GDP. This is how the equation looks in terms of ordinary least square, with statistical confidence of 95%.

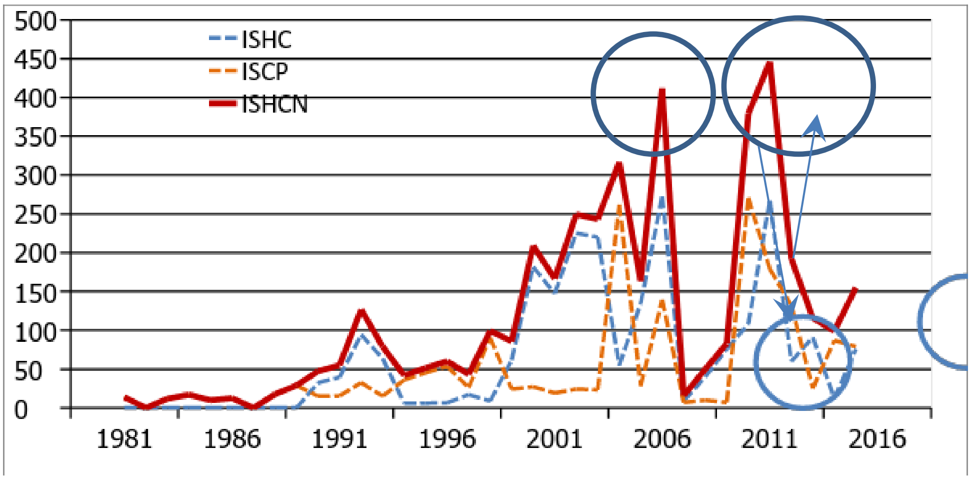
Electricity consumption in food industry = -310.4871 + .1607E-3*GDP

As mentioned, all the equations of energy consumption in every subsector are based on national energy statistical data. The quality of the data is very significant for the estimation. Some problems in the statistics might cause the model not to work properly. Different results can be driven by different data sets.

National Energy Data Incident

Using national energy statistics for outlook remains on bumpy road. Some problems need to be solved in running econometric equations. Some data show fluctuations that cause uncertainty as they swing up and down at times (see Figure 1D.1).

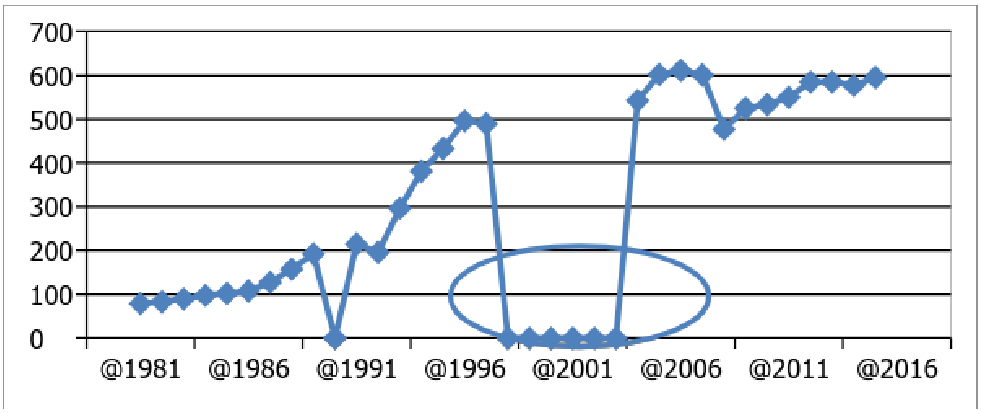
Figure 1D.1 Energy Consumption in Iron and Steel



ISHC = iron and steel hard coal, ISCP = iron and steel coal product, ISHCN; ISHC + ISCP
Source: Author' data generated from LEAP.

Moreover, many data are missing in the time series. Although missing data within a short period of time can be solved statistically, this can be hard when a longer period of time is involved. A good example is the electricity consumption in cement industry. We realise that cement is consistently produced every year. What is hard to believe is that they stopped the process for a certain period (see Figure 1D.2)

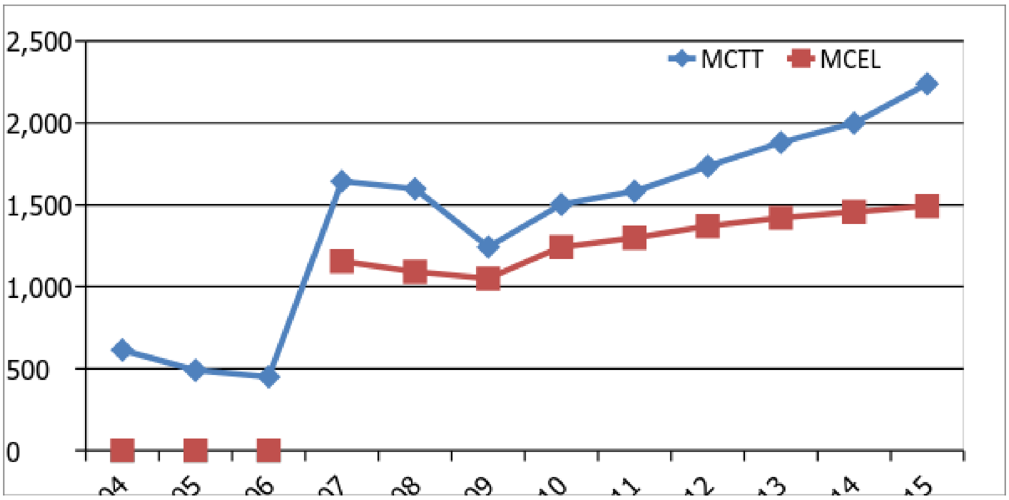
Figure 1D.2. Electricity Consumption in Cement



Source: Author' data generated from the LEAP

As some products tend to fade away in the market while new ones are introduced, certain period is needed to learn its behaviour. Although not directly concerned with data problem, it can cause confusion. An example for this is fabricated metal (see Figure 1D.3).

Figure 1D.3. Metal and Fabricated Metal Energy Consumption



Source: Author' data generated from the LEAP

Thailand's energy statistics data provide details in time series in sectors and in subsectors that are adequate to make energy model. However, double checking dates for accuracy is important as original sources tend to change them.

Data Treatment

Sometimes, statistical problems in data information can be statistically treated by dummy and irregular terms and some problems can be ignored. But such is not always the case. Although many statistical tools are available for solving matters, some data are really hard to be treated statistically as they tend to make matters worse. When faced with too many missing and inconsistent data, several definitions on the same set of data, too many uncertainties in observation, and too many irregularities, we have no choice but to reset all data.

1E.Viet Nam's National Energy Data Estimations

Introduction

This chapter aims to use Viet Nam's national energy data for estimation of energy demand formulas for 2018 and 2019 instead of the energy data from the International Energy Agency's energy balances.

Energy demand equations were based on national data such as historical energy and socio-economic data obtained from the Asia Pacific Energy Research Centre.

Real price of international oil (RPOIL) was used as main drivers of energy demand. Where RPOIL did not affect the demand equations, estimates were made based on domestic energyfuel prices obtained from domestic or other study sources in Viet Nam.

Estimation Results

The estimation results of energy demand formulas by each fuel in each sector are presented as follows:

Industrial sector model

- Coal

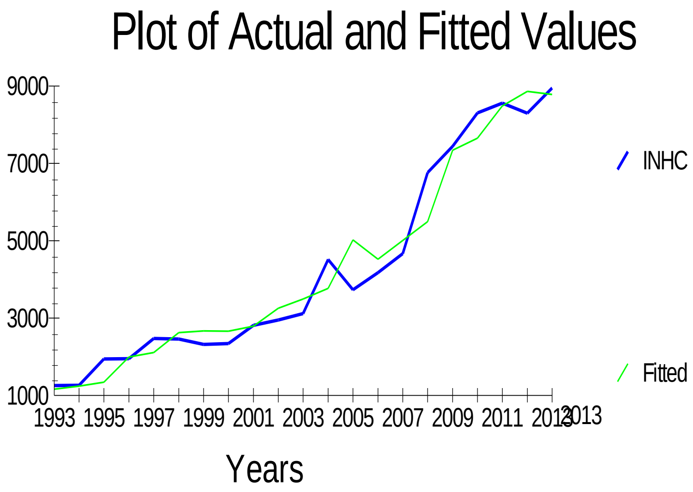
INHC = -362.4500*CONS + .0030152*INGDP -.0057528*RPOIL + .80775*INHC(-1)

Table 1E.1. Coefficient Estimates of Coal Demand in Industrial Sector

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is INHC
 21 observations used for estimation from 1993 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                    -362.4500          409.0371             -.88611[.388]
 INGDP                    .0030152          .0018658              1.6160[.124]
 RPOIL                   -.0057528           .062197            -.092493[.927]
 INHC(-1)                   .80775            .12337              6.5471[.000]
*******************************************************************************
 R-Squared                     .95768   R-Bar-Squared                   .95021
 S.E. of Regression          586.1541   F-stat.    F(  3,  17)  128.2249[.000]
 Mean of Dependent Variable    4297.8   S.D. of Dependent Variable      2626.8
 Residual Sum of Squares      5840802   Equation Log-likelihood      -161.4242
 Akaike Info. Criterion     -165.4242   Schwarz Bayesian Criterion   -167.5132
 DW-statistic                  2.2761   Durbin's h-statistic      -.76684[.443]
*******************************************************************************
```

Source: Author's calculation.

Figure 1E.1. Plot of Actual and Fitted Values of Coal Demand in Industrial Sector



Source: Author's calculation.

- Diesel oil

INGD = 16.4679*CONS + .6956E-3*INGDP + .4128E-3*RPOIL + .52806*INGD(-1)

Table 1E.2. Coefficient Estimates of Diesel Oil Demand in Industrial Sector

Ordinary Least Squares Estimation

Dependent variable is INGD

23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	16.4679	73.3551	.22450[.825]
INGDP	.6956E-3	.3935E-3	1.7677[.093]
RPOIL	.4128E-3	.0080159	.051498[.959]
INGD(-1)	.52806	.26463	1.9955[.061]

R-Squared	.93672	R-Bar-Squared	.92673
S.E. of Regression	98.8770	F-stat. F(3, 19)	93.7588[.000]
Mean of Dependent Variable	720.9526	S.D. of Dependent Variable	365.2956
Residual Sum of Squares	185756.5	Equation Log-likelihood	-136.0976
Akaike Info. Criterion	-140.0976	Schwarz Bayesian Criterion	-142.3686
DW-statistic	1.9433	Durbin's h-statistic	*NONE*

Source: Author's calculation.

The sign of coefficient of RPOIL is positive. This is irrational that the demand increases when oil price increases. It proves that RPOIL does not affect the demand of diesel oil. In this case, RPDOIL (real price of domestic diesel oil of Viet Nam) would be used. The revised result is presented as follows:

INGD = 217.5275*CONS + .0012868*INGDP -343.7591*RPDOIL + .41609*INGD(-1) -268.0025*DUM05

Table 1E.3. Coefficient Estimates of Diesel Oil Demand in Industrial Sector (Revised Estimates)

Ordinary Least Squares Estimation

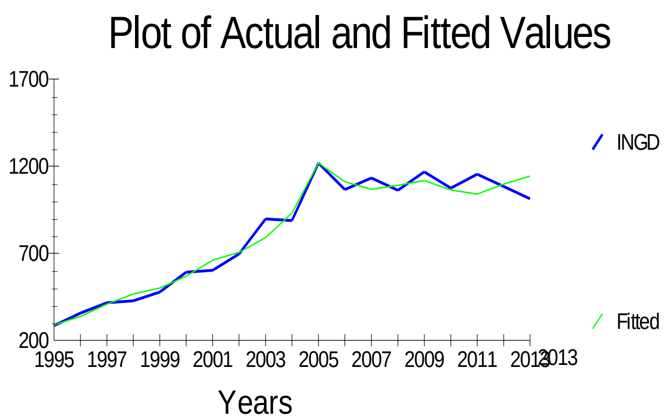
Dependent variable is INGD
19 observations used for estimation from 1995 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	217.5275	107.3368	2.0266[.062]
INGDP	.0012868	.4162E-3	3.0919[.008]
RPDOIL	-343.7591	146.7815	-2.3420[.034]
INGD(-1)	.41609	.17294	2.4060[.031]
DUM05	-268.0025	71.1519	-3.7666[.002]

R-Squared	.96763	R-Bar-Squared	.95839
S.E. of Regression	65.2559	F-stat. F(4, 14)	104.6356[.000]
Mean of Dependent Variable	820.9137	S.D. of Dependent Variable	319.8881
Residual Sum of Squares	59616.7	Equation Log-likelihood	-103.4467
Akaike Info. Criterion	-108.4467	Schwarz Bayesian Criterion	-110.8078
DW-statistic	2.0658	Durbin's h-statistic	-.21839[.827]

Source: Author's calculation.

Figure 1E.2. Plot of Actual and Fitted Values of Diesel Oil Demand in Industrial Sector



Source: Author's calculation.

- Liquefied petroleum gas (LPG)

INLP = -38.5632*CONS + .1757E-3*INGDP -.1279E-3*RPOIL + .55283*INLP(-1)

Table 1E.4. Coefficient Estimates of LPG Demand in Industrial Sector

Ordinary Least Squares Estimation

Dependent variable is INLP

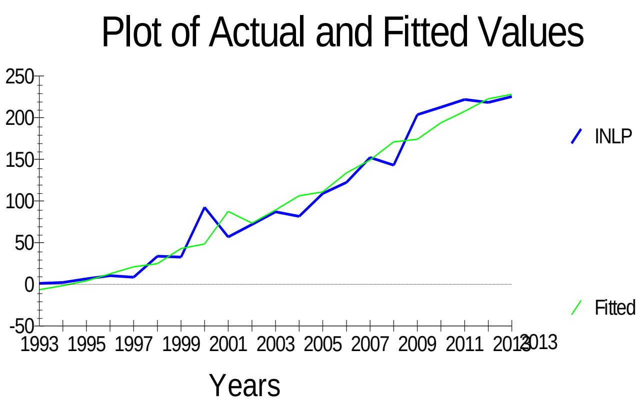
21 observations used for estimation from 1993 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	-38.5632	19.7526	-1.9523[.068]
INGDP	.1757E-3	.6671E-4	2.6344[.017]
RPOIL	-.1279E-3	.0020865	-.061295[.952]
INLP(-1)	.55283	.16718	3.3069[.004]

R-Squared	.95144	R-Bar-Squared	.94287
S.E. of Regression	19.2518	F-stat. F(3, 17)	111.0290[.000]
Mean of Dependent Variable	99.6233	S.D. of Dependent Variable	80.5461
Residual Sum of Squares	6300.8	Equation Log-likelihood	-89.6887
Akaike Info. Criterion	-93.6887	Schwarz Bayesian Criterion	-95.7777
DW-statistic	2.6067	Durbin's h-statistic	-2.1628[.031]

Source: Author's calculation.

Figure 1E.3. Plot of Actual and Fitted Values of LPG Demand in Industrial Sector



- Electricity

INEL = -166.7921*CONS + .6872E-3*INGDP + 1.0552*RPEL + 1.0198*INEL(-1)

The real price of electricity (RPEL) in Viet Nam(VPBank, 2013) was used. However, the sign of coefficient of RPEL is still positive. It proves that RPEL also does not affect the electricity demand. In this case, only INGDP would be used as variable to drive electricity demand as follows:

INEL = -140.4502*CONS + .6697E-3*INGDP + 1.0194*INEL(-1)

Table 1E.5. Coefficient Estimates of Electricity Demand in Industrial Sector

Ordinary Least Squares Estimation

Dependent variable is INEL

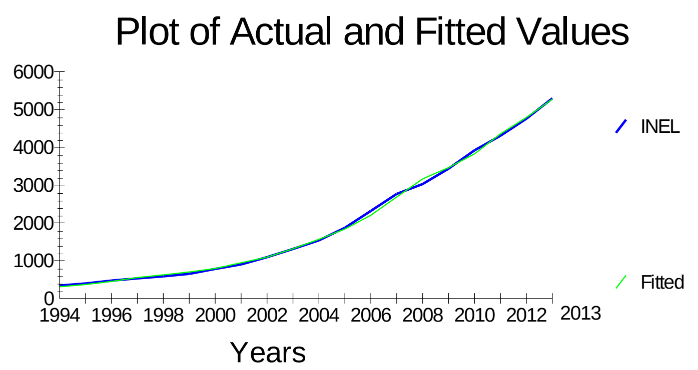
20 observations used for estimation from 1994 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	-140.4502	59.3963	-2.3646[.030]
INGDP	.6697E-3	.1826E-3	3.6680[.002]
INEL(-1)	1.0194	.025530	39.9279[.000]

R-Squared	.99873	R-Bar-Squared	.99858
S.E. of Regression	60.5687	F-stat. F(2, 17)	6686.3[.000]
Mean of Dependent Variable	2014.0	S.D. of Dependent Variable	1607.9
Residual Sum of Squares	62365.7	Equation Log-likelihood	-108.8291
Akaike Info. Criterion	-111.8291	Schwarz Bayesian Criterion	-113.3227
DW-statistic	1.8747	Durbin's h-statistic	.28200[.778]

Source: Author's calculation.

Figure 1E.4. Plot of Actual and Fitted Values of Electricity Demand in Industrial Sector



Source: Author's calculation.

- Natural gas

INNG = -3191.6*CONS + .0041153*INGDP + .044366*RPOIL + .31736*INNG(-1)

The sign of coefficient of RPOIL is positive. It proves that RPOIL also does not affect the natural gas demand. In this case, INGDP would be used as variable to drive natural gas demand as follows:

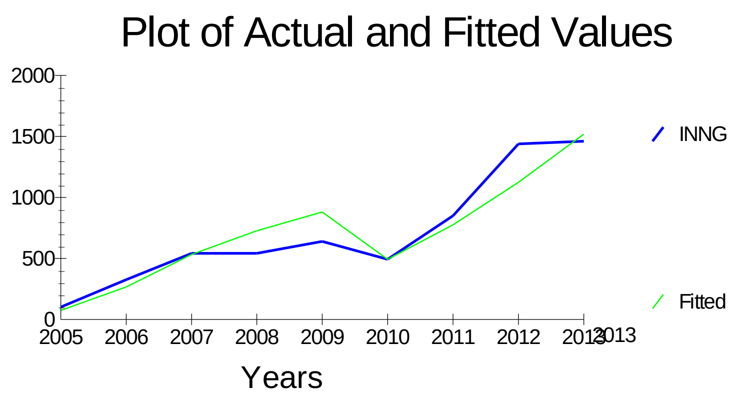
INNG = -2244.3*CONS + .0035561*INGDP + .42423*INNG(-1) + 157.5739*DUM10

Table 1E.6. Coefficient Estimates of Natural Gas Demand in Industrial Sector

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is INNG
 9 observations used for estimation from 2005 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                       -2244.3            1640.1            -1.3684[.229]
 INGDP                    .0035561          .0027523              1.2921[.253]
 INNG(-1)                   .42423            .47668              .88996[.414]
 DUM10                    157.5739          259.7540              .60663[.571]
*******************************************************************************
 R-Squared                     .88211   R-Bar-Squared                   .81138
 S.E. of Regression          202.6003   F-stat.    F(  3,    5)   12.4713[.009]
 Mean of Dependent Variable  709.5111   S.D. of Dependent Variable    466.4972
 Residual Sum of Squares     205234.3   Equation Log-likelihood       -57.9265
 Akaike Info. Criterion      -61.9265   Schwarz Bayesian Criterion    -62.3210
 DW-statistic                  1.4931   Durbin's h-statistic            *NONE*
*******************************************************************************
```

Source: Author's calculation.

Figure 1E.5. Plot of Actual and Fitted Values of Natural Gas Demand in Industrial Sector



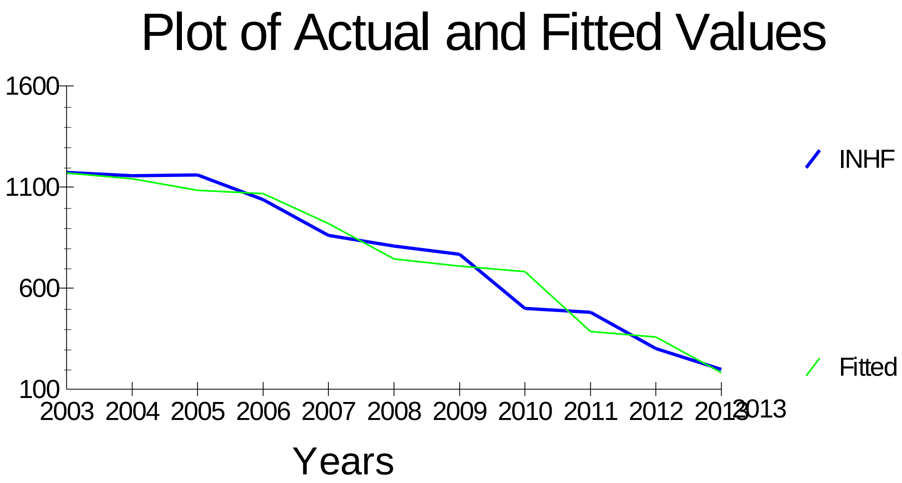
Source: Author's calculation.

- Fuel oil

INHF = 304.2015*CONS -.3610E-3*INGDP -.0064430*RPOIL + .95001*INHF(-1)

The sign of coefficient of INGDP is negative. It proves that fuel oil demand decreases when INGDP increases. In this case, the above demand function should not be used and suppose that fuel oil used in industry would reach zero by 2020 based on the trend of fuel oil used in the past (see Figure 1E.6).

Figure 1E.6. Plot of Actual and Fitted Values of Fuel Oil Demand in Industrial Sector



Source: Author's calculation.

Transport sector demand model

- Air/jet kerosene

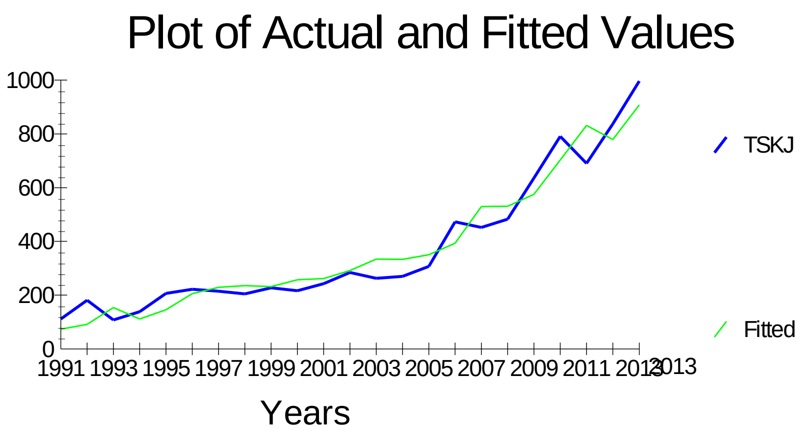
TSKJ = -72.0365*CONS + .1548E-3*GDP -.0012082*RPOIL + .72335*TSKJ(-1)

Table 1E.7. Coefficient Estimates of Jet Kerosene Demand in Air Transport

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is TSKJ
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                     -72.0365            52.5324            -1.3713[.186]
 GDP                      .1548E-3            .7756E-4            1.9958[.060]
 RPOIL                   -.0012082            .0049970           -.24179[.812]
 TSKJ(-1)                   .72335              .20351            3.5544[.002]
*******************************************************************************
 R-Squared                      .93756   R-Bar-Squared                   .92770
 S.E. of Regression            68.0991   F-stat.    F(  3,  19)   95.1013[.000]
 Mean of Dependent Variable   371.8757   S.D. of Dependent Variable    253.2700
 Residual Sum of Squares       88112.3   Equation Log-likelihood      -127.5206
 Akaike Info. Criterion      -131.5206   Schwarz Bayesian Criterion   -133.7916
 DW-statistic                   2.0955   Durbin's h-statistic     -1.0512[.293]
*******************************************************************************
```

Source: Author's calculation.

Figure 1E.7. Plot of Actual and Fitted Values of Jet Kerosene in Air Transport



Source: Author's calculation.

- Road/Gasoline

TSMG = -522.1186*CONS + .0010506*GDP + .013665*RPOIL + .54695*TSMG(-1)

The sign of coefficient of RPOIL is positive. This is irrational that the demand increases when oil price increases. It proves that RPOIL (or international oil price) does not affect the domestic demand of diesel oil. In this case, ERIA commented that the RPGOIL (price of gasoline of Viet Nam) should be used. The result is presented as follows:

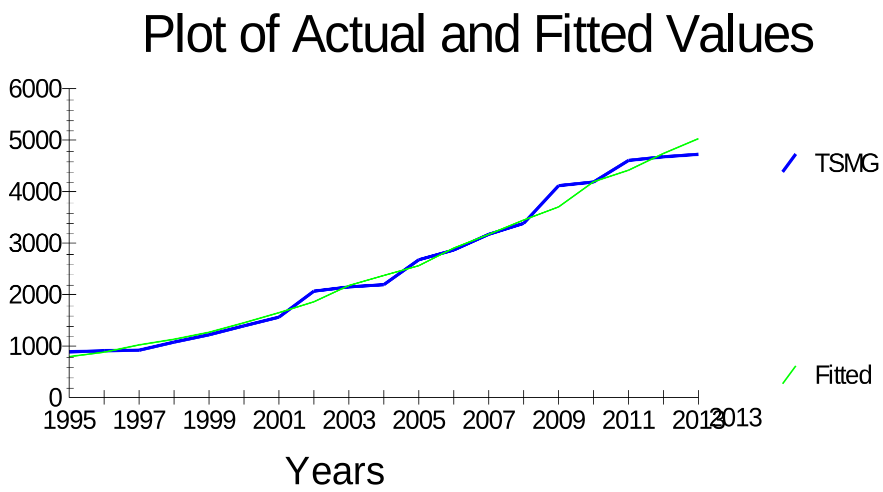
TSMG = -967.5575*CONS + .0018675*GDP -356.2257*RPGOIL + .34983*TSMG(-1)

Table 1E.8. Coefficient Estimates of Gasoline Demand in Road Transport

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is TSMG
 19 observations used for estimation from 1995 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                    -967.5575          340.0138            -2.8456[.012]
 GDP                      .0018675          .5540E-3             3.3709[.004]
 RPGOIL                  -356.2257          696.5289            -.51143[.616]
 TSMG(-1)                   .34983            .25415             1.3765[.189]
*******************************************************************************
 R-Squared                     .98748   R-Bar-Squared                   .98497
 S.E. of Regression          170.3102   F-stat.    F(  3,  15)  394.2578[.000]
 Mean of Dependent Variable    2565.0   S.D. of Dependent Variable      1389.3
 Residual Sum of Squares     435083.3   Equation Log-likelihood       -122.3289
 Akaike Info. Criterion     -126.3289   Schwarz Bayesian Criterion    -128.2178
 DW-statistic                  1.9922   Durbin's h-statistic             *NONE*
*******************************************************************************
```

Source: Author's calculation.

Figure 1E.8. Plot of Actual and Fitted Values of Gasoline in Road Transport



Source: Author's calculation.

- Road/Diesel

  TSGD = -155.7043*CONS + .8473E-3*GDP + .012516*RPOIL + .61874*TSGD(-1)

The sign of coefficient of RPOIL is positive. It proves that RPOIL (or international oil price) does notaffect the domestic demand of diesel oil. In this case, RPDOIL should be used. The result is presented as follows:

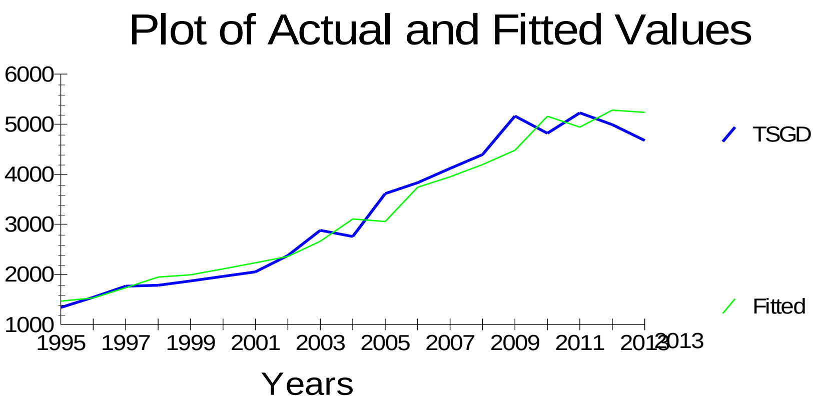
TSGD = -56.0251*CONS + .7703E-3*GDP -416.9328*RPDOIL + .74988*TSGD(-1)

Table 1E.9. Coefficient Estimates of Diesel Demand in Road Transport

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is TSGD
 19 observations used for estimation from 1995 to 2013
*******************************************************************************
 Regressor              Coefficient        Standard Error         T-Ratio[Prob]
 CONS                      -56.0251             441.5668          -.12688[.901]
 GDP                       .7703E-3             .8761E-3           .87923[.393]
 RPDOIL                   -416.9328               1083.1          -.38494[.706]
 TSGD(-1)                    .74988               .33622           2.2303[.041]
*******************************************************************************
 R-Squared                    .94997   R-Bar-Squared                     .93996
 S.E. of Regression         340.0748   F-stat.    F(  3,  15)    94.9306[.000]
 Mean of Dependent Variable   3218.5   S.D. of Dependent Variable        1387.9
 Residual Sum of Squares     1734763   Equation Log-likelihood        -135.4683
 Akaike Info. Criterion    -139.4683   Schwarz Bayesian Criterion     -141.3572
 DW-statistic                 2.0760   Durbin's h-statistic              *NONE*
*******************************************************************************
```

Source: Author's calculation.

Figure 1E.9. Plot of Actual and Fitted Values of Diesel in Road Transport



Source: Author's calculation.

- Other/Fuel oil

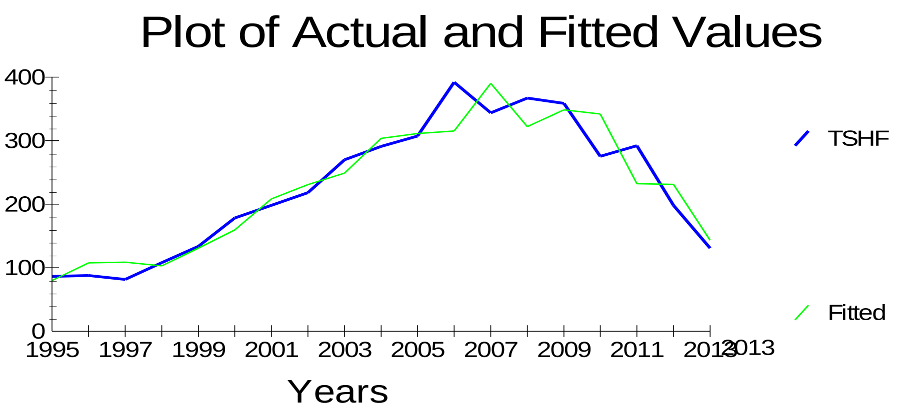
TSHF = 38.2912*CONS + .1623E-4*GDP -150.1930*RPDOIL + 1.0713*TSHF(-1)

Table 1E.10. Coefficient Estimates of Fuel Oil Demand in Transport

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is TSHF
 19 observations used for estimation from 1995 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                      38.2912            45.8308             .83549[.417]
 GDP                      .1623E-4           .7519E-4             .21590[.832]
 RPDOIL                  -150.1930           124.2344            -1.2089[.245]
 TSHF(-1)                   1.0713             .13667             7.8388[.000]
*******************************************************************************
 R-Squared                     .88695   R-Bar-Squared                   .86434
 S.E. of Regression           38.1992   F-stat.    F(  3,  15)   39.2290[.000]
 Mean of Dependent Variable  227.2068   S.D. of Dependent Variable    103.7129
 Residual Sum of Squares      21887.7   Equation Log-likelihood       -93.9276
 Akaike Info. Criterion      -97.9276   Schwarz Bayesian Criterion    -99.8165
 DW-statistic                  3.0808   Durbin's h-statistic     -2.9328[.003]
*******************************************************************************
```

Source: Author's calculation.

Figure 1E.10. Plot of Actual and Fitted Values of Fuel Oil in Transport



Source: Author's calculation.

Residential sector demand model

- Coal

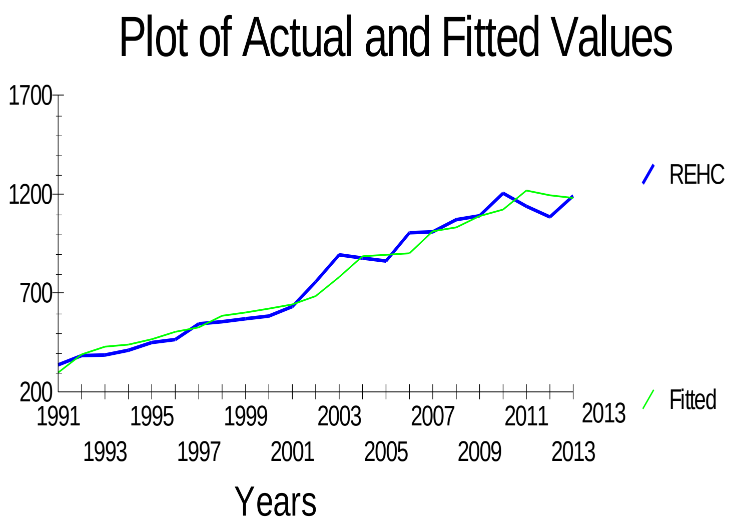
REHC = 69.6896*CONS + .1602E-3*GDP + .64842*REHC(-1)

Table 1E.11. Coefficient Estimates of Coal Demand in Residential Sector

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is REHC
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                       69.6896              31.3586           2.2223[.038]
 GDP                      .1602E-3             .9146E-4           1.7517[.095]
 REHC(-1)                   .64842               .18290           3.5452[.002]
*******************************************************************************
 R-Squared                    .96602   R-Bar-Squared                   .96263
 S.E. of Regression          57.3717   F-stat.    F(  2,  20)  284.3337[.000]
 Mean of Dependent Variable  760.0035   S.D. of Dependent Variable     296.7707
 Residual Sum of Squares      65830.1   Equation Log-likelihood       -124.1680
 Akaike Info. Criterion     -127.1680   Schwarz Bayesian Criterion    -128.8712
 DW-statistic                  1.7442   Durbin's h-statistic      1.2776[.201]
*******************************************************************************
```

Source: Author's calculation.

Figure 1E.11. Plot of Actual and Fitted Values of Coal in Residential Sector



Source: Author's calculation.

- Diesel oil

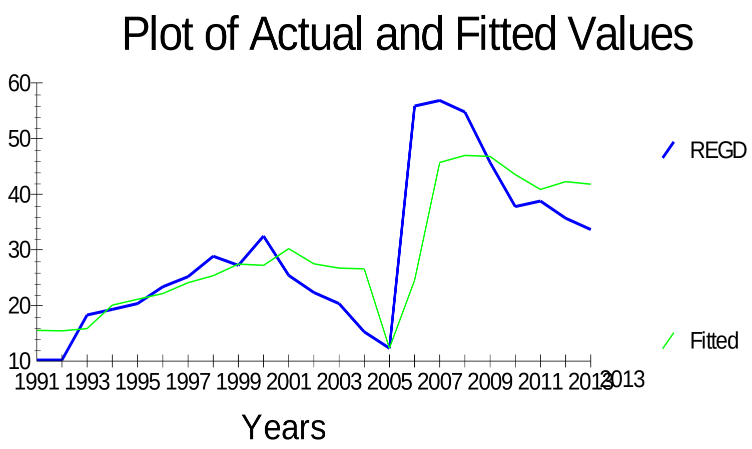
REGD = -6.8421*CONS + .7572E-5*GDP + .46540*REGD(-1) + 12.7738*DUM05

Table 1E.12. Coefficient Estimates of Diesel Demand in Residential Sector

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is REGD
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                     -6.8421            10.9403            -.62541[.539]
 GDP                     .7572E-5            .4826E-5            1.5690[.133]
 REGD(-1)                  .46540             .20521             2.2679[.035]
 DUM05                    12.7738            10.1240             1.2617[.222]
*******************************************************************************
 R-Squared                     .62169   R-Bar-Squared                   .56196
 S.E. of Regression            9.2906   F-stat.    F(  3,  19)   10.4079[.000]
 Mean of Dependent Variable   29.1174   S.D. of Dependent Variable     14.0374
 Residual Sum of Squares       1640.0   Equation Log-likelihood       -81.7055
 Akaike Info. Criterion      -85.7055   Schwarz Bayesian Criterion    -87.9765
 DW-statistic                  1.1682   Durbin's h-statistic     11.2518[.000]
*******************************************************************************
```

Source: Author's calculation.

Figure 1E.12. Plot of Actual and Fitted Values of Diesel Demand in Residential Sector



Source: Author's calculation.

- LPG

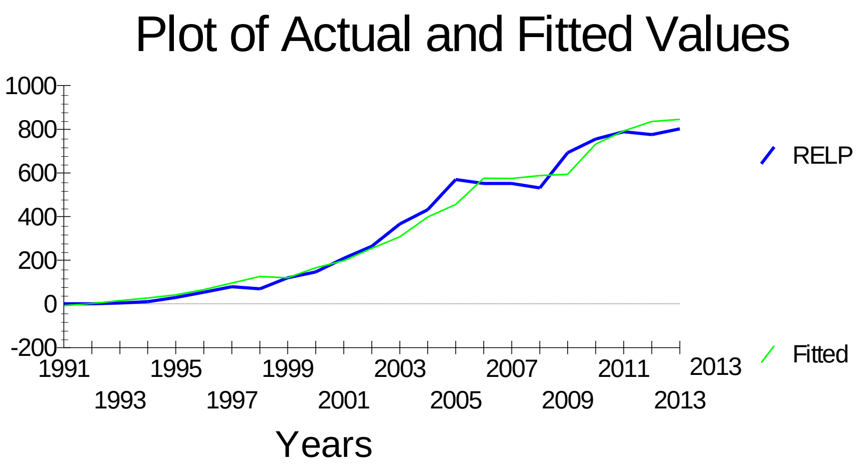
RELP = -62.2959*CONS + .1330E-3*GDP -.0016185*RPOIL + .76858*RELP(-1)

Table 1E.13. Coefficient Estimates of LPG Demand in Residential Sector

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is RELP
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                     -62.2959           135.2485            -.46060[.650]
 GDP                      .1330E-3           .1242E-3             1.0709[.298]
 RPOIL                   -.0016185           .0058828            -.27512[.786]
 RELP(-1)                   .76858             .31468             2.4424[.025]
*******************************************************************************
 R-Squared                    .97832   R-Bar-Squared                    .97490
 S.E. of Regression          47.4248   F-stat.    F(  3,  19)  285.8473[.000]
 Mean of Dependent Variable 338.9857   S.D. of Dependent Variable     299.3505
 Residual Sum of Squares     42733.0   Equation Log-likelihood       -119.1988
 Akaike Info. Criterion    -123.1988   Schwarz Bayesian Criterion    -125.4698
 DW-statistic                 1.6404   Durbin's h-statistic             *NONE*
*******************************************************************************
```

Source: Author's calculation.

Figure 1E.13. Plot of Actual and Fitted Values of LPG Demand in Residential Sector



Source: Author's calculation.

- Electricity

REEL = -125.9780*CONS + .3589E-3*GDP -.0061136*RPOIL + .87991*REEL(-1)

Table 1E.14. Coefficient Estimates of Electricity Demand in Residential Sector

Ordinary Least Squares Estimation

Dependent variable is REEL

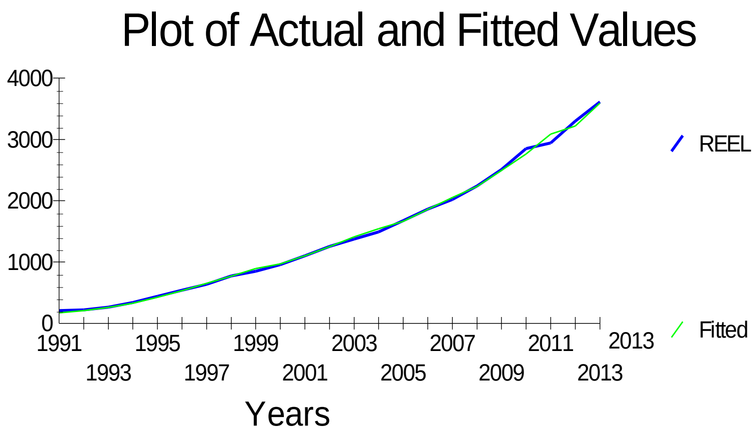
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	-125.9780	120.1574	-1.0484[.308]
GDP	.3589E-3	.1888E-3	1.9012[.073]
RPOIL	-.0061136	.0037420	-1.6338[.119]
REEL(-1)	.87991	.12144	7.2456[.000]

R-Squared	.99809	R-Bar-Squared	.99779
S.E. of Regression	49.1702	F-stat. F(3, 19)	3305.8[.000]
Mean of Dependent Variable	1454.5	S.D. of Dependent Variable	1045.0
Residual Sum of Squares	45936.5	Equation Log-likelihood	-120.0301
Akaike Info. Criterion	-124.0301	Schwarz Bayesian Criterion	-126.3011
DW-statistic	2.8031	Durbin's h-statistic	-2.3690[.018]

Source: Author's calculation.

Figure 1E.14. Plot of Actual and Fitted Values of Electricity Demand in Residential Sector



Source: Author's calculation.

Commercial sector demand model

- Coal

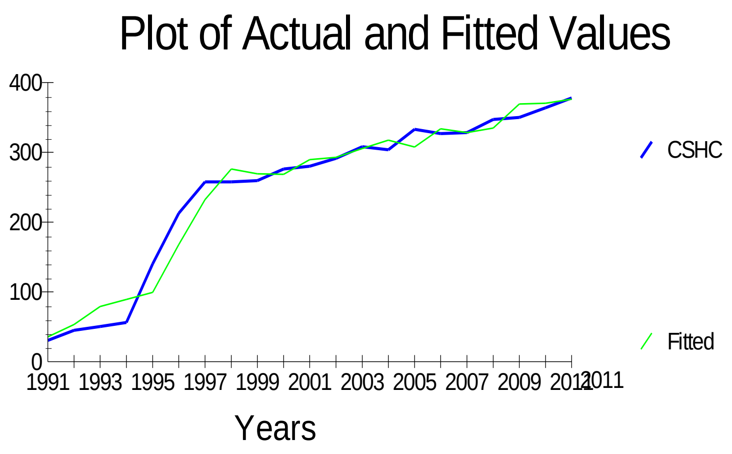
CSHC = 22.9810*CONS + .0048148*GDPC -.0030803*RPOIL + .78805*CSHC(-1)

Table 1E.15. Coefficient Estimates of Coal Demand in Commercial Sector

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is CSHC
 21 observations used for estimation from 1991 to 2011
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                     22.9810            18.2174              1.2615[.224]
 GDPC                    .0048148           .0032558              1.4789[.157]
 RPOIL                  -.0030803           .0020160             -1.5279[.145]
 CSHC(-1)                  .78805             .11459              6.8771[.000]
*******************************************************************************
 R-Squared                     .96767   R-Bar-Squared                    .96196
 S.E. of Regression           22.1823   F-stat.    F(  3,  17)  169.5997[.000]
 Mean of Dependent Variable  247.3910   S.D. of Dependent Variable     113.7367
 Residual Sum of Squares       8364.9   Equation Log-likelihood        -92.6641
 Akaike Info. Criterion      -96.6641   Schwarz Bayesian Criterion     -98.7532
 DW-statistic                  1.5768   Durbin's h-statistic       1.1395[.254]
*******************************************************************************
```

Source: Author's calculation.

Figure 1E.15. Plot of Actual and Fitted Values of Coal Demand in Commercial Sector



Source: Author's calculation.

- Diesel

CSGD = 48.7576*CONS -.0010448*GDPC -.0012584*RPOIL + .95891*CSGD(-1)

Table 1E.16. Coefficient Estimates of Diesel Demand in Commercial Sector

Ordinary Least Squares Estimation

Dependent variable is CSGD

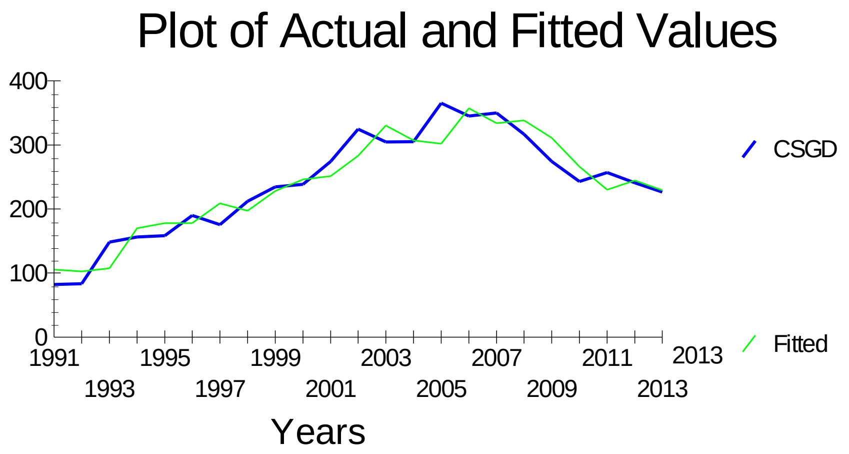
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	48.7576	19.8688	2.4540[.024]
GDPC	-.0010448	.0018937	-.55173[.588]
RPOIL	-.0012584	.0020656	-.60923[.550]
CSGD(-1)	.95891	.10182	9.4174[.000]

R-Squared	.89275	R-Bar-Squared	.87582
S.E. of Regression	28.3333	F-stat. F(3, 19)	52.7193[.000]
Mean of Dependent Variable	239.3709	S.D. of Dependent Variable	80.4019
Residual Sum of Squares	15252.8	Equation Log-likelihood	-107.3513
Akaike Info. Criterion	-111.3513	Schwarz Bayesian Criterion	-113.6223
DW-statistic	2.2885	Durbin's h-statistic	-.79270[.428]

Source: Author's calculation.

Figure 1E.16. Plot of Actual and Fitted Values of Diesel Demand in Commercial Sector



Source: Author's calculation.

The sign of coefficient of GDPC (GDP per capita) is negative. It proves that diesel oil demand decreases when GDPC increases. In this case, the above demand function should not be used and suppose that diesel oil used in commercial sector would be reduced according to the past trend of diesel oil consumption in 2005–2013.

- Fuel oil

CSHF = 38.1485*CONS -.0012298*GDPC -.6799E-3*RPOIL + .86958*CSHF(-1)

Table 1E.17. Coefficient Estimates of Fuel Oil Demand in Commercial Sector

Ordinary Least Squares Estimation

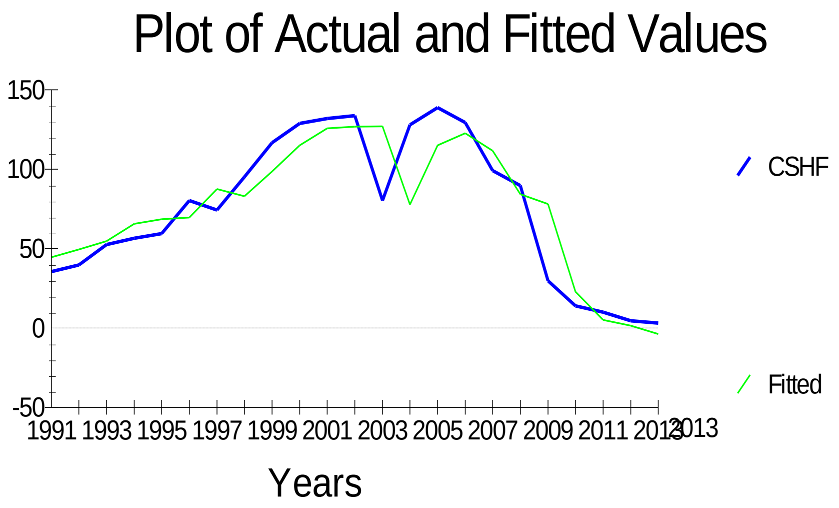
Dependent variable is CSHF
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	38.1485	18.1013	2.1075[.049]
GDPC	-.0012298	.0011758	-1.0459[.309]
RPOIL	-.6799E-3	.0016344	-.41600[.682]
CSHF(-1)	.86958	.10899	7.9783[.000]

R-Squared	.79815	R-Bar-Squared	.76628
S.E. of Regression	22.2189	F-stat. F(3, 19)	25.0437[.000]
Mean of Dependent Variable	75.2426	S.D. of Dependent Variable	45.9598
Residual Sum of Squares	9379.9	Equation Log-likelihood	-101.7602
Akaike Info. Criterion	-105.7602	Schwarz Bayesian Criterion	-108.0311
DW-statistic	2.1785	Durbin's h-statistic	-.50196[.616]

Source: Author's calculation.

Figure 1E.17. Plot of Actual and Fitted Values of Fuel Oil Demand in Commercial Sector



Source: Author's calculation.

The sign of coefficient of GDPC (GDP per capita) is negative. It proves that fuel oil demand decreases when GDPC increases. In this case, we do not need to use the above demand function and suppose that fuel oil used in commercial sector would reach to zero by 2018 based on the trend of fuel oil used in the past.

- LPG

CSLP = -135.3638*CONS + .015032*GDPC -.0011385*RPOIL + .44156*CSLP(-1)

Table 1E.18. Coefficient Estimates of LPG Demand in Commercial Sector

Ordinary Least Squares Estimation

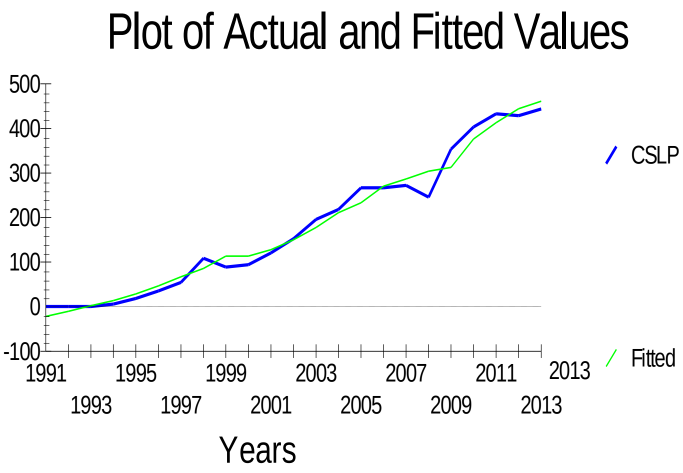
Dependent variable is CSLP
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	-135.3638	67.5549	-2.0038[.060]
GDPC	.015032	.0054312	2.7677[.012]
RPOIL	-.0011385	.0021789	-.52251[.607]
CSLP(-1)	.44156	.25152	1.7556[.095]

R-Squared	.97875	R-Bar-Squared	.97540
S.E. of Regression	24.1156	F-stat. F(3, 19)	291.7148[.000]
Mean of Dependent Variable	182.8157	S.D. of Dependent Variable	153.7413
Residual Sum of Squares	11049.7	Equation Log-likelihood	-103.6442
Akaike Info. Criterion	-107.6442	Schwarz Bayesian Criterion	-109.9152
DW-statistic	1.7954	Durbin's h-statistic	*NONE*

Source: Author's calculation.

Figure 1E.18. Plot of Actual and Fitted Values of LPG Demand in Commercial Sector



Source: Author's calculation.

- Electricity

CSEL = -105.0106*CONS + .3768E-3*CSGDP -.0030676*RPOIL + .85787*CSEL(-1)

Table 1E.19. Coefficient Estimates of Electricity Demand in Commercial Sector

Ordinary Least Squares Estimation

Dependent variable is CSEL

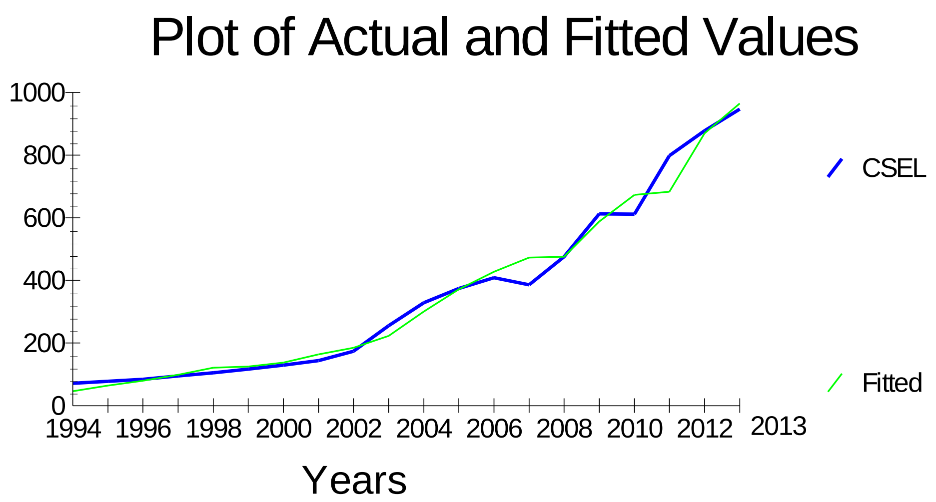
20 observations used for estimation from 1994 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	-105.0106	58.1914	-1.8046[.090]
CSGDP	.3768E-3	.1859E-3	2.0272[.060]
RPOIL	-.0030676	.0047521	-.64552[.528]
CSEL(-1)	.85787	.12525	6.8490[.000]

R-Squared	.98054	R-Bar-Squared	.97689
S.E. of Regression	43.0940	F-stat. F(3, 16)	268.7260[.000]
Mean of Dependent Variable	353.4550	S.D. of Dependent Variable	283.4806
Residual Sum of Squares	29713.5	Equation Log-likelihood	-101.4150
Akaike Info. Criterion	-105.4150	Schwarz Bayesian Criterion	-107.4065
DW-statistic	2.2797	Durbin's h-statistic	-.75502[.450]

Source: Author's calculation.

Figure 1E.19. Plot of Actual and Fitted Values of Electricity Demand in Commercial Sector



Source: Author's calculation.

Agricultural sector demand model

- Coal

AGHC = 20.1040*CONS -.1350E-4*AGGDP -.6261E-4*RPOIL + .33333*AGHC(-1)

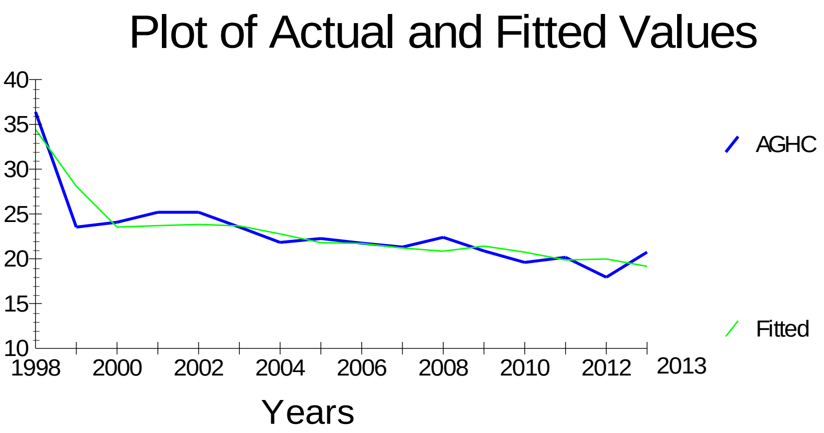
The sign of coefficient of AGGDP is negative. It proves that coal demand decreases when AGGDP increases. In this case, we do not need to use the above demand function and suppose that coal used in agriculture would be reduced based on the past trend of coal consumption in 2002–2012 (see figure below).

Table 1E.20. Coefficient Estimates of Coal Demand in Agricultural Sector

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is AGHC
 16 observations used for estimation from 1998 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                      20.1040            5.6359              3.5671[.004]
 AGGDP                   -.1350E-4           .1849E-4            -.73016[.479]
 RPOIL                   -.6261E-4           .2463E-3            -.25416[.804]
 AGHC(-1)                   .33333           .080149              4.1589[.001]
*******************************************************************************
 R-Squared                     .83661   R-Bar-Squared                    .79576
 S.E. of Regression            1.8556   F-stat.     F(  3,  12)   20.4813[.000]
 Mean of Dependent Variable   22.9175   S.D. of Dependent Variable       4.1059
 Residual Sum of Squares      41.3172   Equation Log-likelihood        -30.2925
 Akaike Info. Criterion      -34.2925   Schwarz Bayesian Criterion     -35.8377
 DW-statistic                  2.4960   Durbin's h-statistic      -1.0473[.295]
*******************************************************************************
```

Source: Author's calculation.

Figure 1E.20. Plot of Actual and Fitted Values of Coal Demand in Agricultural Sector



- Diesel oil

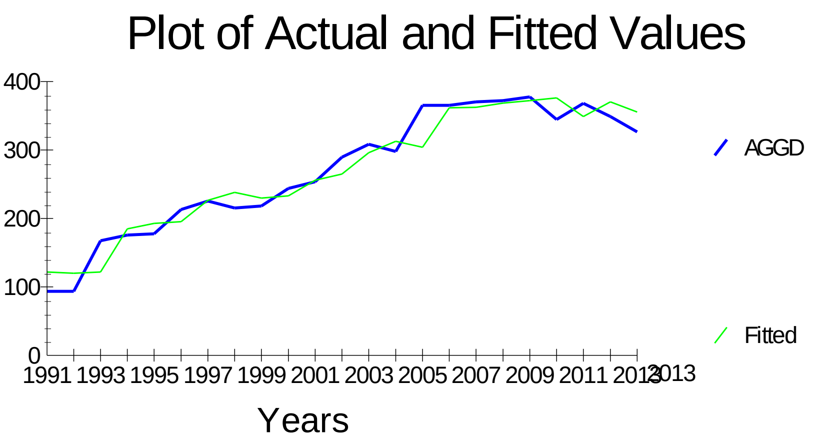
  AGGD = 25.6198*CONS + .9438E-4*AGGDP - .2746E-3*RPOIL + .84035*AGGD(-1)

Table 1E.21. Coefficient Estimates of Diesel Demand in Agricultural Sector

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is AGGD
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                       25.6198              30.9489            .82781[.418]
 AGGDP                      .9438E-4             .2785E-3           .33890[.738]
 RPOIL                     -.2746E-3             .0019254          -.14261[.888]
 AGGD(-1)                     .84035               .19867           4.2298[.000]
*******************************************************************************
 R-Squared                     .93036   R-Bar-Squared                   .91936
 S.E. of Regression           25.6746   F-stat.    F(  3,  19)    84.6048[.000]
 Mean of Dependent Variable  270.0896   S.D. of Dependent Variable     90.4119
 Residual Sum of Squares      12524.5   Equation Log-likelihood      -105.0850
 Akaike Info. Criterion     -109.0850   Schwarz Bayesian Criterion   -111.3560
 DW-statistic                  2.1886   Durbin's h-statistic     -1.4895[.136]
*******************************************************************************
```

Source: Author's calculation.

Figure 1E.21. Plot of Actual and Fitted Values of Diesel Demand in Agricultural Sector



Source: Author's calculation.

- Gasoline

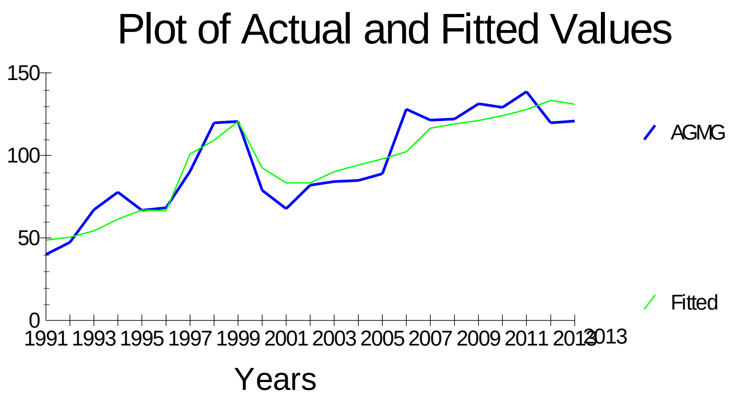
AGMG = 19.8562*CONS + .2514E-3*AGGDP + .27416*AGMG(-1) -31.4888*DUM9799

Table 1E.22. Coefficient Estimates of Gasoline Demand in Agricultural Sector

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is AGMG
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                      19.8562            10.9492             1.8135[.086]
 AGGDP                    .2514E-3            .6623E-4            3.7961[.001]
 AGMG(-1)                   .27416             .16367             1.6751[.110]
 DUM9799                  -31.4888             8.2874            -3.7996[.001]
*******************************************************************************
 R-Squared                     .86061   R-Bar-Squared                    .83860
 S.E. of Regression           11.7479   F-stat.    F(  3,  19)   39.1025[.000]
 Mean of Dependent Variable   95.3943   S.D. of Dependent Variable      29.2421
 Residual Sum of Squares       2622.3   Equation Log-likelihood        -87.1030
 Akaike Info. Criterion      -91.1030   Schwarz Bayesian Criterion     -93.3740
 DW-statistic                  1.5621   Durbin's h-statistic       1.6948[.090]
*******************************************************************************
```

Source: Author’s calculation.

Figure 1E.22. Plot of Actual and Fitted Values of Gasoline Demand in Agricultural Sector



Source: Author’s calculation.

- Electricity

AGEL = -14.3394*CONS + .1086E-3*AGGDP + 1.2218*RPEL + .71964*AGEL(-1) - 24.6472*DUM1013

The sign of coefficient of RPEL (domestic price of electricity) is positive. This is irrational (demand increases when price increases). It proves that RPEL does not affect the domestic demand of electricity. In this case, only AGGDP should be used as variable to drive electricity demand as follows:

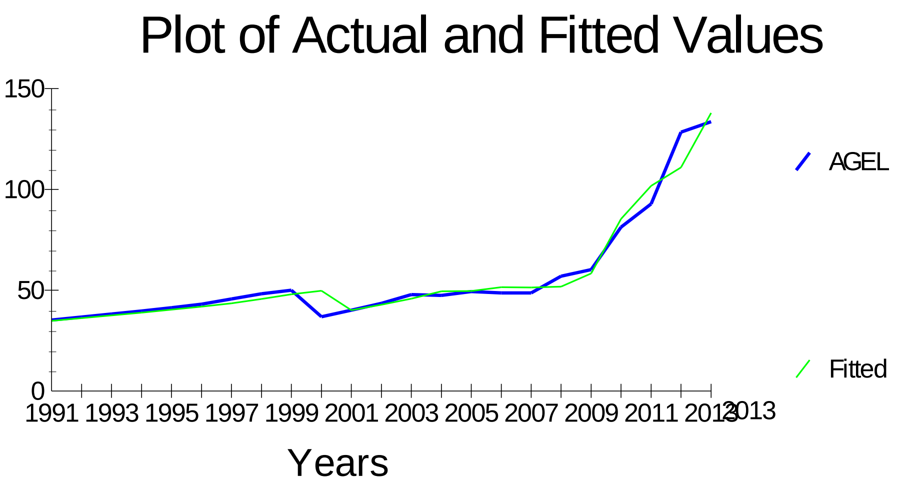
AGEL = 28.1367*CONS + .2999E-4*AGGDP + .75365*AGEL(-1) - 24.5577*DUM1013

Table 1E.23. Coefficient Estimates of Electricity Demand in Agricultural Sector

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is AGEL
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                      28.1367            11.2218              2.5073[.021]
 AGGDP                     .2999E-4           .2427E-4             1.2354[.232]
 AGEL(-1)                   .75365             .11958              6.3024[.000]
 DUM1013                  -24.5577             5.9555             -4.1235[.001]
*******************************************************************************
 R-Squared                     .95939   R-Bar-Squared                   .95298
 S.E. of Regression            5.9076   F-stat.    F(  3,  19)  149.6367[.000]
 Mean of Dependent Variable   56.1926   S.D. of Dependent Variable     27.2449
 Residual Sum of Squares     663.1057   Equation Log-likelihood       -71.2921
 Akaike Info. Criterion      -75.2921   Schwarz Bayesian Criterion    -77.5631
 DW-statistic                  2.6081   Durbin's h-statistic      -1.7799[.075]
*******************************************************************************
```

Source: Author's calculation.

Figure 1E.23. Plot of Actual and Fitted Values of Electricity Demand in Agricultural Sector



Source: Author's calculation.

- Fuel oil

  AGHF = 4.5139*CONS - .8940E-5*AGGDP - .1423E-3*RPOIL + .99036*AGHF(-1)

Table 1E.24. Coefficient Estimates of Fuel Oil Demand in Agricultural Sector

Ordinary Least Squares Estimation

Dependent variable is AGHF

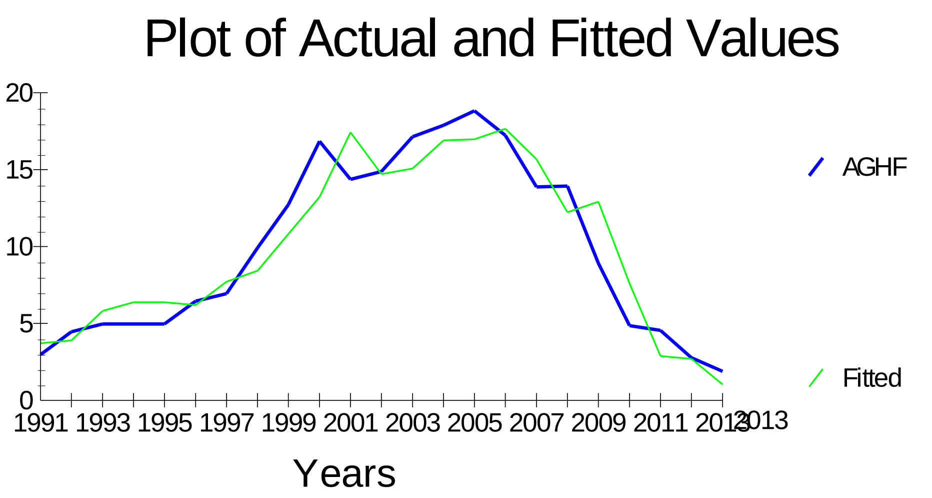
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	4.5139	1.7634	2.5598[.019]
AGGDP	-.8940E-5	.8739E-5	-1.0230[.319]
RPOIL	-.1423E-3	.1462E-3	-.97334[.343]
AGHF(-1)	.99036	.081244	12.1900[.000]

R-Squared	.89416	R-Bar-Squared	.87745
S.E. of Regression	2.0093	F-stat. F(3, 19)	53.5060[.000]
Mean of Dependent Variable	9.8391	S.D. of Dependent Variable	5.7397
Residual Sum of Squares	76.7081	Equation Log-likelihood	-46.4875
Akaike Info. Criterion	-50.4875	Schwarz Bayesian Criterion	-52.7585
DW-statistic	1.9995	Durbin's h-statistic	.0013089[.999]

Source: Author's calculation.

Figure 1E.24. Plot of Actual and Fitted Values of Fuel Oil Demand in Agricultural Sector



Source: Author's calculation.

The sign of coefficient of AGGDP is negative. It proves that fuel oil demand decreases when AGGDP increases. In this case, we do not need to use the demand function above and suppose that fuel oil used in agriculture would reach zero by 2020 based on the trend of fuel oil used in the past.

Conclusion

The estimation results of energy demand formulas show that the data issue has become the most important factor affecting the energy demand in next periods. In the case of Viet Nam, the quality of data is still unsatisfactory, especially the existing unstable data chain and the inconsistency between the data source of the Asia Pacific Energy Research Centreand the energy balances of the International Energy Agency. Reasons for these includeissues on data collection, data checking, and processing.

From the above findings, it is necessary that the Economic Research Institute for ASEAN and East Asiacooperate with the Asia Pacific Energy Research Centre to improvethe energy data quality of Viet Nam.

Reference

Vietnam Prosperous Bank (VPBank), (2013), Report of Power Sector of Viet Nam. Ha Noi: VPBank Securities..

Chapter 2

Case Studies: Keeping CO_2 Emissions at 2013 Level by 2040

This chapter presents case studies where a scenario of keeping carbon dioxide (CO_2) emissions at 2013 level up to 2040 is set by the working group. For some countries belonging to the East Asian Summit, finding the best energy mix while keeping CO_2 from 2013 till 2040 at the same level is a very challenging task. Upscaling renewable energy with energy efficiency programmes remains the key energy policy towards low-carbon economy in East Asian Summit countries. The Paris Agreement bridges today's policies and climate neutrality before the end of the century. However, the Energy Outlook and Saving Potential in East Asia 2016 by the Economic Research Institute for ASEAN and East Asia shows that although emissions reductions under the Alternative Policy Scenario are significant, CO_2 emissions from energy demand in the Alternative Policy Scenario case in 2040 will still be above the 2013 levels and more than three times higher than the 1990 levels. This chapter explores the possibility of each country in ASEAN plus Australia and China keeping CO_2 emissions to the 2013 level up until 2040. Since some countries such as Japan, the Republic of Korea, China, and New Zealand will likely reduce energy consumption, they are not included in this case study.

For this case study, the scenarios are:

- Apply renewable energy and nuclear power generation aggressively;
- Apply energy efficiency and conservation to achieve the maximum energy savings;
- Keep CO_2 emissions to the 2013 level till 2040 to see how it affects the compositions of energy mix in each country.

To achieve this scenario, each country will need to make drastic change to their energy mix, with highly ambitious energy savings through energy efficiency and conservation and huge contribution from renewable energy where nuclear options become dispensable. This study makes clear that reduction of CO_2 emissions is very difficult for some East Asian Summit countries expecting economic growth.

2A. Australia's Case Study: Keeping CO_2 Emission at 2013 Level by 2040

1. Introduction

In 2013, Australia's total primary energy consumption was 129 million tonnes of oil equivalent (Mtoe). Black and brown coal together accounted for 35% of this consumption, its lowest share since the early 1970s. Oil accounted for around 35% of the total primary energy consumption. The share of natural gas increased in recent years to 23%, supported by greater uptake in the electricity-generation sector and growth in industrial use. Total share of fossil fuels was 94%. The remainders were bioenergy, hydropower, wind energy, and solar energy. Carbon dioxide (CO_2) emission in 2013 was 103 million tonnes of carbon (Mt-C).

Australia is endowed with abundant, high-quality, and diverse energy resources. It has around 34% of the world's uranium resources, although not consumed domestically. The country has 14% of the world's black coal resources and almost 2% of the world's gas resources. Australia also has large, widely distributed wind, solar, geothermal, hydroelectric, ocean energy, and bioenergy resources. Wind and solar energy resources are being increasingly exploited, whereas geothermal and ocean energy resources remain largely undeveloped.

Australia's energy resources are a key contributor to its economic prosperity. It exports black coal, uranium oxide, and liquefied natural gas and imports liquid hydrocarbons, including crude oil and most petroleum products.

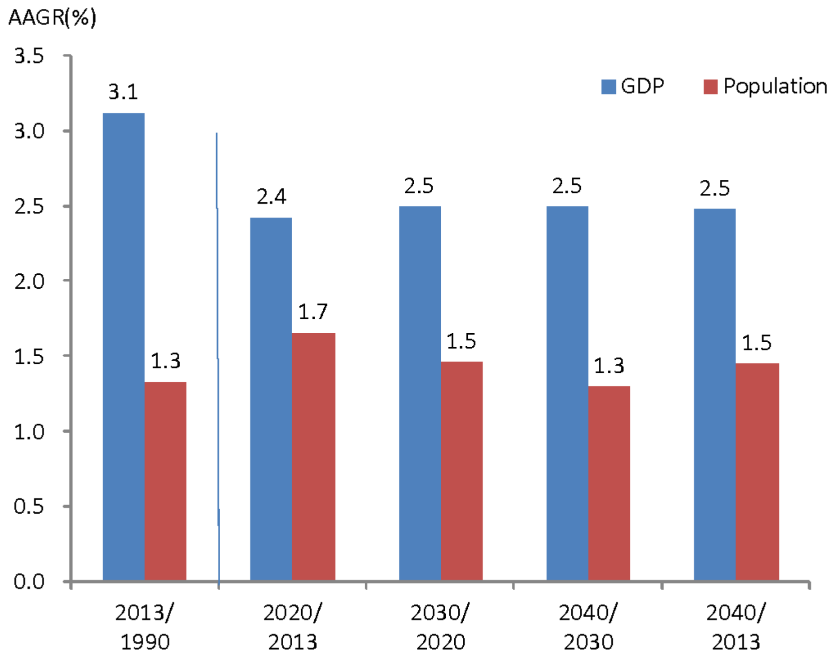
In 2013, Australia's population was 23.1 million and the nominal gross domestic product (GDP) was US$1,472 billion. Nominal GDP per capita was about US$63,700, around 70% higher than the average of Organisation of Economic Co-operation and Development (OECD) countries. Primary energy consumption per capita was 5.6 tonnes of oil equivalent (toe)/person, 30% higher than the average of OECD countries (4.2 toe/person). Australia heavily relies on fossil fuels. Due to the high carbon intensity of its energy use, CO_2 emission per capita was about 4.5 tonnes of carbon (t-C)/person in 2013, 70% higher than the average of OECD countries (2.6 t-C/person).

As Australia's population and GDP are predicted to increase steadily in the next decades, a significant increase in energy consumption is expected. To suppress Australia's CO_2 emissions related to energy by 2040 to below 2013 level, several scenarios are discussed in this report.

2. Modelling Assumptions and Scenario Setting

Growth of population and economy affect the size and pattern of energy demand. During 2013–2040, Australia's population is projected to increase by 1.5% per year, reaching 34 million by 2040. The average annual growth rate of real GDP is 2.5% during the same period (Figure 2A-1).

Figure 2A-1. Assumption for Growth Rate of GDP and Population



GDP = gross domestic product.
Source: Author's calculations.

In 2009, Australian governments entered into a partnership agreement and developed a National Strategy on Energy Efficiency to accelerate energy efficiency efforts. These activities – in particular, improved efficiency of refrigeration, air conditioning, and electronics; minimum performance standards for a range of common household appliances; and energy efficiency requirements in the Building Code – are beginning to show up in Australia's energy use trends.

For renewable energy, the Australian government set, in June 2015, a new target for Large-scale Renewable Energy Target of 33 terawatt-hours (TWh) by 2020, declining from the previous target of 41 TWh by 2020.

In this report, four scenarios are discussed to restrain Australia's CO_2 emissions related to energy by 2040 (see Table 2A.1).

Table 2A-1. Scenario Setting

	Final Energy Demand	Power Generation
Business as Usual Scenario (BAU)	Extension of historical trend based on current policy	
Energy Conservation Scenario (ECS)	Enhanced energy conservation	Same as BAU
Low-Carbon Power Generation Scenario (LCP)	Same as BAU	Further development of renewable energy
Alternative Policy Scenario (APS)	Between BAU and ECS	Between BAU and LCP

Source: Author's assumption.

3. Results of Energy Consumption and CO_2 Emissions

Final energy demand

In the Business as Usual (BAU) scenario, final energy demand will increase at 2.2% during the outlook period, and reach 145 metric tonnes of oil equivalent (Mtoe) by 2040 from 81 Mtoe in 2013 (see Figure 2A.2).

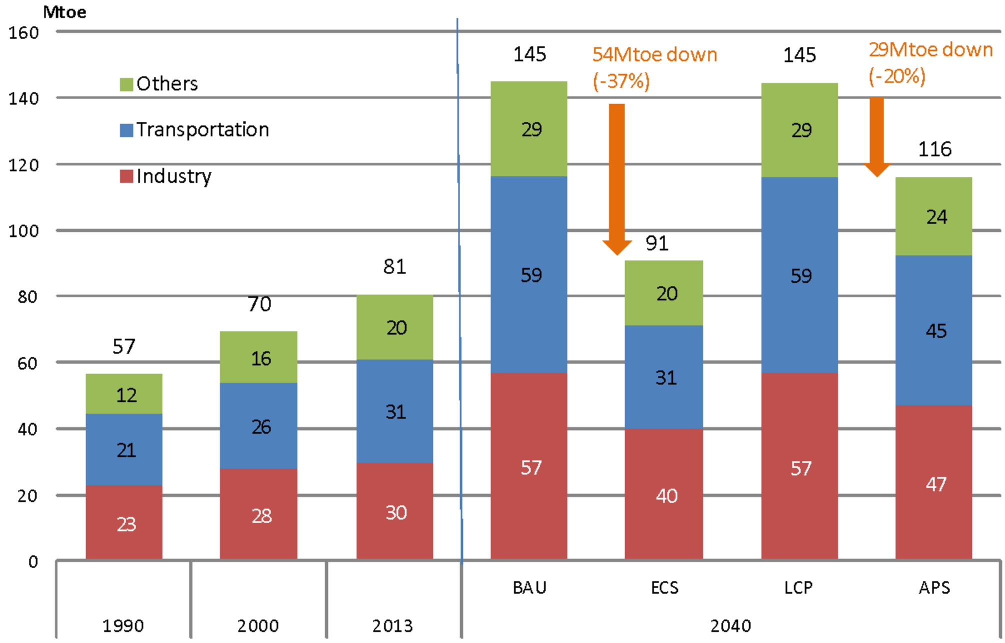
The transport sector accounted for 38.5% of final energy demand in 2013. The transport sector's consumption, most of which are oil and petroleum products, is expected to grow steadily over the projection period at an average rate of 2.4% per year, driven largely by economic growth. Its share in final energy demand is projected to increase to 40.9% in 2040. The industry sector (here, including the non-energy use) is the second largest user of final energy in Australia, accounting for a share of 37.1% in 2013. This sector covers several relatively energy-intensive subsectors such as petroleum refining, iron and steel, aluminium smelting, and minerals processing. Whereas energy consumption in the industry sector is projected to increase at an average annual rate of 3.1% over the outlook period, the share of the sector is expected to increase to 39.4%. The mining sector is projected to have the highest energy consumption growth rate over the outlook period. This reflects the continuation of global demand for energy and mineral commodities and the large number of mineral and energy projects (including liquefied natural gas and coal seam gas) assumed to come on stream over the outlook period.

The 'others' including agriculture, commercial, and residential sectors is projected to increase at 1.4% per year.

In the Energy Conservation Scenario (ECS), significant energy savings need to be achieved in all sectors. Final energy demand in 2040 will be 91 Mtoe, 13% higher than the 2013 level, but 54 Mtoe (37%) lower than that in BAU. The transport sector accounts for around half of the total energy saving. With improvement of fuel economy and the further development of electric vehicles, energy consumption per car is assumed to decrease by 35% from the 2013 level. About 30% of energy saving will come from the industry sector. Average annual growth rate of the industry sector's energy demand needs to be suppressed to 1.7%. Energy demand of others sector in 2040 is assumed to be suppressed into the 2013 level, 31% lower than that in BAU.

In the Alternative Policy Scenario (APS), the final energy demand will reach 116 Mtoe by 2040, an increase of 36 Mtoe from 2013, between the level of ECS and BAU. The industry sector will account for nearly half of the increment of final energy demand during the outlook period. The transport sector's demand will increase moderately at 1.4% per year according to the expanding volume of cars. The energy consumption per car is assumed to be improved by 7% from the 2013 level, much modest compared with ECS. The average annual growth rate of the others sector's energy demand will be 0.7%, half of that in BAU.

Figure 2A-2. Final Energy Demand by Sector



Note: 'Others' sector includes agricultural, residential, and commercial sectors. Non-energy use is included in energy consumption of the 'Industry' sector.

Mtoe = metric tonne of oil equivalent.
Source: Author's calculations.

Power generation

For electricity generation, coal has been the major fuel source for electricity generation in Australia, although its share in total production fell from 83% in 2000 to around 65% in 2013. In contrast, natural gas-fired generation continued to rise from 2006, and reached 21% in 2013. The share of renewables in Australian electricity generation rose from approximately 8% in 2000 to around 13% in 2013. Although hydropower is still the largest resource for power generation, rapidly increased use of wind energy and solar photovoltaic system in recent year accounts for most of the increment of renewables (see Figure 2A.3).

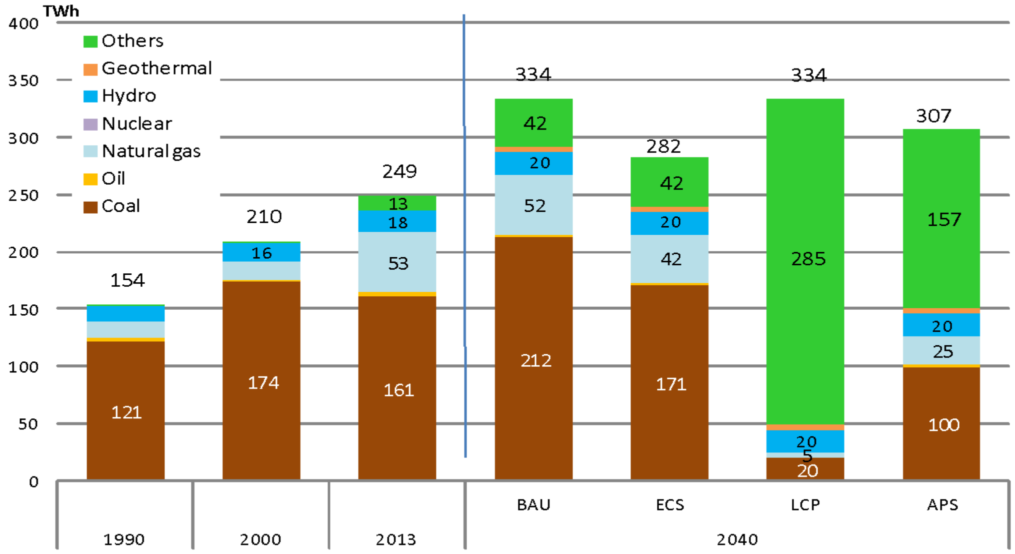
In the BAU scenario, electricity generation is projected to grow by 34% (or 1.1% per year) from 249 TWh in 2013 to 334 TWh in 2040. Coal is expected to remain the dominant source of electricity generation. The share of coal in electricity generation is projected to remain broadly constant at around 64%, growing at 1% per year. Due to the declining cost of renewable generation (mostly wind and solar energy) over the projection period, electricity production from renewables is expected to grow by 2.9% per year over the projection period. The share of renewables is expected to increase to 20% by 2040. Meanwhile electricity production from natural gas is expected to keep the current level and drop its share to 16% by 2040.

In ECS, due to moderate increase of electricity demand, total electricity production in 2040 is only 13% up from the 2013 level, 16% lower than that in BAU. In ESC, due to less demand, coal and natural gas electricity production in 2040 will be lower than that in BAU. The total amount of electricity production by fossil fuels will be almost the same as that in 2013.

In Low-Carbon Power Generation Scenario (LCP), given the same electricity consumption as BAU, to reduce CO_2 emissions from the fossil fuel-fired power generation, wind and solar power generation should increase dramatically from BAU. The share of renewables in electricity production is assumed to exceed 90%.

In APS, due to less demand and further development of renewable energy, coal and natural gas power generation in 2040 will decrease to half of that in BAU. Renewables need to triple that in BAU, with the share of 59% in 2040.

Figure 2A-3. Electricity Production by Fuel Type



APS = Alternative Policy Scenario, BAU = Business as Usual, ECS = Energy Conservation Scenario, LCP = Low Carbon Power Generation, TWh = terawatt hour.
Source: Author's calculations.

Primary energy consumption

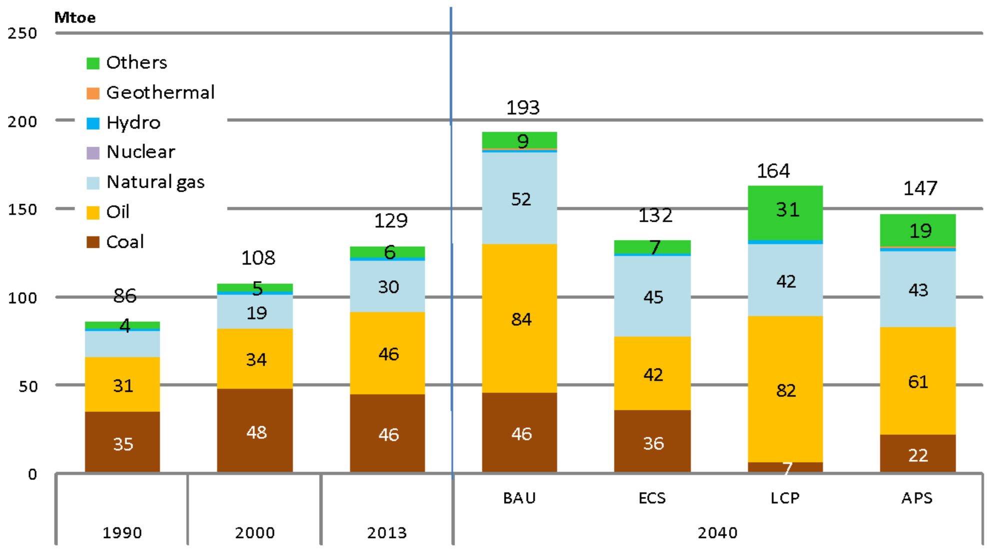
In BAU, total primary energy consumption is projected to reach 193 Mtoe in 2040, a growth of nearly 50% (or 1.5% per year) over the projection period. This compares with average annual growth in primary energy consumption in Australia of 1.8% per year from 1990 to 2013. Oil will increase its presence in Australia's energy consumption, and the share will increase from 36% in 2013 to 44% in 2040 due to increasing demand of the transport sector (see Figure 2A.4). The use of gas (conventional and unconventional natural gas) is expected to grow over the outlook period and increase its share from 23% in 2013 to 27% in 2040 with the growth in consumption of gas in liquefied natural gas production. The consumption of coal will keep the current level, dropping its share from 35% to 24%. Renewable energy consumption is projected to increase at the rate of 1.3% per year over the projection period. The growth in renewable energy is mainly driven by strong growth in wind and solar energy. Meanwhile, the increase of hydropower and biomass energy will be limited.

In ECS, due to the saving of final energy demand and the less power generation, primary energy consumption in 2040 will be 32% lower than that in BAU, slightly up from the 2013 level. The sum of fossil fuel consumption in 2040 will be 1.8 Mtoe, higher than that in 2013. Increased demand of natural gas in industry and liquefied natural gas production will surpass the decreased demand in power generation.

In LCP, primary energy consumption in 2040 will be larger than that in 2013. To offset the increase of oil in final demand, coal in power generation needs to be reduced dramatically, replaced by renewable energy.

In APS, primary energy consumption is projected to grow at a lower rate of 0.5% per year to 147 Mtoe in 2040. Coal is expected to decline at 2.7% per year. Increase of oil and natural gas demand will be moderate compared with BAU, being 1.1% and 1.4% per year, respectively. Renewables energy in 2040 will triple the level in 2013 and double that in BAU.

Figure 2A-4. Primary Energy Consumption and Its Composition



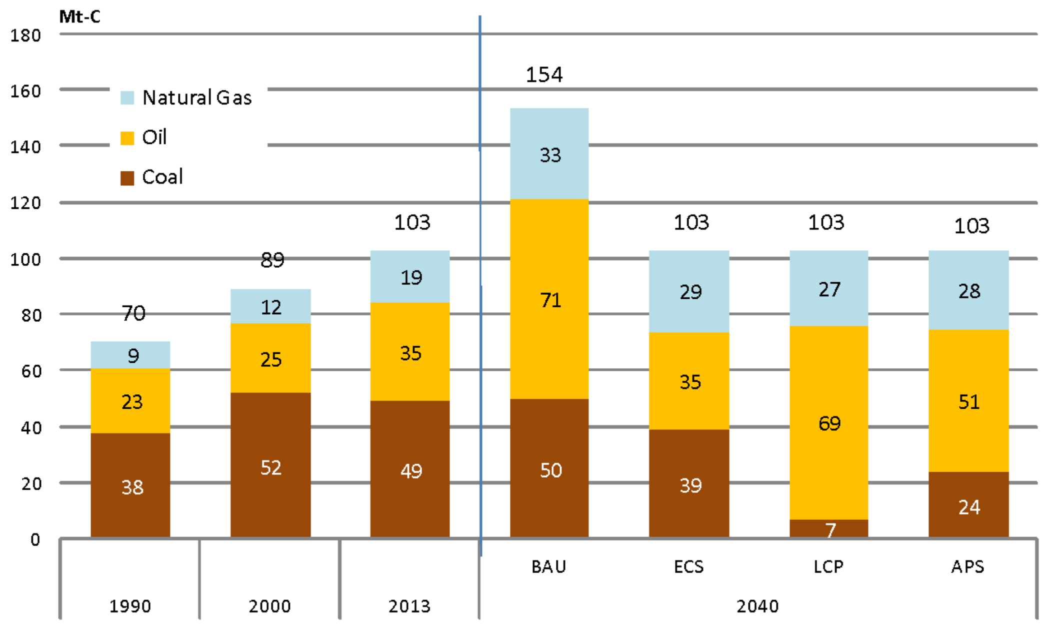
APS = Alternative Policy Scenario, BAU = Business as Usual, ECS = Energy Conservation Scenario, LCP = Low Carbon Power Generation, Mtoe = metric tonne of oil equivalent.
Source: Author's calculations.

CO_2 emissions

CO_2 emissions in BAU will increase by 50% from 103 metric tonnes of carbon (Mt-C) in 2013 to154 Mt-C in 2040 (see Figure 2A.5).

In ECS, CO_2 emissions in 2040 are suppressed to the 2013 level by the stabilisation of oil demand and the shift from coal to natural gas. In LCP, CO_2 emissions from oil consumption will double the 2013 level. However, with the dramatic shift from coal and gas to renewable energy in power generation, total CO_2 emissions in 2040 will eventually be almost the same as that in 2013. In APS, with the conservative assumptions on energy saving in final demand than ECS and the moderate development of renewables compared to LCP, CO_2 emissions in 2040 is also suppressed to the 2013 level.

Figure 2A-5. CO_2 Emissions from Energy Consumption



APS = Alternative Policy Scenario, BAU = Business as Usual, CO_2 = carbon dioxide, ECS = Energy Conservation Scenario, LCP = Low Carbon Power Generation, Mt-C = million tonne of carbon.
Source: Author's calculation.

Conclusions and Implications

The current projections show that Australia's energy consumption will continue to grow over the next 40 years at a lower rate than in the past 20 years. This is because of the substitution of renewables for fossil fuels in electricity generation – which require much less energy use to generate electricity – and because of expected energy efficiency improvements.

Renewables will show significant increase in the next decades, mainly driven by strong growth in wind and solar energy. However, oil and coal will continue to supply the bulk of Australia's energy needs, although the share of coal in the energy mix is expected to decline. The use of gas is expected to grow steadily over the outlook period.

Transition to a low-carbon economy will require long-term structural adjustment in the Australian energy sector. Although Australia has an abundance of energy resources, this transformation will need to be underpinned by significant investment in energy supply chains to allow for better integration of renewable energy sources and emerging technologies into its energy systems. It will be critical to ensure that the broader energy policy framework continues to support cost-effective investment in Australia's energy future, and timely adjustments to market settings in response to emerging pressures and market developments.

References

Syed, A. (2016), *Australian Energy Government Projections to 2050*. Jakarta: Economic Research Institute for ASEAN and East Asia.

Council of Australian Government (2009), *National Strategy on Energy Efficiency*. https://www.gbca.org.au/uploads/56/2360/Energy_efficiency_measures_table.pdf (accessed 24 April 2017)

CHAPTER 2B.Cambodia's Case Study
Keeping CO_2 Emissions at 2013 Level by 2040

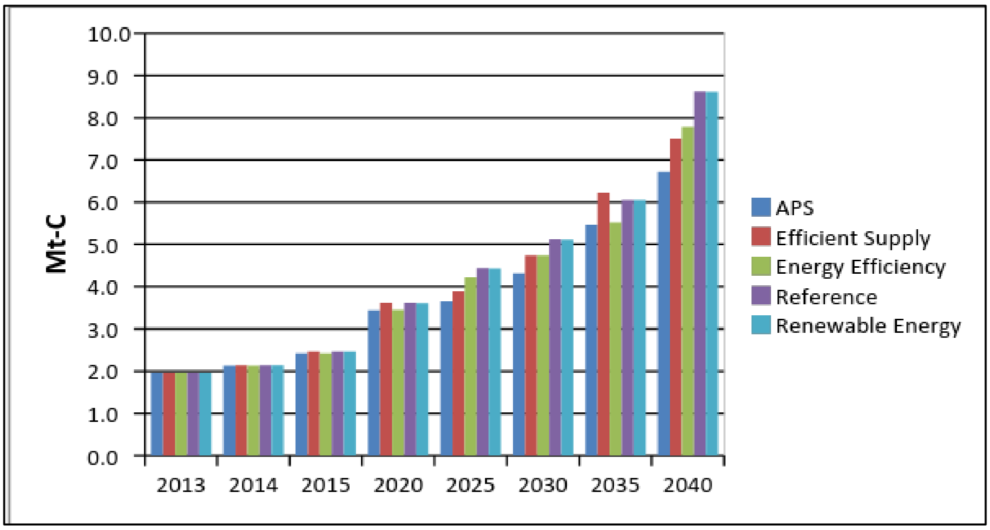
1. Background

The Energy Outlook and Energy Saving Potential in East Asia 2016 by the Economic Research Institute for ASEAN and East Asia (ERIA) projects an increasing energy demand in the Alternative Policy Scenario (APS) and the Business as Usual (BAU) scenario. As a result, total carbon dioxide (CO_2) emissions will also increase in the future.

APS is a combination of different scenarios. In the case of Cambodia, the scenarios include reference (BAU), energy efficiency (APS1), renewable energy (APS2), efficient supply (APS3), and alternative policy (APS).

For the BAU scenario (Figure 2B.1), Cambodia's total CO_2 emissions were around 2 metric tonnes of carbon (Mt-C) in 2013 (base year) and projected to reach almost 9 Mt-C by 2040.

Figure 2B.1. CO_2 Emissions of Cambodia in ERIA's Outlook 2016



APS = Alternative Policy Scenario, CO_2 = carbon dioxide, ERIA = Economic Research Institute for ASEAN and East Asia, Mt-C = metric tonne of carbon.
Source: Author's calculations.

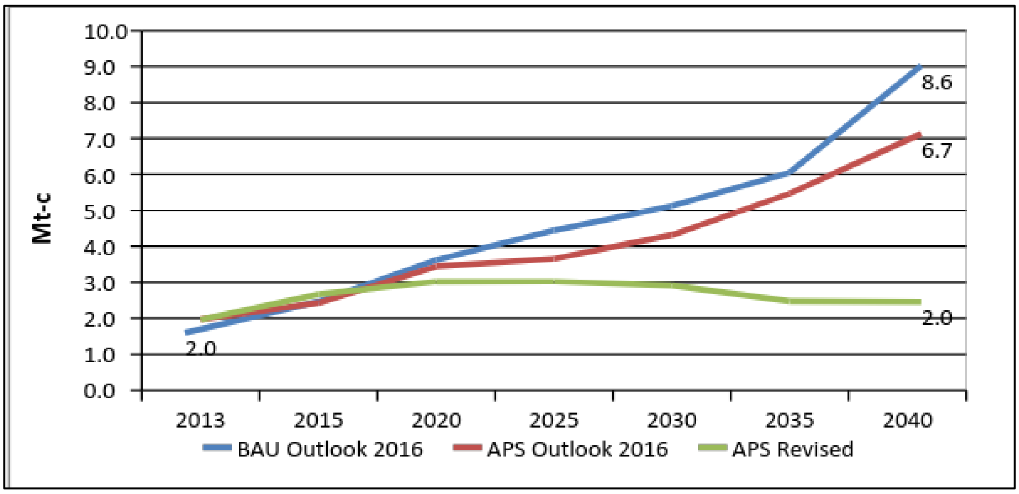
Assuming implementation of more efficient technology in the final and supply sector and higher penetration of renewable energy, total CO_2 emissions will only increase to around 7 Mt-C by 2040. Thus, implementing APS will result in a 22-% reduction of CO_2 emissions in 2040 as compared to the BAU scenario.

This case study is to identify possible solutions to mitigate CO_2 emissions in 2040 to the 2013 level. Since APS has the lowest CO_2 emissions, this scenario will be the basis for the case study.

2. Methodology

The APS consists of APS1, APS2, and APS3. Implementing APS still results in an increase of CO_2 emissions in 2040 compared to the base year 2013. To ensure that the total CO_2 emissions remain at the 2013 level (Figure 2B.2), more efforts will be needed to achieve national development target without increasing CO_2 emissions from its base year level.

Figure 2B.2. CO_2 Emissions Comparison



APS = Alternative Policy Scenario, BAU = Business as Usual, CO_2 = carbon dioxide, Mt-C = metric tonne of carbon.
Source: Author's calculations.

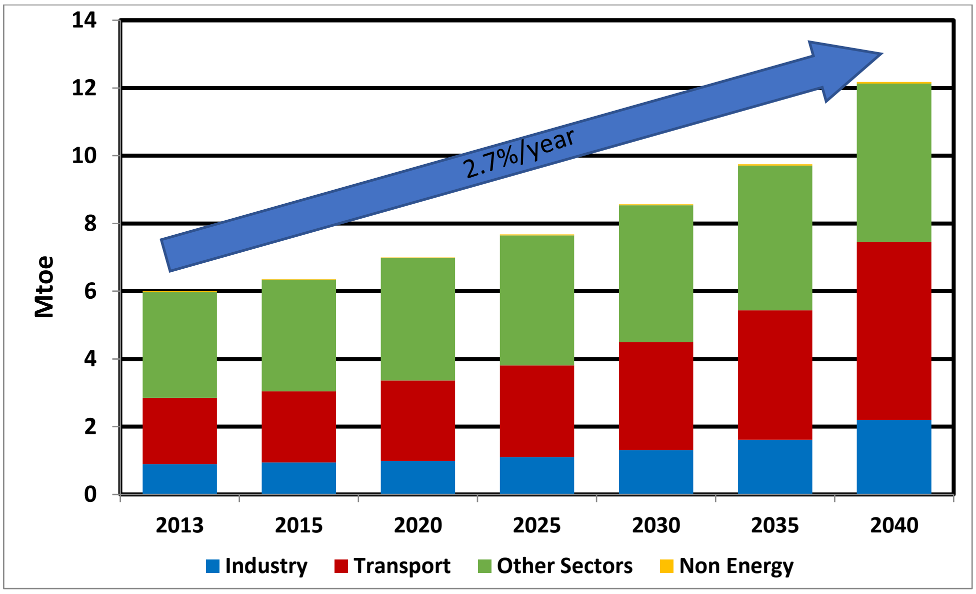
The parameters to consider would be energy saving in the final consumption sector, high-efficient thermal power plants, hydropower and geothermal resources, solar/photovoltaic (PV) and wind resources, and other renewable energy.

The approach for the exercise will be to make energy efficiency targets more stringent; use less fossil fuels and more renewable energy; increase use of biofuels such as biogasoline (bioethanol), biodiesel, and biogas; limit use of fossil fuels in the power sector; and increase use of renewables for power generation.

3. Final Energy Demand

In the ERIA's Energy Outlook and Energy Saving Potential in East Asia 2016, (Energy Outlook 2016), the final energy demand of Cambodia under APS will be growing at an average rate of 2.7% over the 2013–2040 period (Figure 2B.3).

Figure 2B.3. Final Energy Demand in ERIA's Outlook 2016 APS

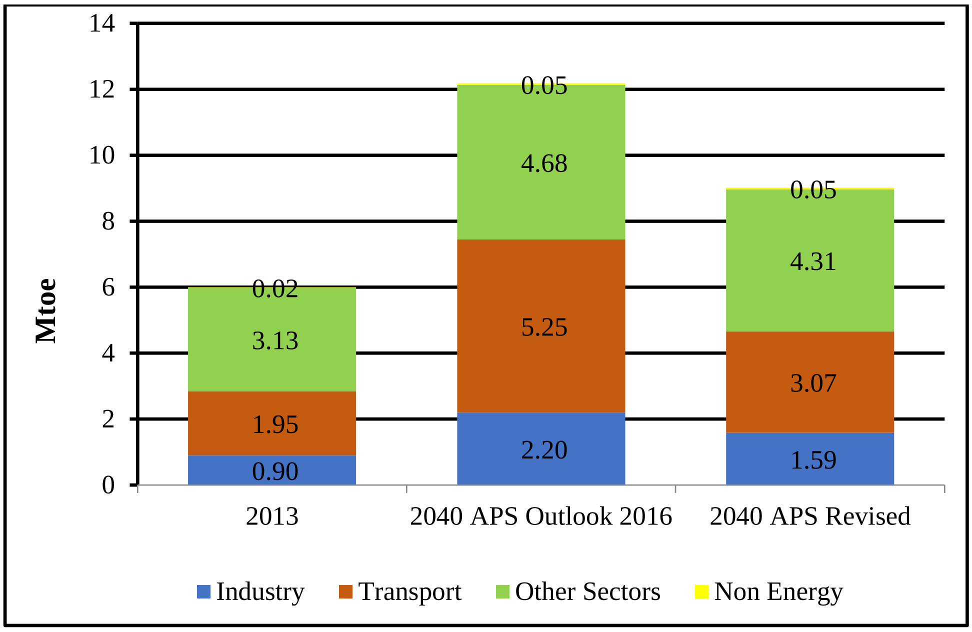


APS = Alternative Policy Scenario, ERIA = Economic Research Institute for ASEAN and East Asia, Mtoe = metric tonne of oil equivalent.
Source: Author's calculations.

Revising the assumption for energy efficiency (EE) and increased use of biofuels will slow down the increase of the final energy demand. The final energy demand of the revised APS will grow at an average annual rate of 1.5% per year over the 2013–2040 period. Revising the EE target will reduce the total final energy demand of 2040 by almost 26% the level of the APS in the ERIA's Energy Outlook 2016 (Figure 2B.4).

The use of biofuels will be increasing since the assumption was revised especially in the transport sector. Biogas for households is also assumed to increase more in the revised APS.

Figure 2B.4. Final Energy Demand Comparison

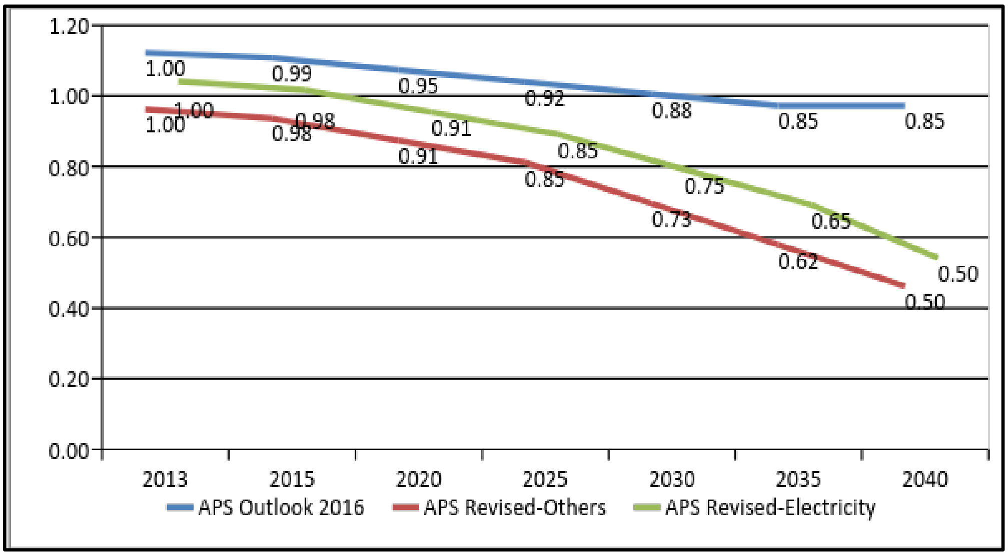


APS = Alternative Policy Scenario, Mtoe = metric tonne of oil equivalent.
Source: Author's calculations.

4. EE Targets

The EE target for electricity and others in the ERIA's Energy Outlook 2016 APS is assumed to be 15% by 2040. In the revised APS, the target is more stringent. Around 50% saving target is assumed for both electricity and other fuels (Figure 2B.5).

Figure 2B.5. EE Targets



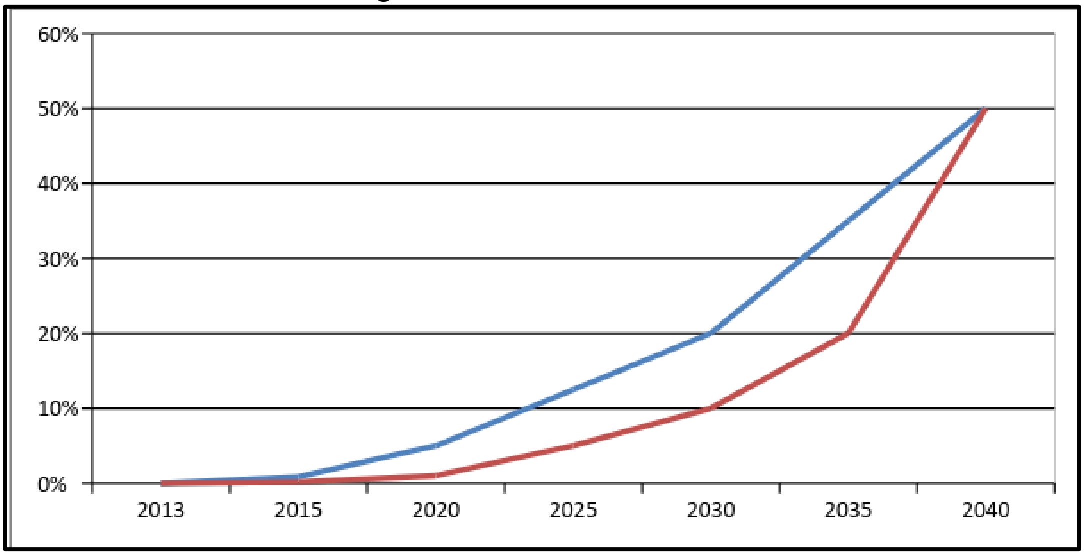
APS = Alternative Policy Scenario, EE = Energy Efficiency

Source: Author's calculations.

Biofuel Penetration

Beside the EE target, biofuel penetration is included in the revised APS. In the APS of the ERIA's Outlook 2016, no penetration of biofuel is assumed. It is assumed that the penetration of biofuel in the revised APS will reach 50% by 2040 for both biodiesel and biogasoline (Figure 2B.6).

Figure 2B.6. Biofuel Penetration



Source: Author's calculations.

Power Generation

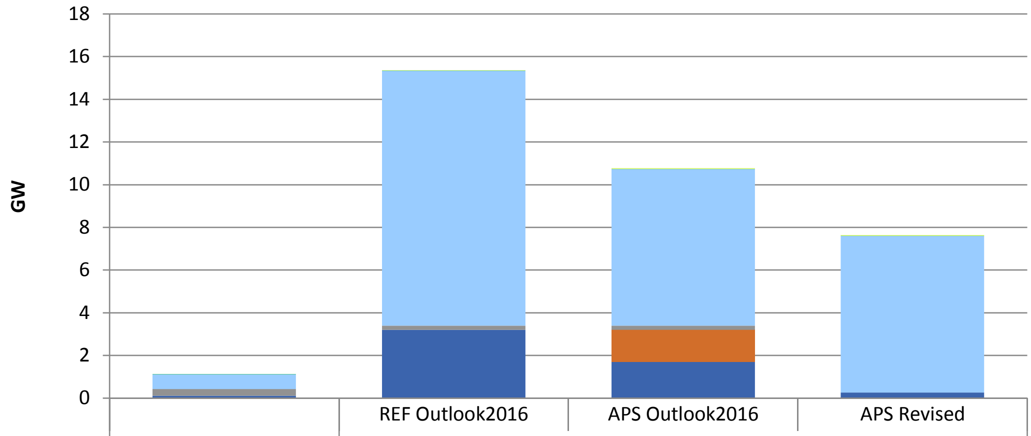
The parameters in the power generation sector of the LEAP (Long-range Energy Alternatives Planning) model include dispatch rule, merit order, efficiency, maximum availability, exogenous capacity, etc., most of which are similar to that of APS in the ERIA's Energy Outlook 2016. The difference is in the capacity expansion of the various power plants. In the revised APS, more renewable energy capacities are being assumed for the future.

Capacity

As shown in Figure 2B.7, the total capacity in APS of the ERIA's Energy Outlook 2016 is around 11 gigawatts (GW) in 2040 while it is lower (almost 8 GW) in the revised APS. An assumption is made on the expansion of fossil fuels in the revised APS so as to achieve

CO_2 emissions by 2040 similar to the 2013 level.

Figure 2B.7. Total Capacity (GW)



	2013	2040 REF Outlook2016	2040 APS Outlook2016	2040 APS Revised
Biogas	-	-	0.01	0.01
Natural Gas	-	-	-	-
Solar	-	0.01	0.01	0.01
Biomass	0.01	0.02	0.02	0.02
Hydro	0.68	11.94	7.34	7.34
Oil SPP	-	-	-	-
Oil	0.33	0.19	0.19	-
Coal New	-	-	1.50	-
Coal	0.11	3.20	1.70	0.26

GW = gigawatt.
Source: Author's calculations.

In the case of coal power plants, no additional expansion is assumed except the one planned in 2015 (258 MW). In addition, the existing 110-MW coal power plants are assumed to be retired in 2040.

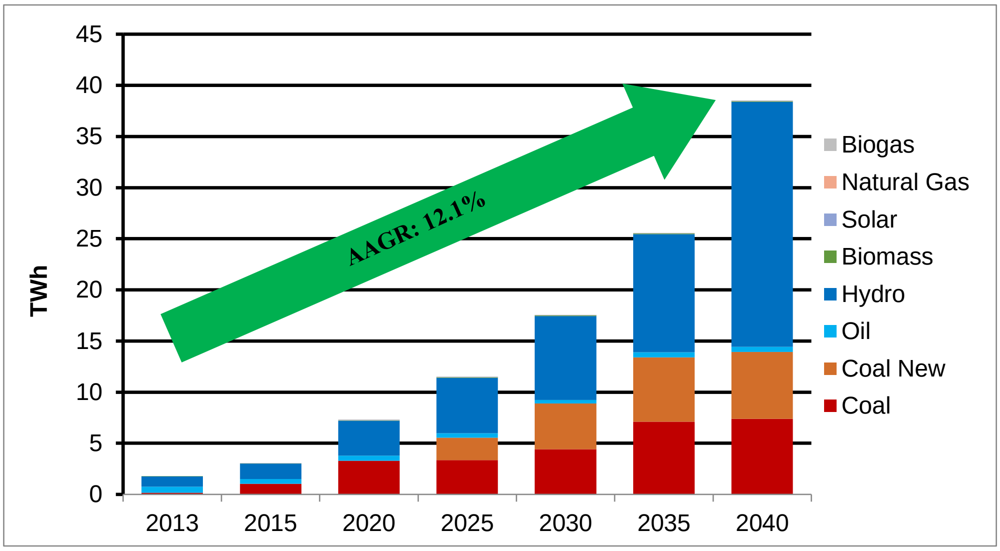
There is also no expansion assumed for oil power plants and that the existing plants will gradually be retired by 2030.

In the case of renewable power plants, the expansion assumed in APS of the ERIA's Energy Outlook 2016 will still be the same in the revised APS. Thus, hydropower plants will dominate the total capacity in 2040. Biomass and solar and wind energy plants capacities will be small (20 MW for wind power and 10 MW for solar energy and biomass, respectively).

Power generation

The revised APS generation of electricity will be around 23 TWh in 2040, lower than the 38 TWh generated in APS of the ERIA's Energy Outlook 2016 (Figures 2B.8 and 2B.9). The average annual growth rate of electricity production in ERIA's Energy Outlook 2016 APS is 12.1% while in the revised APS, the rate is slower, at 9.9% per year.

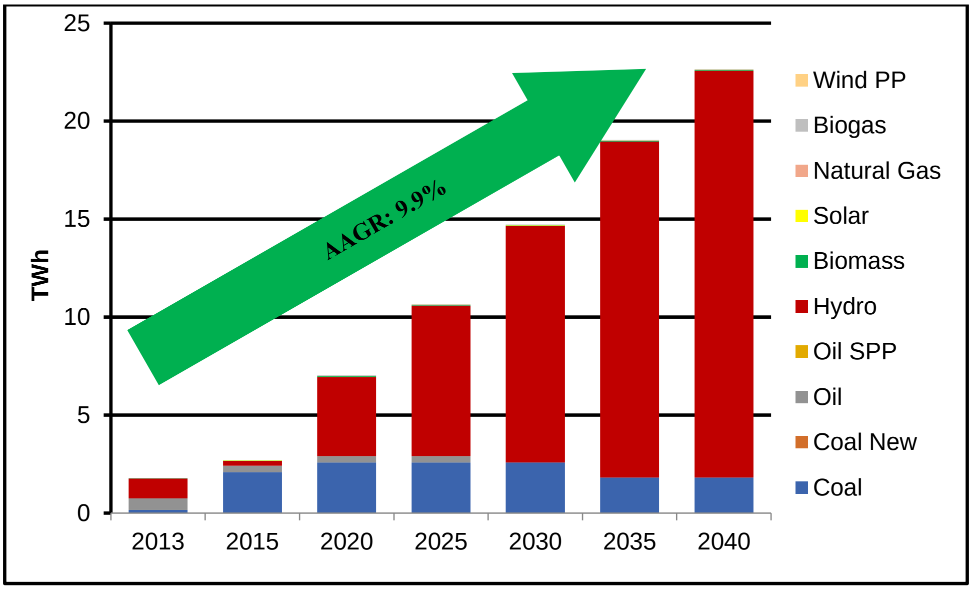
Figure 2B.8. Power Generation by Type in APS Outlook 2016



AAGR = Average Annual Growth Rate , APS = Alternative Policy Scenario, TWh = terawatt hour.
Source: Author's calculations.

Since the target is to achieve CO_2 emissions in 2040 to the same level as that of in 2013, the renewable generation in the revised APS will account for almost 92% of the total generation. In ERIA's Energy Outlook 2016 APS, the renewable share in total generation is around 62%. Generation from hydropower plants dominates the total generation of renewable energy for both APSs.

Figure 2B.9. Power Generation by Type in APS Revised

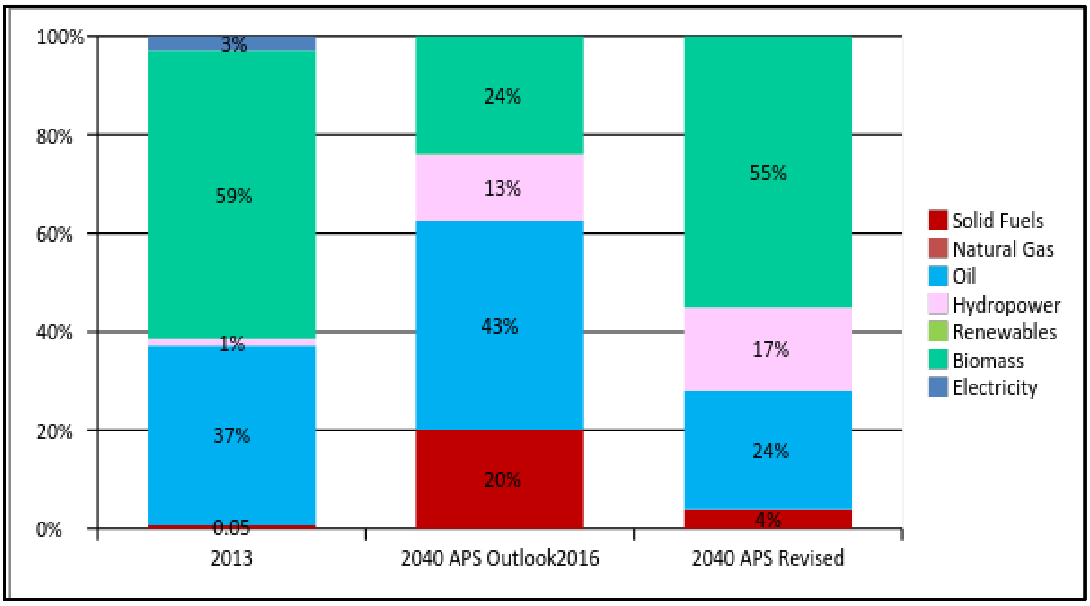


AAGR =Average Annual Growth Rate, PP = power plants, SPP =, TWh = terawatt-hour.
Source: Author's calculations.

Primary Energy Supply

With revised EE target, biofuel penetration, and increased share of renewable energy in the power sector, the total primary energy supply of the revised APS will be around 10 Mtoe in 2040. The total primary energy supply of the revised APS in 2040 is 32% lower than the total primary energy supply in APS of the ERIA's Energy Outlook 2016 (Figure 2B.10). In terms of the share in the total energy mix of 2040, 72% comes from renewable energy including biomass and hydropower.

Figure 2B.10. Primary Energy Supply

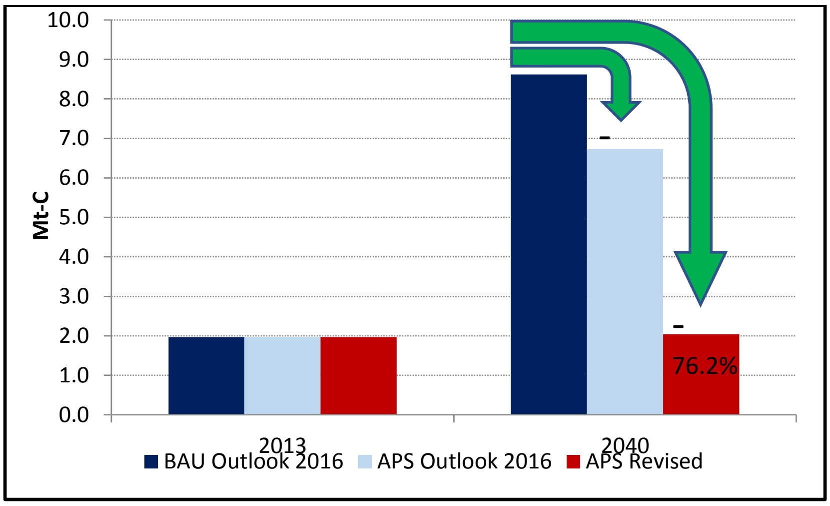


APS = Alternative Policy Scenario.
Source: Revised LEAP model outcome.

CO_2 Emissions

The resulting CO_2 emissions of the revised APS in 2040 (3.7 Mt-C) is 76% lower than the level in APS of the ERIA's Energy Outlook 2016, which is 10.7 Mt-C (Figure 2B.11).

Figure 2B.11. CO_2 Emissions Reduction by 2040



APS = Alternative Policy Scenario, BAU = Business as Usual, CO_2 = carbon dioxide, Mt-C = metric tonne of carbon.
Source: Author's calculations.

Conclusion

ERIA's Energy Outlook 2016 results in total CO_2 emissions of almost 8.6 Mt-C by 2040 for the BAU scenario and 6.7 Mt-C for APS. For the total CO_2 emissions in 2040 to have the same level as the base year (3.7 Mt-C), efforts imposed in APS of the ERIA's Energy Outlook 2016 have to be more stringent in the revised APS.

Revising the EE target, the biofuel penetration, and increasing the share of renewables in power generation have made it possible for the total CO_2 emissions of the revised APS to be similar to the base year level. The CO_2 emissions reduction in the APS of the ERIA's Energy Outlook 2016 is around 22% by 2040, while the revised APS will result in a 76% reduction compared to the BAU scenario.

CHAPTER 2C. India's Country Report[1]

Keeping CO_2 Emissions at 2013 Level by 2040

1. Energy situation

India is currently the fourth largest consumer of primary energy in the world after China, USA, and Russia. Its primary energy consumption per capita (toe/person) has grown at an annual rate of 2.5% from 0.35% in 1990 to 0.62% in 2013 (IEA, 2015; TERI, 2016).

India's total primary energy consumption grew at an annual rate of 4.1% from 306.62 million tonnes of oil equivalent (Mtoe) in 1990 to 775.45 Mtoe in 2013. Between 1990 and 2013, the annual growth rates of primary energy consumption from the various sources of energy were: coal, 5.8%; oil, 4.7%; natural gas, 6.4%; nuclear power, 7.8%; hydropower, 3.0%; and solar and wind power, 29%. In 2013, coal was the dominant source of primary energy and about 341.38 Mtoe of coal were consumed. This represents 44% of the total primary energy consumed in that year. This was followed by biomass and oil with shares of 24.3% and 22.7%, respectively. Natural gas had a share of 5.7% while other sources of energy had shares of approximately 28% (IEA, 2015).

India's final energy demand has been increasing over the years. Its total energy demand grew at an annual rate of 3.4% from 243.49 Mtoe in 1990 to 528.34 Mtoe in 2013. Within the same period, the industry sector grew at an annual rate of 4.4%, transportation at 5.7% while other sectors grew at 2.3%. The final energy demand from the non-energy sector grew at an average annual rate of 4.5%. In 2013, the share of the industrial sector in the total energy demand was 33.9%, the transportation sector had share of 14% while other sectors had shares of 45.1%. The non-energy sector's share in the final energy demand was only 6.9% (IEA, 2015).

With respect to power generation, India has made a giant stride in increasing its power generation output. As of March 2015, India had a total installed power capacity of 271 gigawatts (GW) which represents an increase of around 11% during 2014–2015. Power generation is mainly from thermal plants and coal-fired plants that make up about 87% of the entire thermal plants in the country. For electricity consumption, the industry sector accounts for the highest share with 35%, followed by the household sector with 26% and agriculture with 21%.

India's total carbon dioxide (CO_2) emissions from fossil fuel combustion have also been on the rise in the last 2 decades. This can be akin to the use of coal, oil, and natural gas for electricity

[1] Based on model run and broad assumptions by the Institute of Energy Economics, Japan (IEEJ).

generation, transportation, and other economic activities. CO_2 emissions from fossil fuel combustion have increased from 794.0 million tonnes of carbon dioxide (Mt-CO_2) in 1998 to 2019.7 Mt-CO_2 in 2014 or about 154% increase. CO_2 emission from coal was the highest due to the high reliance on coal for power generation. In 2014, CO_2 emission from coal was 1492.9 Mt-CO_2; oil, 468.2 Mt-CO_2; and gas, 57.3 Mt-CO_2. In terms of sectoral CO_2 emissions, emission from electricity generation was the highest in 2014 with 1046.6 Mt-CO_2, followed by manufacturing and construction industries with emissions of 533.4 Mt-CO_2. Emissions from the transport sector, other sectors, and other energy industry use were 231.8 Mt-CO_2, 171.8 Mt-CO_2, and 36.2 Mt-CO_2, respectively (IEA, 2016).

2. Modelling Assumptions

Macro-economic assumptions

It is assumed that India's gross domestic product (GDP) will continue to grow robustly at a rate of 6.5% from 2013 to 2040 due to increase in workforce population, improved quality of labour force, opening up of the market, and growing foreign direct investment. By 2040, India is poised to become the third largest economy in the world.

With its population assumed to grow at an annual rate of 0.9%, India's total population will reach 1.6 billion in 2040 to become the world's most populous country.

In 2040, India's GDP per capita will reach US$5,200 (2005 constant price) or 4.3 times higher than that in 2013.

Business as Usual (BAU) scenario

It is assumed that in the future electricity supply, the share of coal in electricity generation will continue to be the largest. The shares of nuclear power and others, especially wind and solar power, are projected to increase by 2040, whereas the shares of oil and hydropower are expected to fall.

Case setting for mitigating CO_2 emissions by 2040

Building on the Alternative Policy Scenario (APS) developed a year ago, three cases have been established for CO_2 emissions mitigation.

Assumptions across APS are:

APS 1: The assumptions made in this scenario are energy-saving measures in the final demand. This is achieved by introducing the best available technologies in the industry sector, improved vehicle fuel economy and introduction of hybrid electric vehicles, plugin hybrid electric vehicles, electric vehicles, and fuel cell vehicles in the transport sector, and the use of efficient appliances in the household sector.

APS 3: This scenario assumes further development of renewable energy resources like wind energy, solar photovoltaic (PV) system, hydropower, and biofuels.

APS 4: This scenario assumes a further development of nuclear energy in the power sector.

APS 5: This scenario assumes a combination of APS 1, APS 3, and APS 4.

The main assumptions for three cases are as follows:

Case 1: This case considers dramatic energy conservation by increasing efficiency in the final energy demand. The case assumes that APS1 will quadruple.

Case 2: This case looks at zero emission in the power sector by increasing the share of non-fossil fuels in the power generation. The case assumes that the sum of APS3 and APS4 will be tripled.

Case 3: Full mitigation is considered in this case through enhancing APS5. Thus, this case assumes a compromised combination of case 1 and case 2 scenarios. It is worth mentioning that the aim of case 3 is to suppress the CO_2 emissions in 2040 under the 2013 level by back casting, so there are no detailed realistic technologies and policies which are assumed.

The case settings are further summarised in Table 1C.1.

Table 1C.1. Case Settings for CO_2 Mitigation by 2040

	Case①	**Case②**	**Case③**
Final energy demand	<< APS1 <BAU	= BAU	<APS1< BAU >Case①
Low carbon power generation	= BAU	Zero emission power	>APS3 + APS4 < Case②

APS = Alternative Policy Scenario, BAU = Business as Usual, CO_2 = carbon dioxide.
Source: Author's assumptions.

3. Outlook Results

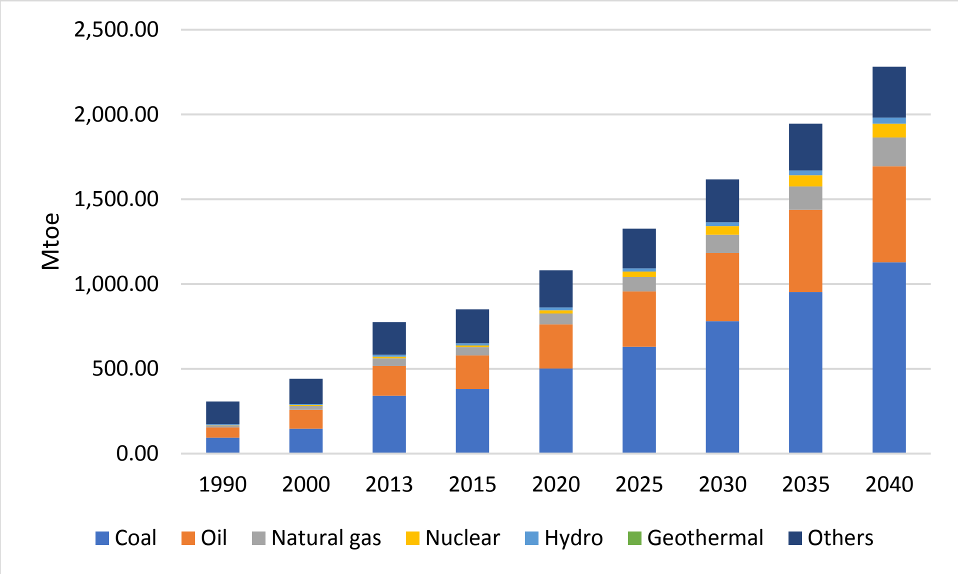
Results of BAU

Primary energy supply

Under the BAU scenario, primary energy consumption is expected to increase and grow at an annual rate of 4.1% from 775.45 Mtoe in 2013 to 2,281.14 Mtoe by 2040 (Figure 1C.1). During this period, the average annual rate of coal consumption grew by 4.5% and oil by 4.4%. Natural gas and nuclear energy grew by 5.1% and 8.5%, respectively. Hydropower consumption also experienced a growth increase of 4.0% while solar, wind, and ocean energy consumption grew at 9.6%.

Also, in 2040, coal will have the dominant share of total primary energy consumption with 49.5%, followed by oil with 24.8%. Biomass energy (others) consumption will have a share of 11.2% while natural gas will have 7.5%.

Figure 1C.1. Total Primary Energy Supply in BAU



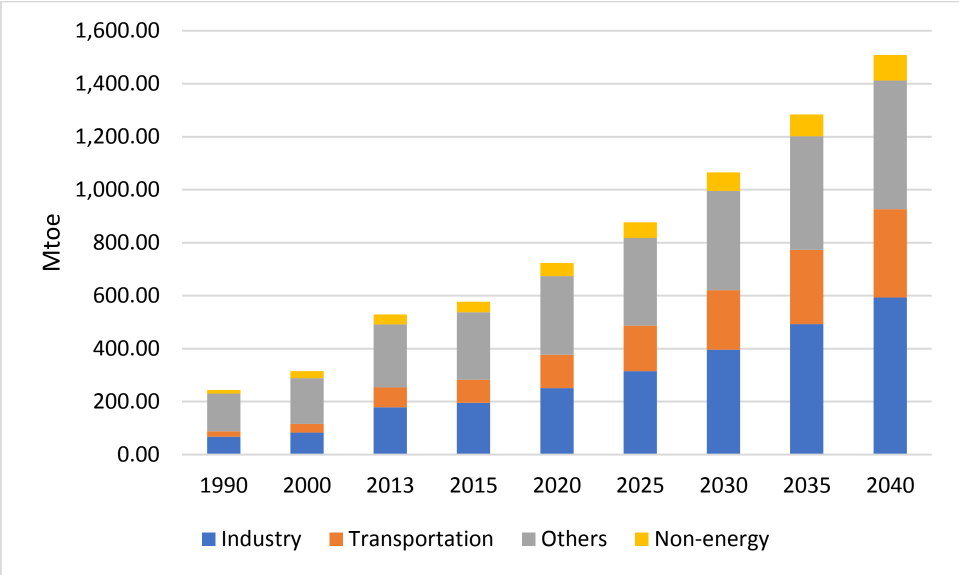
BAU = Business as Usual, Mtoe = million tonne of oil equivalent.
Source: Author's calculations.

4. Final Energy Demand

In the BAU scenario, total sectoral final energy demand is expected to increase by an annual rate of 4% from 528 Mtoe in 2013 to 1508 Mtoe in 2040 (Figure 2C.2). Energy demand in the industry sector increased from 179 Mtoe in 2013 to 593 Mtoe in 2040. The industry sector contributes the largest to total final energy demand in 2040 with a share of 39.3%. The transport sector final energy demand increased from 75 Mtoe in the base year to 334 Mtoe in 2040. This represents a share of 22% in the total final energy demand in 2040. The final energy demand of the other sectors and non-energy use also witnessed increase of 238 Mtoe and 36 Mtoe in 2013 to 486 Mtoe and 96 Mtoe, respectively, by 2040.

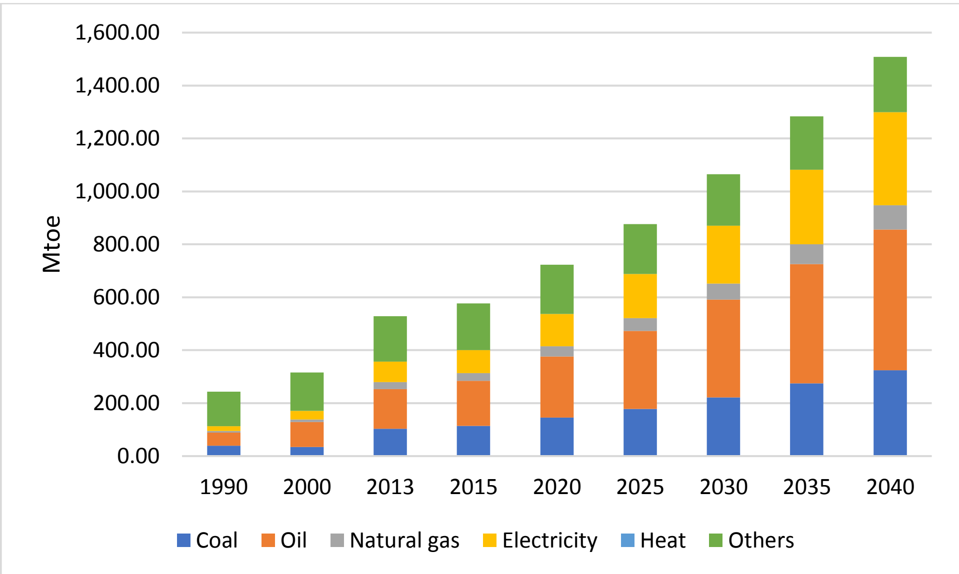
In view of the final energy demand of different sources of energy, it is observed that during 2013 to 2040, electricity demand will grow at a rate of 5.8%, coal will grow at 4.3%, and oil by 4.8%. The demand for natural gas and others will also grow at rates of 4.7% and 0.7%, respectively. The results further show that by 2040, the demand for oil will be the largest with a share of 35.2%, followed by electricity with a share of 23.3%. The final energy demand for coal by 2040 will be 324.71 Mtoe, which represents a share of 21.5% in the total final energy demand (Figure 2C.3).

Figure 2C.2. Sectoral Final Energy Demand in BAU



BAU = Business as Usual, Mtoe = metric tonne in oil equivalent.
Source: Author's calculations.

Figure 2C.3. Final Demand of Energy Sources in BAU



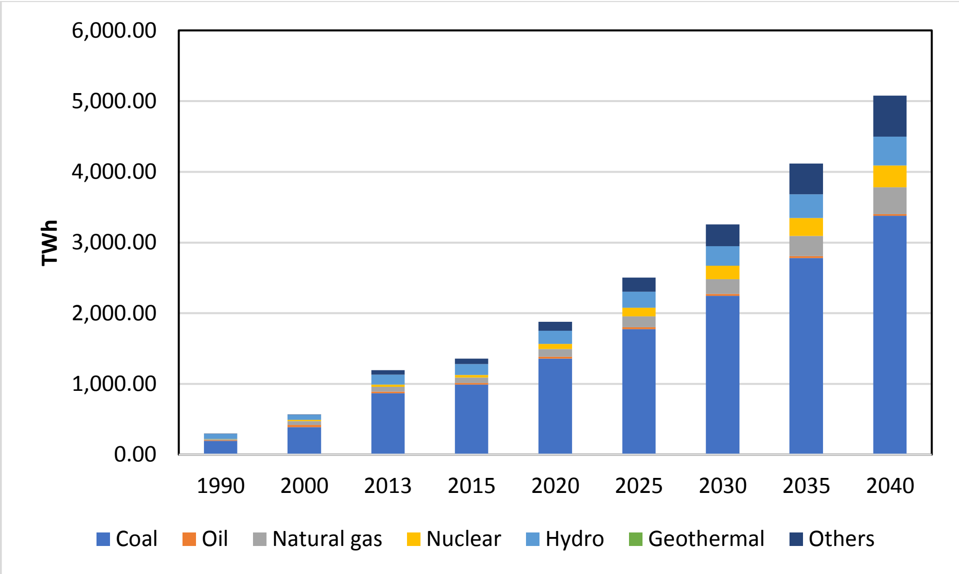
BAU = Business as Usual, Mtoe = million tonne in oil equivalent.
Source: Author's calculations.

5. Power Generation

Total power generation is expected to increase at an annual rate of 5.5% from 1,193 terawatt hours (TWh) in 2013 to 5,077 TWh by 2040 (Figure 2C.4). Coal continues to dominate the Indian electricity generation mix as the power generated from coal increased at a rate of 5.2% from 869 TWh in 2013 to 3,377 TWh in 2040. Generation from hydropower also increased at an annual rate of 4% during the same period from 141.64 TWh to 408 TWh. Also, power generation from oil, natural gas, nuclear power, and others grew at annual rates of 0.2%, 6.8%, 8.5%, and 8.7% respectively.

Owing to the high reliance on coal for power generation, the share of coal in the power generation mix in 2040 is the highest with 66.5%, followed by 'others' with 11.4%, then hydro with 8.0%. Oil, natural gas, and nuclear power will have shares of 0.5%, 7.5%, and 6.1%, respectively, in 2040.

Figure 2C.4: Power Generation Output in BAU

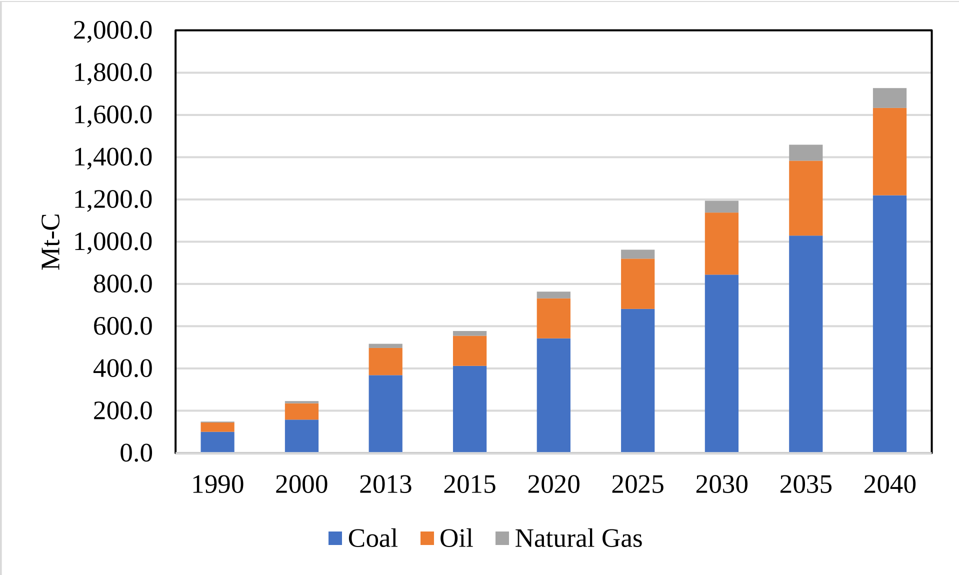


BAU = Business as Usual, TWh = terawatt hour.
Source: Author's calculations.

CO_2 Emissions

In BAU, total CO_2 emissions grew from 516.7 million tonnes of carbon (Mt-C) in 2013 to 1,726.6 Mt-C in 2040 which is around 4.6% annual growth during this period (Figure 2C.5). Much of the emissions is observed to be from coal which grew at an annual rate of 4.5% from 368.7 Mt-C in 2013 to 1,219.3 Mt-C in 2040. Also, emissions from oil and natural gas grew at rates of 4.4% and 6.0% from 128.3 Mt-C and 19.6 Mt-C in 2013 to 413 Mt-C and 94 Mt-C in 2040, respectively. The shares of emissions from coal, oil, and natural gas in 2040 are 70.6%, 23.9%, and 5.4%, respectively.

Figure 2C.5. CO_2 Emissions in BAU



BAU = Business as Usual, CO_2 = carbon dioxide, Mt-C = metric tonne of carbon.
Source: Author's calculations.

Energy reduction and CO_2 mitigation in the case scenarios

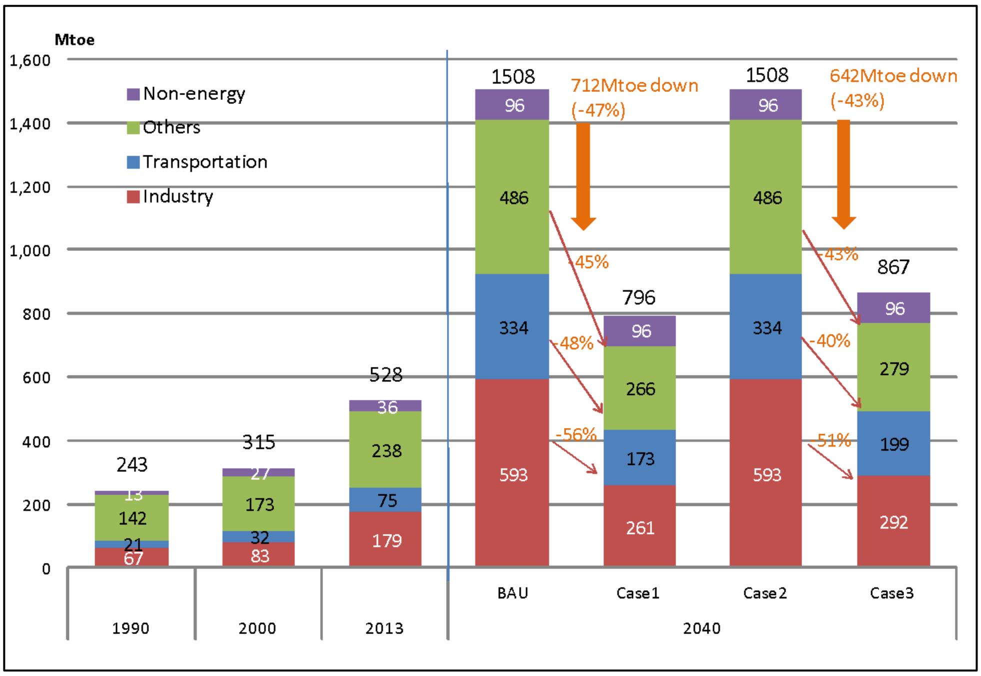
Final energy demand

With the implementation of case 1 which represents a strong practice of energy efficiency and conservation, energy demand by 2040 will be 796 Mtoe (Figure 2C.6). This is a drop by 47% which corresponds to a reduction of 712 Mtoe by 2040 relative to BAU. The percentage of energy demand reduction is observed to be largest in the industry sector with a drop of 56% which is equivalent to 332 Mtoe reduction relative to BAU. This great reduction of energy demand is due to the use of energy-efficient machineries and the gross practice of energy conservation in the industry sector. With the introduction of fuel-efficient and economic vehicles in the transportation sector, strong reduction was also recorded and energy demand reduced to 173 Mtoe which is equivalent to 48% reduction compared to BAU. Strong reduction was also observed in the other sectors. Final energy demand reduced by 45% which amounts to 266 Mtoe by 2040. The final energy demand of the non-energy use sector remains constant at 96 Mtoe.

Under case 2, final energy demand remains constant as in BAU scenario which has already been highlighted.

In case 3 scenario, final energy demand is expected to be 867 Mtoe by 2040. This implies a 43% reduction in energy demand which is equivalent to 642 Mtoe compared to BAU. Sustaining the efforts on energy efficiency practices, the industry sector continues to remain with the greater share of percentage reduction. Final energy demand in the industry sector is expected to be 292 Mtoe by 2040 which is a drop of 51% relative to case 2 and BAU scenarios. The final energy demand in other sectors is also expected to fall by 43% to 279 Mtoe. The transport sector also has a reduction of 40% which is equivalent to 199 Mtoe in the final energy demand.

Figure 2C.6. Final Energy Demand in Cases 1-3



BAU = Business as Usual, Mtoe = million tonne of oil equivalent.
Source: Author’s calculations.

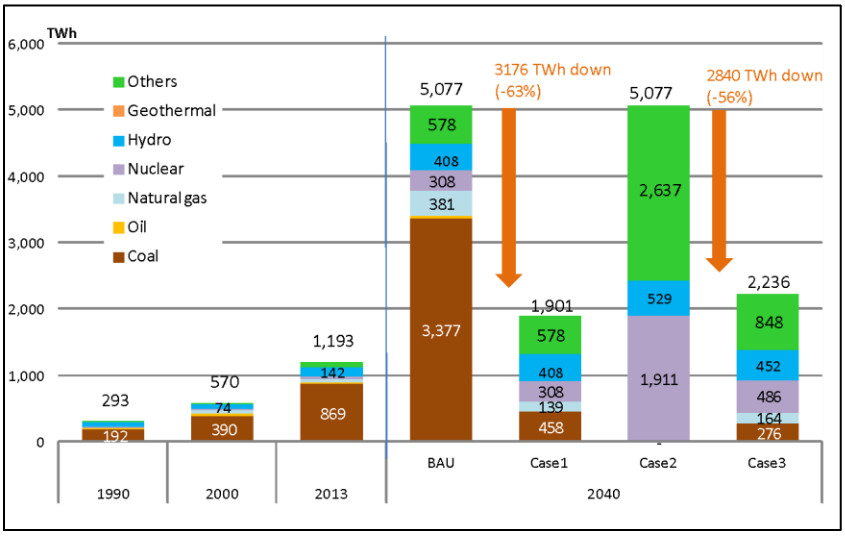
Power Generation

Under case 1, total power generation will increase at an annual rate of 1.7% from 1,193 terawatt hour (TWh) in 2013 to 1901 TWh in 2040 (Figure 2C.7). This represents a 63% decrease in total power generation or 3176 TWh relative to BAU. In an attempt to decarbonie the power sector, power generation output from coal will be 458 TWh in 2040, which is equivalent to 2919 TWh or 86% reduction compared to BAU. Also, power generation from natural gas is expected to drop in 2040 by 242 TWh which is approximately a 64% decrease compared to BAU. Power output from oil is also expected to fall by 16 TWh. Power generation from nuclear power, hydropower, and ‘others’ energy stand at 308 TWh, 408 TWh, and 578 TWh, respectively, in 2040 which is the same as in the BAU scenario.

In case 2, power generation will increase from 1,193 TWh in 2013 to 5,077 TWh in 2040, which is approximately a 5.5% annual increase just as in the case of BAU. In this scenario, it is assumed that by 2040, the power sector is fully decarbonied, thus the share of coal, oil, and natural gas in the electricity mix will be negligible or equivalent to zero. Power generation from 'others' is expected to be the highest at 2,637 TWh, which is about 2059 TWh increase compared to BAU. Nuclear power and hydropower generation is also expected to increase in 2040 to 1,911 TWh and 529 TWh, respectively. This represents an increase of 1603 TWh and 121 TWh in nuclear power and hydropower generation, respectively, when compared to BAU.

In case 3, power generation is expected to increase at a rate of 2.4% annually from 1,193 TWh in 2013 to 2,236 TWh in 2040. This represents a decline in power generation in 2040 by 56% or 2840 TWh compared to BAU. In 2040, combining case 1 and case 2 as depicted in case 3 scenario shows that power generation from 'others' will be the maximum which is 848 TWh, an increase of 270 TWh relative to BAU. This scenario also suggests that hydropower and nuclear power generation will increase to 452 TWh and 486 TWh which corresponds to an increase of 44 TWh and 178 TWh, respectively, when compared to BAU. It was further observed that power output from coal will drastically decline to 276 TWh, which is about 3101 TWh reduction relative to BAU. The output from natural gas and oil also declined by 217 TWh and 14 TWh, respectively, when compared to BAU.

Figure 2C.7. Power Generation in Cases 1-3



BAU = Business as Usual, TWh = terawatt hour.
Source: Author's calculations

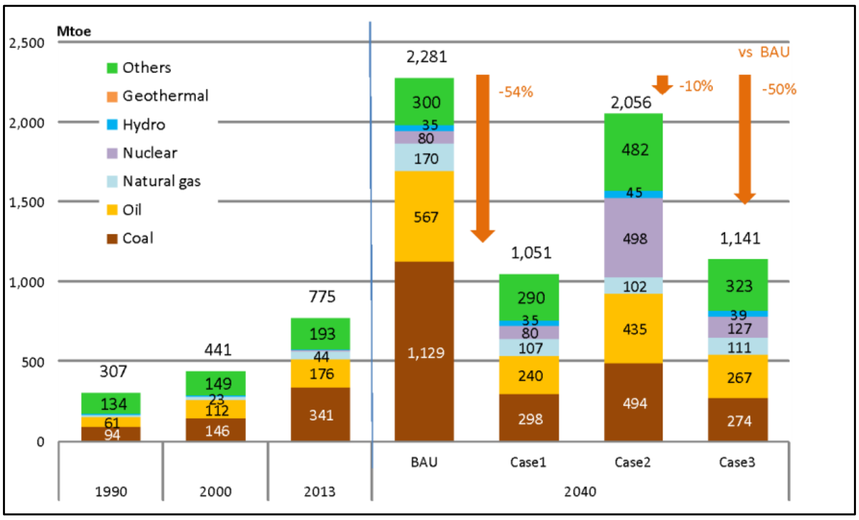
Primary Energy Supply

In case 1, total primary energy supply increased from 775 Mtoe in 2013 to 1,051 Mtoe in 2040 (Figure 2C.8). This represents a decrease of 54% compared to BAU. In 2040, much of the decrease was observed to come from coal. The consumption of coal, oil, and natural gas is 298 Mtoe, 240 Mtoe, and 107 Mtoe, respectively, which is equivalent to reductions of 831 Mtoe, 327 Mtoe, and 63 Mtoe, respectively, when compared to BAU. Also, the 'others' consumption reduced to 290 Mtoe or 10 Mtoe reduction relative to BAU. However, the consumption of nuclear power and hydropower remains constant at 80 Mtoe and 35 Mtoe, respectively, just as in BAU.

Under case 2, total energy consumption will increase from 775 Mtoe in 2013 to 2,056 Mtoe in 2040. When compared to BAU in 2040, this is just a 10% decrease in energy consumption. Owing to the efforts to keep a low-carbon economy, the consumption of coal, oil, and natural gas will decline to 494 Mtoe, 435 Mtoe, and 102 Mtoe, respectively, which represents a reduction of final energy consumption by 635 Mtoe, 132 Mtoe, and 5 Mtoe, respectively, relative to BAU. On the other side, energy consumption from nuclear power, hydropower, and others resources will increase. By 2040, the consumption of nuclear power and hydropower will be 498 Mtoe and 45 Mtoe, respectively, which corresponds to an increase of 418 Mtoe and 10 Mtoe, respectively, compared to BAU. Also, the consumption of 'others' will increase by 182 Mtoe in 2040 relative to BAU.

Under case 3, total energy consumption in 2040 will decline by 50% relative to BAU. Coal will continue to have the largest share in energy reduction. The consumption of coal will be 274 Mtoe, which is about 855-Mtoe reduction compared to BAU. Furthermore, the consumption of oil and natural gas will fall to 267 Mtoe and 111 Mtoe, respectively. This corresponds to reductions of 300 Mtoe and 59 Mtoe in oil and natural gas, respectively, compared to BAU. This scenario also suggests that the consumption of nuclear power, hydropower, and 'others' energy will increase in 2040 by 47 Mtoe, 4 Mtoe, and 23 Mtoe, respectively, compared to BAU.

Figure 2C.8. Primary Energy Supply in Cases 1-3



BAU =Business as Usual, Mtoe = metric tonne of oil equivalent.
Source: Author's calculations.

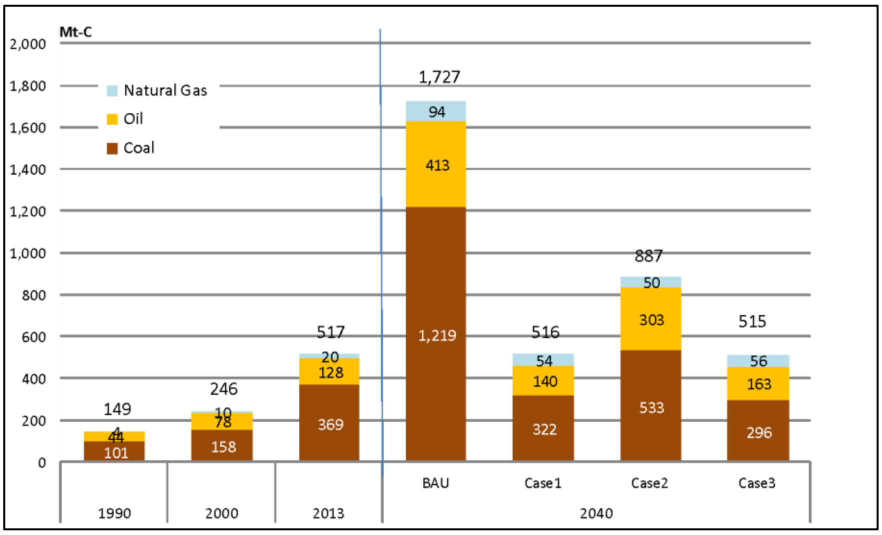
CO_2 Emissions

In case 1, total CO_2 emissions in 2040 will drop to 516 Mt-C or by 70% compared to BAU (Figure 2C.9). As expected, most of the emission reduction will be coming from coal. Coal emission will decline to 322 Mt-C in 2040, which represents a reduction of 897 Mt-C relative to BAU. Also, emissions from oil and natural gas will fall to 140 Mt-C and 54 Mt-C, respectively, by 2040. Comparing with BAU, this implies a reduction of 273 Mt-C and 40 Mt-C from oil and natural gas, respectively.

In case 2, total emissions will be 887 Mt-C by 2040, which represents a decline of 840 Mt-C or 49% relative to BAU. With great efforts to shift from fossil-based fuels to sustainable energy sources, emission from coal in 2040 will be 533 Mt-C, which is a reduction of 686 Mt-C compared to BAU. The emissions from oil and natural gas are 303 Mt-C and 50 Mt-C, respectively, which represent reductions of 110 Mt-C and 44 Mt-C, respectively, compared to BAU.

Under case 3, total emissions will be 515 Mt-C in 2040, which is 1212 Mt-C or approximately 70% reduction compared to BAU. Emissions reductions in 2040 from coal, oil, and natural gas will decline by 923 Mt-C, 250 Mt-C, and 38 Mt-C, respectively, relative to BAU.

Figure 2C.9. CO_2 Emission in Cases 1-3



BAU = Business as Usual, CO_2 = carbon dioxide, Mt-C = million tonne of carbon.
Source: Author's calculations.

Energy and CO_2 Emissions Intensity

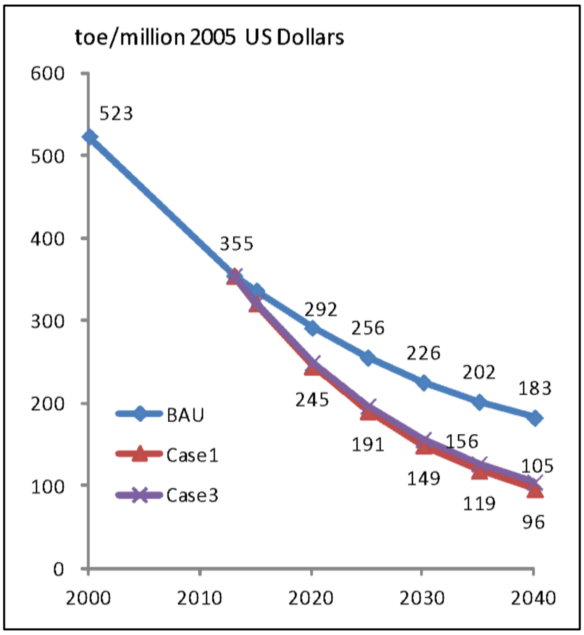
Final energy consumption per GDP

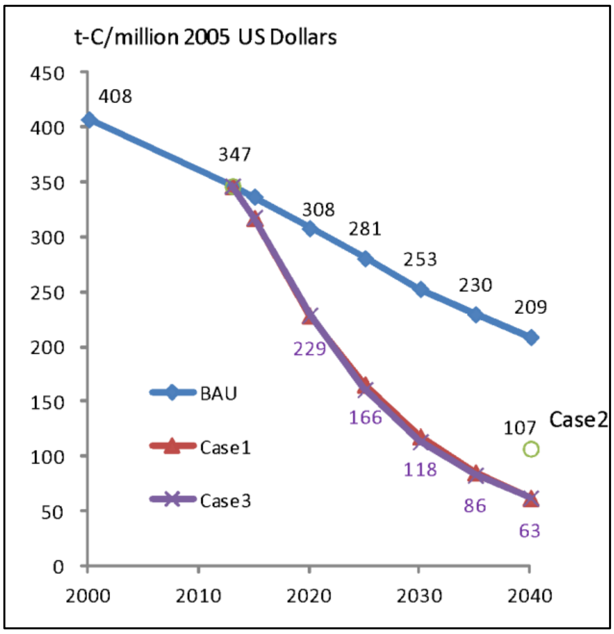
Final energy consumption per GDP will gradually decline in the BAU scenario at an annual rate of 2.4% from 2013 and will be 183 toe/US$2005 million in 2040. In case 1, final energy consumption per GDP will also decline at a rate of 4.7% to 96 toe/US$2005 million in 2040 which represents a reduction of 87 toe/US$2005 million relative to BAU. Also, reduction will occur in case 3 and will decline at a rate of 4.4% to 105 toe/US$2005 million which is about 78 toe/US$2005 million reduction compared to BAU (see Figure 2C.10).

CO_2 emissions per GDP

CO_2 emissions per GDP will gradually decline in the BAU scenario at an annual rate of 1.9% from 2013 and will be 209 t-C/US$2005 million in 2040. In case 1 and case 3, CO_2 emissions per GDP will also decline at an average rate of 6.15% to 63 t-C/US$2005 million in 2040 which represents a reduction of 146 t-C/US$2005 million relative to BAU. Also, reduction will occur in case 2 and will decline at a rate of 4.2% to 107 t-C/US$2005 million which is about 102 t-C/US$2005 million reduction compared to BAU (see Figure 2C.10).

Figure 2C.10. Final Energy Consumption and CO_2 Emissions per GDP





BAU = Business as Usual, CO_2 = carbon dioxide, GDP = gross domestic product, toe = tonne of oil equivalent, t-c = tonne of carbon.
Source: Author's calculations.

Implication

Increasing energy efficiency, demand side management, and use of new and sustainable energy technologies will go a long way towards achieving low-carbon economy by 2040.

Modelling results show that with the available technologies in India, it will be impossible to suppress CO_2 emissions in 2040 to 2013 level. For example, in case 2, the result shows that even if the Indian power generation is fully replaced with non-fossil fuel, emissions will still be higher compared to 2013. Hence, there is a need to accelerate efforts towards investment in research and development in the energy sector. This will involve the deployment of new technologies and improved energy efficiency practice in all sectors of the economy. This will have a strong effect on fuel use in the various sectors of the economy and demand-side practices. Mitigating CO_2 in the Indian economy will definitely come with several policy and financial challenges. Thus, there is the need to put forward sound policies that can encourage energy consumers to change their behaviour towards adopting energy efficiency practices and policies that can clear all the obstacles that might be limiting energy efficiency improvements.

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2D. Indonesia's Case Study
Keeping CO_2 Emissions at 2013 Level by 2040

Background

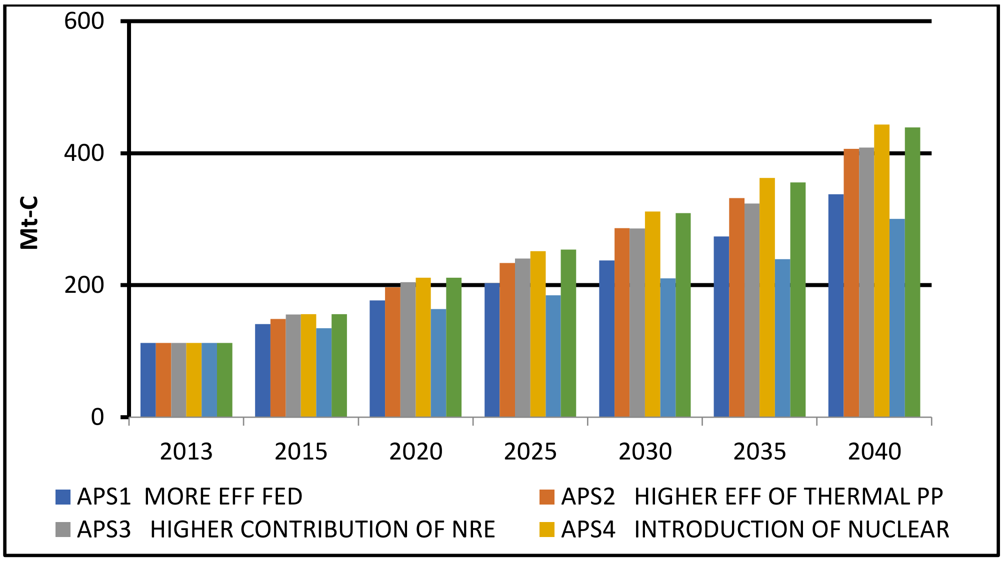
The Energy Outlook and Energy Saving Potential in East Asia 2016 by the Economic Research Institute for ASEAN and East Asia (ERIA) projects an increasing demand for the Alternative Policy Scenario (APS) and the Business as Usual (BAU) scenario. As a result, total carbon dioxide (CO_2) emissions will increase in the future.

APS is a combination of different scenarios. In the case of Indonesia, the scenarios are reference (BAU), more efficient FED (APS1), higher efficiency of thermal power plants (APS2), higher contribution of non-renewable energy (APS3), introduction of nuclear power (APS4), and combined APS1 to APS4 (APS5/APS)

For the BAU scenario (Figure 2D.1), Indonesia's total CO_2 emissions were 113 metric tonnes of carbon (Mt-C) in 2013 (base year) and projected to reach 439 Mt-C by 2040. Assuming that the government of Indonesia will apply more efficient technology in the final sector and higher efficiency of thermal power plants in addition to promoting higher penetration of new and renewable energy and constructing nuclear power plants (APS), then total CO_2 emissions will only increase to 301 Mt-C by 2040. Thus, implementing APS will result in a 31% reduction of CO_2 emissions in 2040 compared to BAU.

This case study on CO_2 emissions aims to identify possible solutions to mitigate CO_2 emissions in 2040 to the 2013 level. Since the APS scenario has the lowest CO_2 emissions, then this scenario will be the basis for the case study.

Figure 2D.1. CO_2 Emissions of Indonesia in ERIA's Outlook 2016



CO_2 = carbon dioxide, ERIA = Economic Research Institute for ASEAN and East Asia, Mt-C = metric tonne of carbon, BAU= Business as Usual, APS = Alternative Policy Scenario, PP= power plant, EFF=efficiency, FED = final energy demand, NRE = new and renewable energy.
Source: Author's calculations.

Methodology

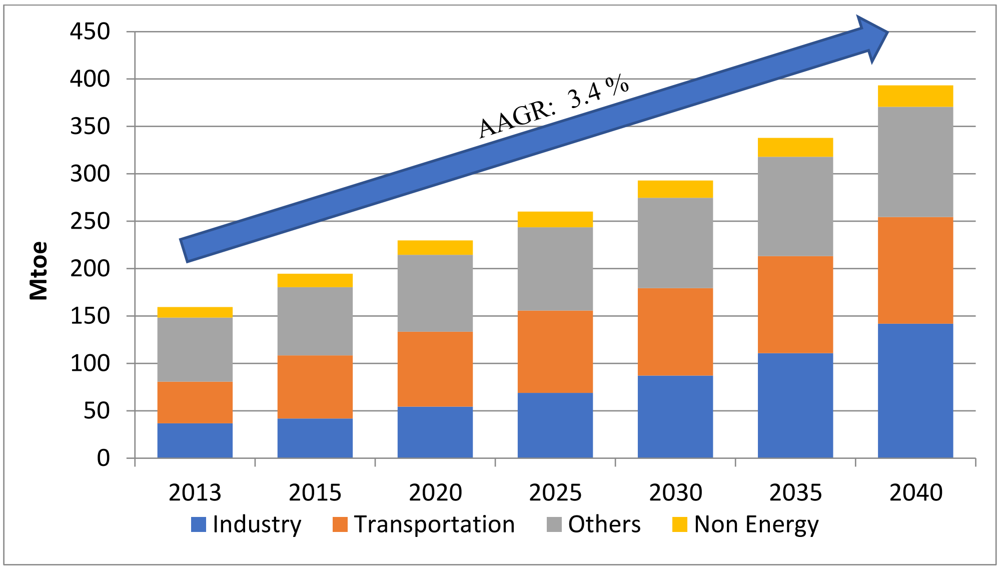
APS consists of APS1, APS2, APS3, and APS4. Implementing APS still results in an increase of CO_2 emissions in 2040 compared to the base year. To ensure that total CO_2 emissions remain at the 2013 level, more efforts will be needed to achieve national development target without increasing CO_2 emissions from their base year level. The parameters to consider would be: energy saving in final consumption sector, high-efficient thermal power plants, hydropower and geothermal energy, solar/photovoltaic (PV) system and wind energy, other renewables, and nuclear energy.

The approach for the exercise will be: less usage of fossil fuels and more of renewables; increase use of biofuels such as biogasoline (bioethanol), biodiesel, and biojetkerosene; limiting use of coal and natural gas in power sector; and increase use of renewables in power generation.

Final Energy Demand

In ERIA's Energy Outlook and Energy Saving Potential in East Asia 2016 (Energy Outlook 2016), the final energy demand of Indonesia under APS will be growing at an average rate of 3.4% over the 2013–2040 period (Figure 2D.2).

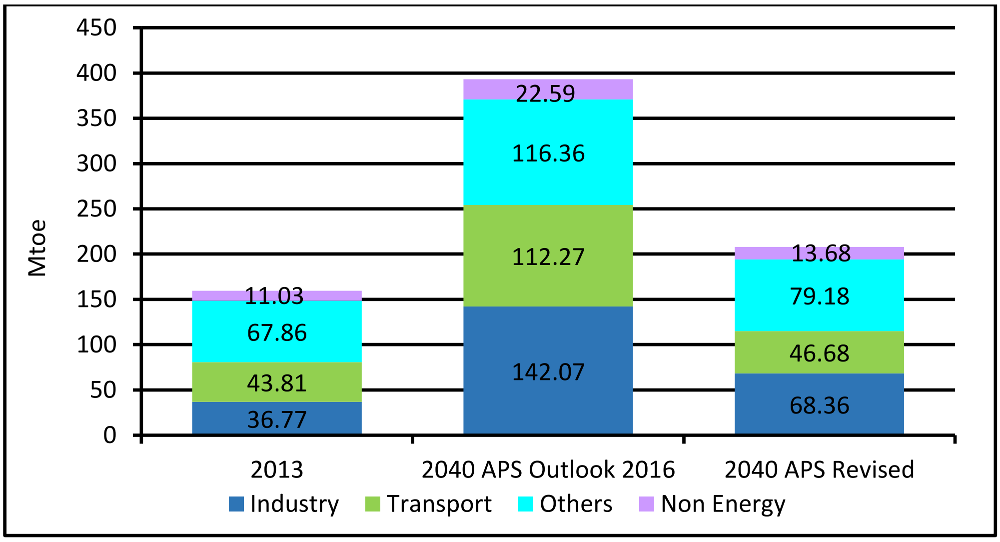
Figure 2D.2. Final Energy Demand in ERIA's APS Outlook 2016



AAGR = average annual growth rate, APS = Alternative Policy Scenario, ERIA = Economic Research Institute for ASEAN and East Asia, Mtoe = metric tonne of oil equivalent.
Source: Author's calculations.

Revising the assumption used for energy efficiency and conservation (EEC) and increased use of biofuels will slow down the increase of the final energy demand. The final energy demand of the revised APS will grow at an average annual rate of 1% per year over the 2013–2040 period. Revising the EEC target reduced the total final energy demand of 2040 by almost 50% the level of ERIA's Energy Outlook 2016 APS (Figure 2D.3).

Figure 2D.3. Final Energy Demand Comparisons



APS = Alternative Policy Scenario, Mtoe = metric tonne of oil equivalent.
Source: Author's calculations.

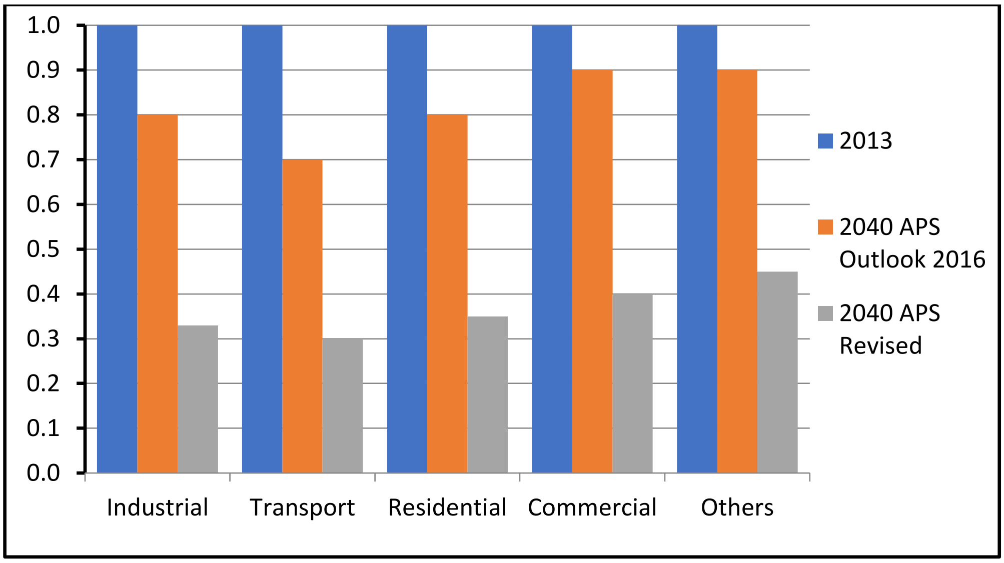
The use of biofuels will be increasing since the assumption was revised especially in the transport sector. Introduction of jet kerosene was assumed in the revised APS, which was excluded in ERIA's Energy Outlook 2016 APS.

EEC targets

The EEC target in ERIA's Energy Outlook 2016 APS is different depending on the sectors. It is assumed that by 2040, there will be a 30-% energy-saving target for the transport sector, a 20-% energy saving for the industrial and residential sectors, and a 10-% saving for the commercial and others sectors.

In the revised APS, the target was more stringent: around 50% saving target for the others sector, a 60-% target for the residential and commercial sectors, and a 70-% saving target for the industry and transport sectors (Figure 2D.4).

Figure 2D.4. EEC Targets

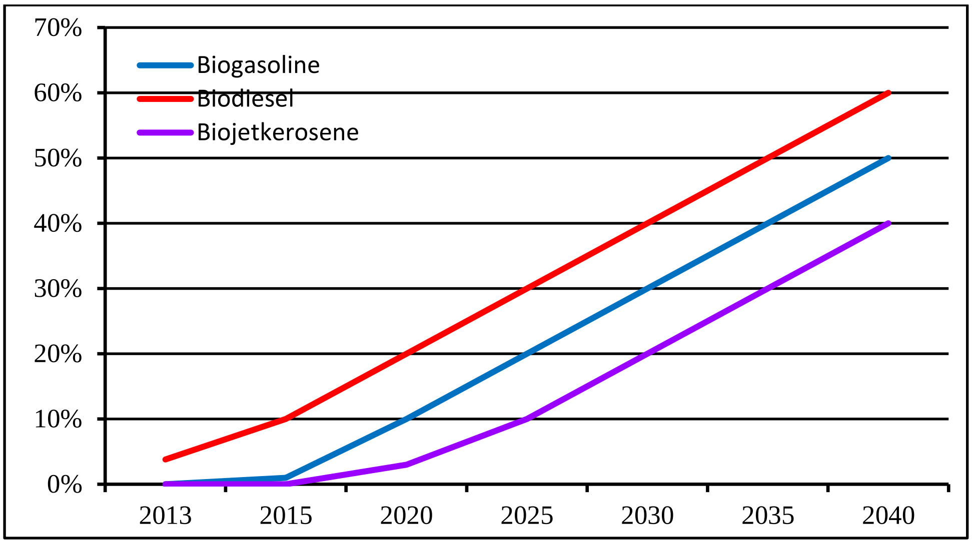


EEC = Energy Efficiency and Conservation, APS = Alternative Policy Scenario
Source: Author's calculations.

Biofuel penetration

Beside the EEC target, the biofuel penetration is also revised. In ERIA's Energy Outlook 2016 APS, penetration of biofuel is around 30% by 2040 for biodiesel and 20% for biogasoline. No penetration of biojetkerosene is assumed in ERIA's Energy Outlook 2016 APS. In the revised APS, the penetration of biodiesel increased to 60% by 2040, while biogasoline has a 50-% penetration rate and biojetkerosene around 40% (Figure 2D.5).

Figure 2D.5. Biofuel Penetration



Source: Author's calculations.

Power Generation

The parameters in the power generation sector of the long-range energy alternatives planning model include dispatch rule, merit order, efficiency, maximum availability, exogenous capacity, etc. Most of these technical parameters are similar to that of ERIA's Energy Outlook 2016 APS.

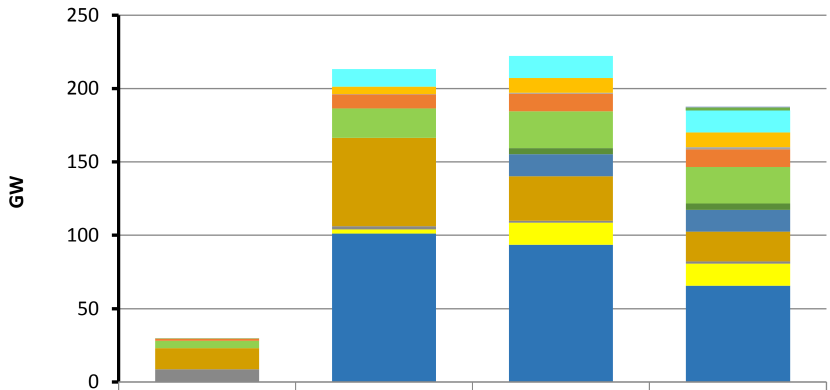
The difference is in the capacity expansion of the various power plants. In the revised APS, there are more renewable energy capacity being assumed for the future.

Capacity

As shown in Figure 2D.6, total capacity in ERIA's Energy Outlook 2016 APS is around 222 gigawatts (GW) in 2040 while it is only 188 GW in the revised APS. The coal- and gas-fuelled power plants are assumed to be lower in the revised APS to allow more renewable-based power generation to be in the generation mix. The ocean thermal energy conversion and biodiesel power plants that were not assumed in the previous ERIA's Energy Outlook have been added in the revised APS.

The nuclear power plant is also assumed in the revised APS, but similar to the assumptions in the APS of the ERIA's Energy Outlook 2016. It is assumed that four nuclear power plants will be in operation in 2040 with a total capacity of 4.2 GW.

Figure 2D.6. Total Capacity (GW)



	2013	2040-REF Outlook 2016	2040-APS Outlook2016	2040-APS Revised
Ocean PP	-	-	-	0.50
Biodiesel	-	-	-	2.00
Biomass PP	0.13	12.00	15.00	15.00
Solar PV	0.01	5.00	10.00	10.00
Wind PP	0.00	0.15	0.70	1.50
Geothermal PP	1.35	9.70	12.00	12.00
Hydro PP	5.17	20.00	25.00	25.00
Nuclear PP	-	-	4.20	4.20
New CCGT	-	-	15.00	15.00
Natural Gas PP	14.38	60.30	30.30	20.30
Oil PP	8.64	2.00	1.50	1.50
New Coal PP	-	3.00	15.00	15.00
Coal PP		101.10	93.50	65.60

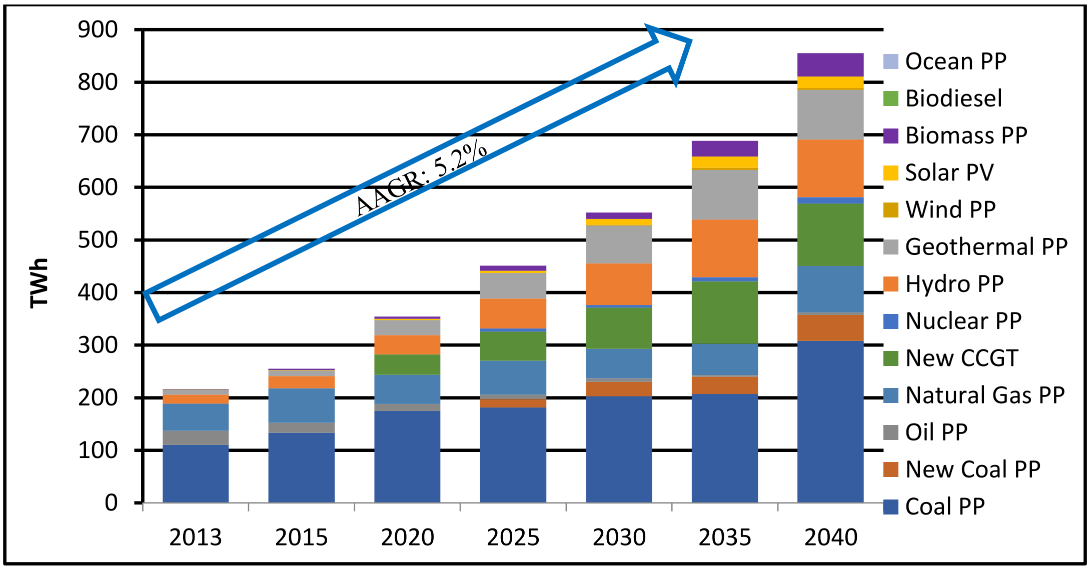
APS = Alternative Policy Scenario, REF = Reference, CCGT = Combined Cycle Gas Turbine, PP = Power Plant, PV =Photovoltaic, GW = gigawatt,
Source: Author's calculations.

Power Generation

The capacity expansion assumed in the revised APS generates around 410 terawatt hours (TWh) of electricity, lower than the 550 TWh power generated in APS of ERIA's Energy Outlook 2016 (Figures 2D.7 and 2D.8). The average annual growth rate of electricity production in APS of ERIA's Energy Outlook 2016 is 5.2% while in the revised APS, the rate is slower, at 2.4% per year.

Around 60% of the total generation comes from renewable energy in the revised APS with the rest coming from fossil fuel power plants. The nuclear power plant generation is included on the renewable generation but with smaller amount of electricity generated as compared to APS of ERIA's Energy Outlook 2016.

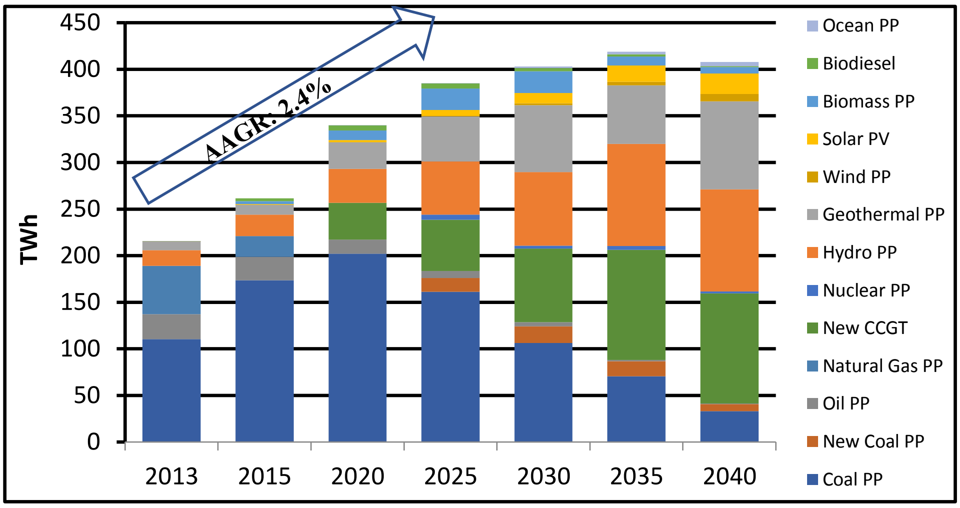
Figure 2D.7. Power Generation by Type in ERIA's Energy Outlook 2016 APS



AAGR = average annual growth rate, APS = Alternative Policy Scenario, CCGT =combined cycle gas turbine, PP = power plant, PV = photovoltaic, TWh = terawatt hour.
Source: Author's calculations.

In terms of renewable energy, more hydropower and geothermal plants are being generated in the revised APS as compared to APS of ERIA's Energy Outlook 2016. Similarly, solar/PV generation also increased in the revised APS. Generation from coal and natural gas-fuelled power plants has been reduced in the APS scenario, more significantly for coal power plants.

Figure 2D.8. Power Generation by Type in the Revised APS

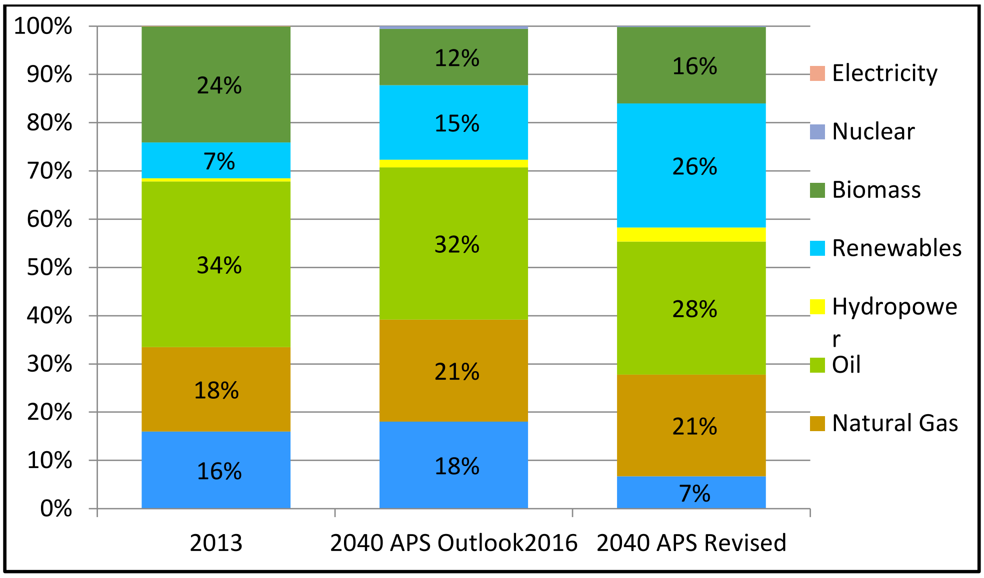


AAGR = average annual growth rate, APS = Alternative Policy Scenario, CCGT = combined cycle gas turbine ,
PP = power plant, PV = photovoltaic, TWh = terawatt hour.
Source: Author's calculations.

Primary Energy Supply

With revised EEC target, biofuel penetration, and increased share of renewable energy in the power sector, the total primary energy supply of the revised APS will almost be 340 Mtoe in 2040, around 42% lower than in APS of ERIA's Energy Outlook 2016 (Figure 2D.9). In terms of share in the total energy mix, 44% comes from renewable energy including biomass while the remaining is that of fossil fuel. Coal share decreased significantly in the revised APS from 18% in APS of ERIA's Energy Outlook 2016 to 7% in the revised APS.

Figure 2D.9. Primary Energy Supply

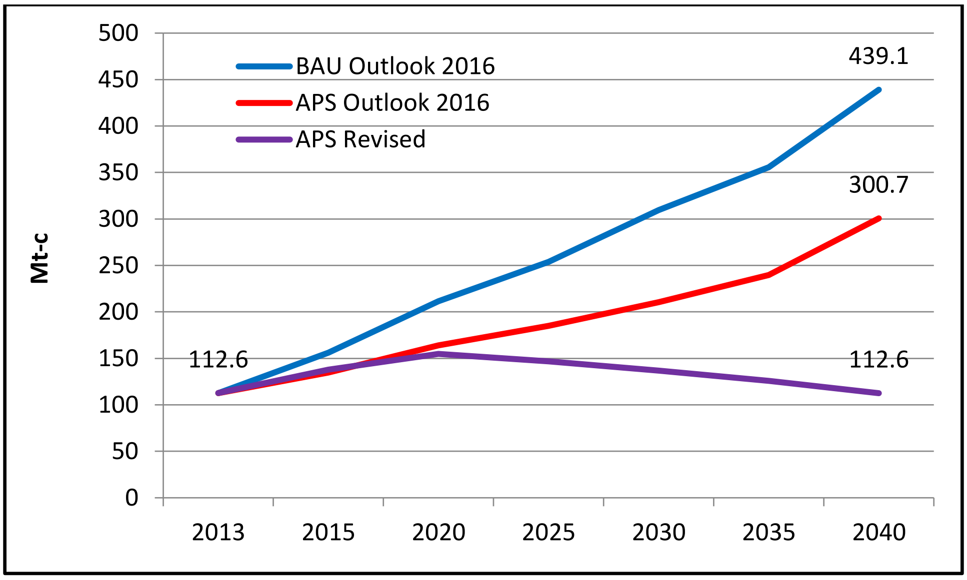


APS = Alternative Policy Scenario.
Source: Author's calculations.

CO_2 Emissions

The resulting carbon dioxide (CO_2) emissions of the revised APS will be 112.6 metric tonnes of carbon (Mt-C), similar to the base year value of 2013 and lower than in APS of ERIA's Energy Outlook 2016, which is 300.7 Mt-C (Figure 2D.10).

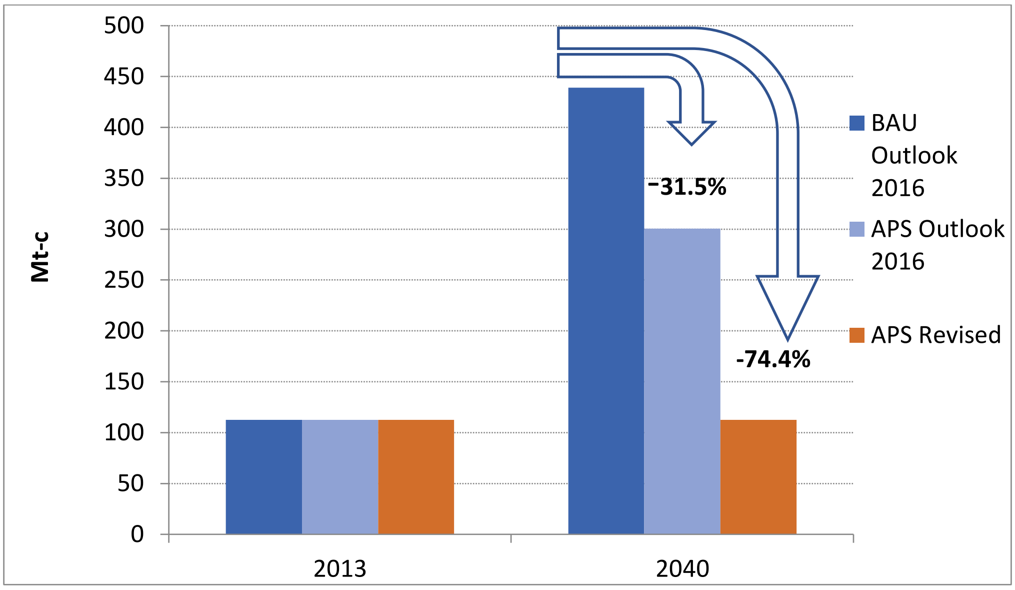
Figure 2D.10. CO_2 Emissions Comparisons



APS = Alternative Policy Scenario, BAU = Business as Usual, CO_2 = carbon dioxide, Mt-C = metric tonne of carbon.
Source: Author's calculations.

Compared to the BAU scenario of ERIA's Energy Outlook 2016, the total CO_2 emissions of APS will be 31.5% lower. In the case of the revised APS, the total CO_2 emissions will be 74.4% lower to beat the same level as the base year (Figure 2D.11).

Figure 2D.11. CO_2 Emissions Reduction by 2040



APS = Alternative Policy Scenario, BAU = Business as Usual, CO_2 = carbon dioxide, Mt-C = metric tonne of carbon.
Source: Author's calculations.

Conclusion

ERIA's Energy Outlook 2016 resulted in total CO_2 emissions of 439 Mt-C by 2040 for the BAU scenario and 301 Mt-C for APS. For the total CO_2 emissions in 2040 to be at the same level as the base year (113 Mt-C), efforts imposed in APS of ERIA's Energy Outlook 2016 have to be more stringent in the revised APS.

Revising the EEC target, the biofuel penetration, and increasing share of renewable in power generation have made it possible for the total CO_2 emissions of the revised APS to be similar to the base year level. Since the CO_2 emissions reduction in APS of ERIA's Energy outlook 2016 is around 31.4% by 2040, the revised APS will result in a 74.4-% reduction compared to the BAU scenario.

2E.The Lao People's Democratic Republic's Case Study

Keeping CO_2 Emissions at 2013 Level by 2040

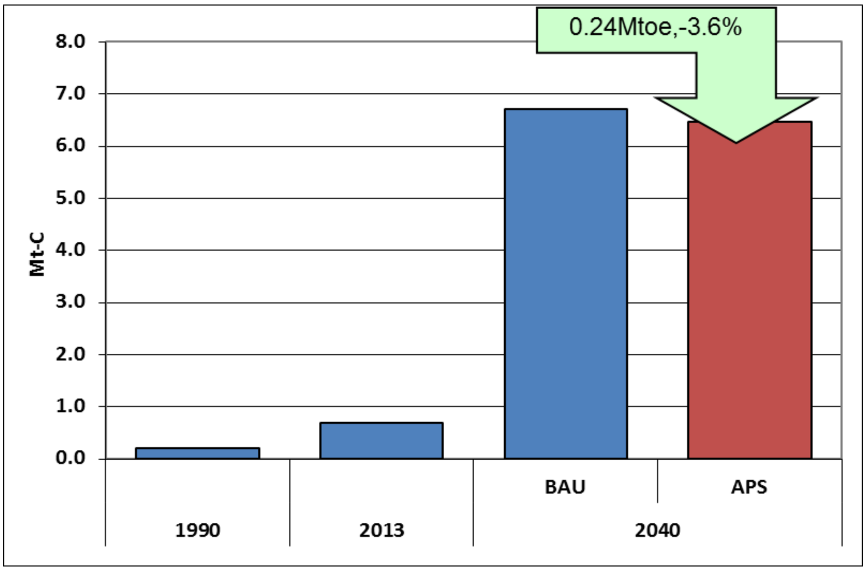
Introduction

This study identifies some necessary scenarios in mitigating the carbon dioxide (CO_2) emissions of the Lao People's Democratic Republic (Lao PDR) in 2040 to the same level of 2013 in the energy sector. In this case, the Lao PDR will attempt a trade-off between greenhouse gases (GHG) and future energy consumption through national energy policies and plans. Energy efficiency and non-carbon energy on national plans might or might not be achieved with this goal. If the national plans alone are not adequate, an analysis will be made to make this target a success.

CO_2 Projections of BAU and APS in 2040

Based on the Business as Usual (BAU) scenario, the Lao PDR's CO_2 emissions are expected to increase sharply from 0.7 million tonne of carbon (Mt-C) in 2013 to 6.7 Mt-C in 2040 because of the annual increase of final energy demand which is expected at 4% coupled with the increase of coal consumption in power plants for power export during this period. However, in APS-5, which combines all four Alternative Policy Scenarios (APS), CO_2 emissions are expected to go down by 3.6% to 0.24 Mt-C (see Figure 2E.1). This reduction of CO_2 reduction was made by implementing the Lao PDR government's measures in energy efficiency and renewable energy development.

Figure 2E.1. CO_2 Projections of BAU and APS in 2040



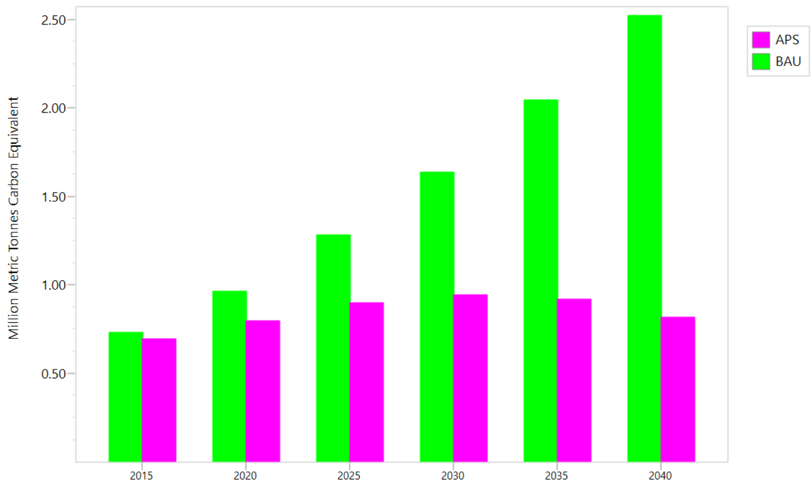
APS = Alternative Policy Scenario, BAU = Business as Usual, Mt-C = metric tonne of carbon, Mtoe = metric tonne of oil equivalent.
Source: Author's calculations.

Scenarios of Keeping CO_2 Total Emissions at 2013 Level by 2040

In order to reduce the 2040 CO_2 total emissions to the 2013 level, the Lao PDR should try many measures or scenarios of energy saving and renewable energy development (see Figure 2E.2). With those measures, the following can be assumed:

1. The Lao PDR will reduce final energy demand to 70% by 2040. This would be the actual saving or reduction.
2. The Lao PDR will increase the share of biodiesel in the total diesel supply by 20% by 2040.

Figure 2E.2. CO_2 Emissions Mitigation in 2040 at 2013 Level



APS = Alternative Policy Scenario, BAU = Business as Usual.
Source: Author's calculations.

Final Energy Demand with CO_2 Emissions Mitigation

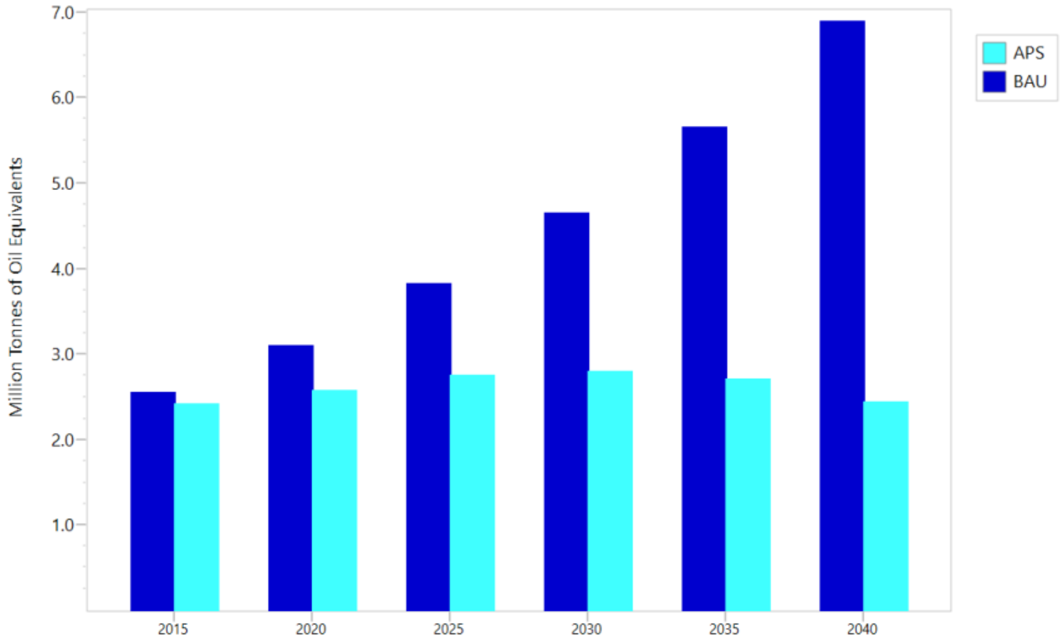
After the Lao PDR's implementation of the above measures, final energy demand is expected to be reduced from 6.9 metric tonnes of oil equivalent (Mtoe) in BAU to 2.4 Mtoe in APS as shown in Table 2E.1 and Figure 2E.3.

Table 2E.1. Final Energy Demand Keeping CO_2 Emissions at 2013 Level by 2040 (BAU vs APS)

Scenarios	2015	2020	2025	2030	2035	2040
APS	2.4	2.6	2.8	2.8	2.7	2.4
BAU	2.6	3.1	3.8	4.7	5.7	6.9

APS = Alternative Policy Scenario, BAU = Business as Usual.
Source: Author's assumption.

Figure 2E.3 Final Energy Demand Keeping CO_2 Emissions at 2013 Level by 2040 (BAU vs APS)



APS = Alternative Policy Scenario, BAU = Business as Usual.
Source: Author's calculations.

2F.Malaysia's Case Study

Keeping CO_2 Emissions at 2013 Level by 2040

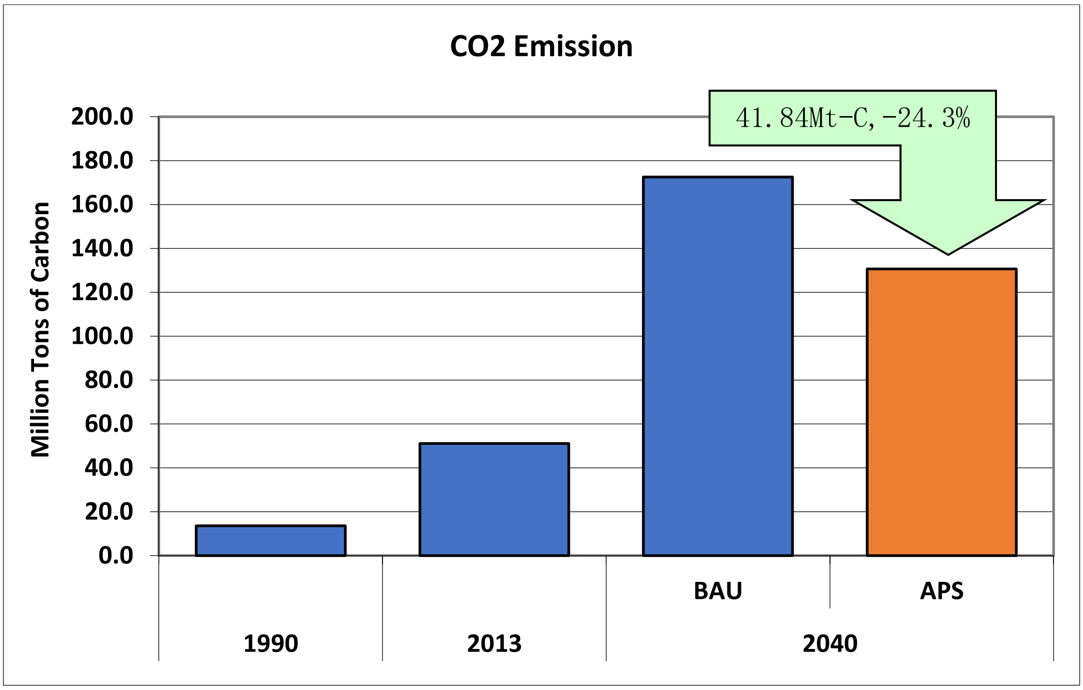
Introduction

This chapter discusses efforts to reduce Malaysia's carbon dioxide (CO_2) emissions level in 2040 to the same level as in 2013. With this target, existing targets or mitigation options will be enhanced by more extreme target or reduction. The mitigation options will be based on current scenarios already identified during last year's project where the level of reduction of emissions in 2040 will be same as in 2013. Although this exercise may not reflect the current and future policies in Malaysia, its analysis may provide an insight for policymakers on the possible mitigation actions that can be implemented.

Methodology

The energy data are from the International Energy Agency (IEA) and the base year for this exercise is 2013. By using the previous year's result as derived from LEAP software, the modification in meeting the objective was made for the LEAP model. Based on last year's result, the total CO_2 emissions in 2013 were 51.1 metric tonnes of carbon (Mt-C). Figure 2F.1 shows the current Business as Usual (BAU) and Alternative Policy Scenario (APS) results for CO_2 emissions in 2013 and 2040.

Figure 2F.1. Current Level of CO_2 Emissions in 2013 and 2040 for BAU and APS



APS = Alternative Policy Scenario, BAU = Business as Usual, CO_2 = carbon dioxide.

Source: Author's calculations.

The figure above shows that in 2040, there is a potential reduction of 24.3% between APS and BAU scenario or a 38.74-Mt-C reduction that can potentially be avoided if mitigation options are implemented. The current mitigation scenarios are shown in Tables 2F.1 to 2F.5:

Table 2F.1. Energy Efficiency Assumptions

Scenario	Assumption
APS1	1. Electricity demand in industrial sector (INEL)
	Potential reduction of electricity demand in industrial sector from 2015 until 2040 by 1.35% per year.
	2. Total energy demand in industrial sector (INTT)
	Potential reduction of total energy demand (electricity + petroleum products + coal + natural gas) in industrial sector by 1% per year from 2015 until 2040.
	3. Total energy demand in commercial sector
	Potential reduction of total energy demand in commercial sector by 1% per year from 2015 until 2040.

APS = Alternative Policy Scenario.
Source: Author's assumption.

Table 2F.2. Higher Efficiency of Thermal Electricity Generation

Scenario	Assumption
APS2	1.Higher efficiency of coal power plant by 40% in 2040
	2. Higher efficiency of natural gas power plant by 46.3% in 2040.

APS = Alternative Policy Scenario.
Source: Author's assumption.

Table 2F.3. Renewables Energy Assumptions

<table>
<tr><th>Scenario</th><th colspan="7">Assumption</th></tr>
<tr><td rowspan="8">APS2</td><td colspan="7">1. By 2030, Malaysia is expected to have these renewable energy (RE) capacities in power generation. The breakdown of the capacity based on type of fuels type is shown below:</td></tr>
<tr><td colspan="7">Cumulative Capacity (MW)</td></tr>
<tr><td>Year</td><td>Biomass</td><td>Biogas</td><td>Mini-Hydro</td><td>Solar PV</td><td>Solid Waste</td><td>Total</td></tr>
<tr><td>2015</td><td>330</td><td>100</td><td>290</td><td>55</td><td>200</td><td>975</td></tr>
<tr><td>2020</td><td>800</td><td>240</td><td>490</td><td>175</td><td>360</td><td>2,065</td></tr>
<tr><td>2025</td><td>1,190</td><td>350</td><td>490</td><td>399</td><td>380</td><td>2,809</td></tr>
<tr><td>2030</td><td>1,340</td><td>410</td><td>490</td><td>854</td><td>390</td><td>3,484</td></tr>
<tr><td colspan="7">2. By 2020, 7% of Malaysia's share of diesel consumption in transport sector will come from biodiesel.</td></tr>
</table>

APS = Alternative Policy Scenario, MW = megawatt, PV = photovoltaic.
Source: Author's assumption.

Table 2F.4. Nuclear Energy Assumptions

Scenario	Assumption
APS4	1. By 2027, a 2000-MW nuclear plant is expected to be commissioned.

APS = Alternative Policy Scenario, MW = megawatt.
Source: Author's assumption.

Table 2F.5. APS Assumptions

Scenario	Assumption
APS5	APS1 + APS2 + APS3 + APS4

APS = Alternative Policy Scenario.
Source: Author's assumption.

Based on all scenarios above, the modification procedures to meet the objective of this exercise will be applied to the LEAP model as shown in Table 2F.6.

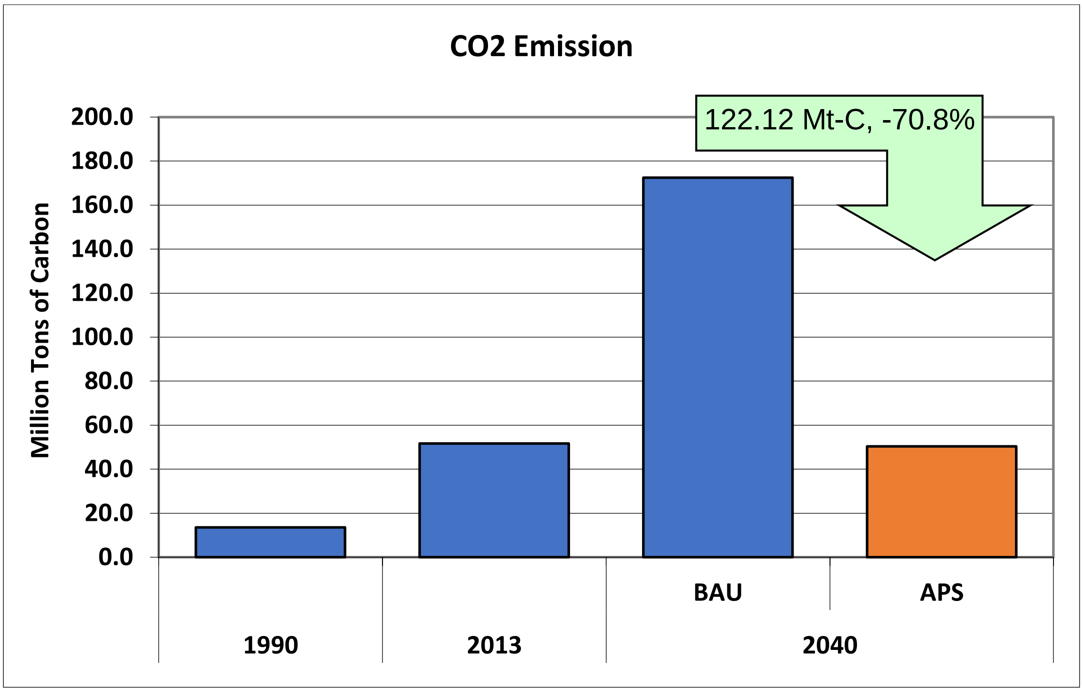
Table 2F.6. Modification Effects on Selected Scenarios

Scenario	Modification
APS1	Industry sector: Reduction of energy for all types of fuel from 2016 until 2040 at 52% compared to the BAU scenario
	Others sector: Reduction of energy for all types of fuel from 2016 until 2040 at 52% compared to the BAU scenario
	Transport sector: Reduction of jet kerosene, gasoline, and diesel from 2016 until 2040 at 52% compared to the BAU scenario
APS2	Power plants: By 2040, the new gas plant will have 55% efficiency while the new coal plant will have 40% efficiency
	Fuel switching from coal to gas by 1000 MW each year from 2020 until 2040
APS3	For power sector: Double the target capacity of RE as in APS scenario
	For transport sector: Increase the share of biodiesel from 10% to 20%
APS4	Introduction of nuclear power plant in 2027 at 2000 MW until 2040

APS = Alternative Policy Scenario, BAU = Business as Usual, MW = megawatt, RE = renewable energy.
Source: Author's assumption.

These modifications only cover the mitigation scenarios based on their potential of reducing CO_2 emissions. Figure 2F.2 illustrates the objective or target of emissions level in 2040.

Figure 2F.2. Target of CO_2 Emissions in 2040

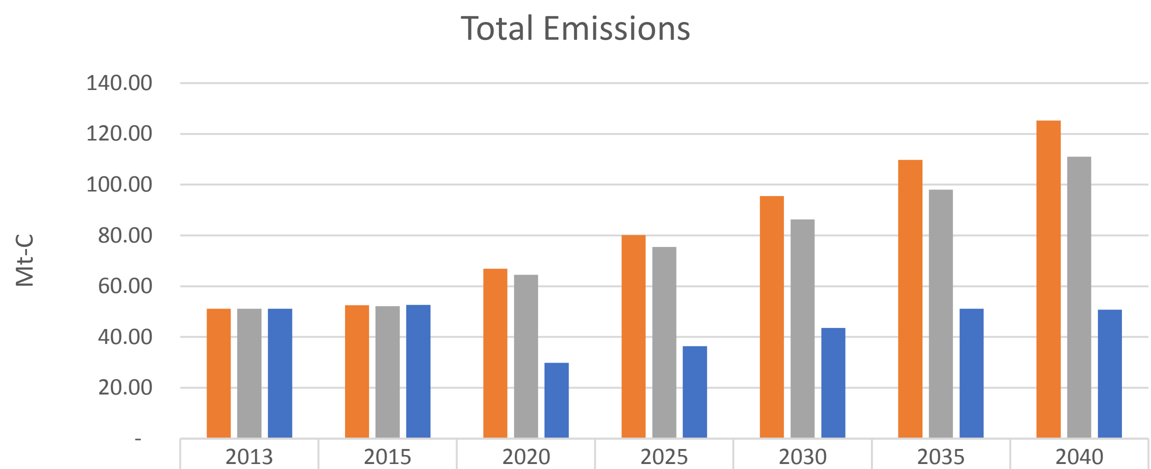


CO_2 = carbon dioxide.
Source: Author's calculations.

Results

Based on the modification effects applied to the LEAP model, results for total emissions for each scenario are shown in Figure 2F.3:

Figure 2F.3. Results of Total Emissions by Scenario



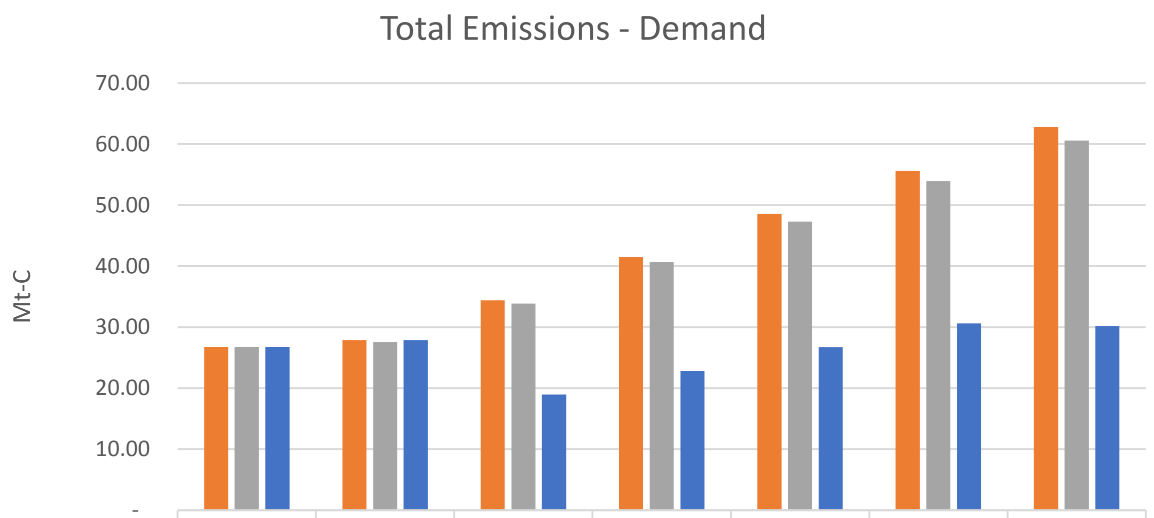
	2013	2015	2020	2025	2030	2035	2040
BAU	51.15	52.49	66.91	80.07	95.45	109.73	125.22
APS Scenario	51.15	52.11	64.46	75.42	86.35	98.04	111.01
CO2	51.15	52.65	29.80	36.32	43.62	51.14	50.72

Mt-C = metric tonne of carbon.

Source: Author's calculations.

By 2040, the level of total CO_2 emissions is projected at 50.721 metric tonnes of carbon (Mt-C), lower than the 51.1-Mt-C target. This indicates that the modification effects applied are overestimated. The result, however, is not so far from the actual target. From the total CO_2 emissions, contribution from the demand sector is shown in Figure 2F.4:

Figure 2F.4. Total CO_2 Emissions from the Demand Sector

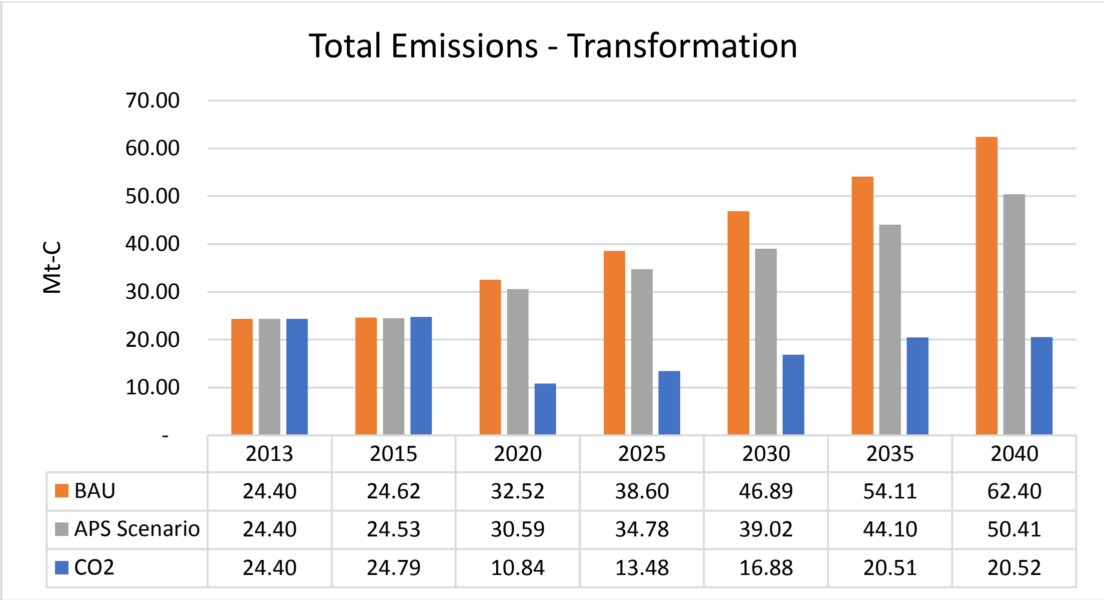


	2013	2015	2020	2025	2030	2035	2040
BAU	26.75	27.86	34.39	41.48	48.56	55.63	62.82
APS Scenario	26.75	27.58	33.87	40.64	47.33	53.94	60.60
CO2	26.75	27.86	18.96	22.85	26.74	30.63	30.20

CO_2 = carbon dioxide.
Source: Author's calculations.

In 2040, the total CO_2 emissions from the demand sector is 30.197 Mt-C, and 62.82 Mt-C, and 60.60 Mt-C for the BAU and APS scenarios, respectively. Result from LEAP shows that under transformation sector, total CO_2 emissions are projected at 20.52 Mt-C as shown in Table 2F.5.

Figure 2F.5. Total CO_2 Emission from Transformation Sector



	2013	2015	2020	2025	2030	2035	2040
BAU	24.40	24.62	32.52	38.60	46.89	54.11	62.40
APS Scenario	24.40	24.53	30.59	34.78	39.02	44.10	50.41
CO2	24.40	24.79	10.84	13.48	16.88	20.51	20.52

Mt-C = metric tonne of carbon.
Source: Author's calculations.

Conclusions

The results show that extreme measures in mitigating CO_2 emissions in the energy sector will affect the total level of emissions in the future. However, a lot of factors need to be considered in the mitigating scenarios, such as investment cost for a high-efficient power plant, tariff setting when fuel switching is applied at the power plant, public acceptance for a nuclear power plant, issues on security of supply when converting fossil fuel power plants into renewable power plants and others.

In tackling the climate change issues especially in the energy sector, policymakers should consider and identify the near-, medium- and long-term plans in mitigating CO_2 emissions. Cost-effective measures should be priorities to minimise losses and maximise savings. Workshops and roundtable discussions should be regularly conducted for inputs and better planning.

2G. Myanmar's Case Study

Keeping CO_2 Emissions at 2013 Level by 2040

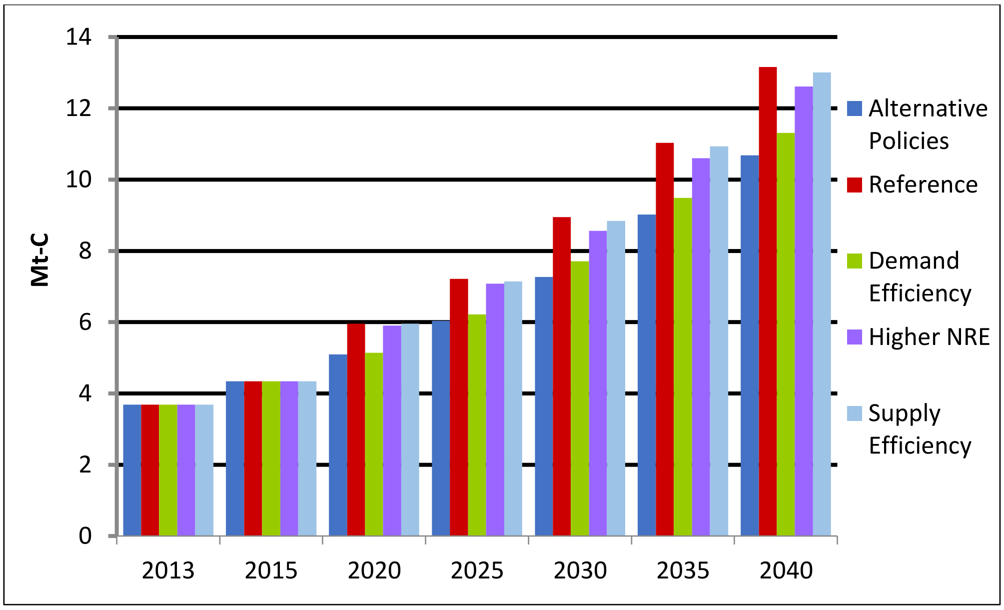
Background

The Energy Outlook and Energy Saving Potential in East Asia 2016 by the Economic Research Institute for ASEAN and East Asia (ERIA) projects an increasing demand for both the Alternative Policy Scenario (APS) and the Business as Usual (BAU) scenario. As a result, the total carbon dioxide (CO_2) emissions will also be increasing in the future.

APS is a combination of different APS scenarios. In the case of Myanmar, the scenarios are: reference (BAU), energy efficiency (APS1), efficient supply (APS2), higher renewable energy (APS3), and alternative policies (APS).

The total CO_2 emissions in 2013 (base year) was around 3.7 metric tonnes of carbon (Mt-C) and are projected to reach 13 Mt-C by 2040 for the BAU scenario (Figure 2G.1).

Figure 2G.1. CO_2 Emissions of Myanmar in ERIA's Energy Outlook 2016



CO_2 = carbon dioxide, ERIA = Economic Research Institute for ASEAN and East Asia, Mt-C = metric tonne of carbon.
Source: Author's calculations.

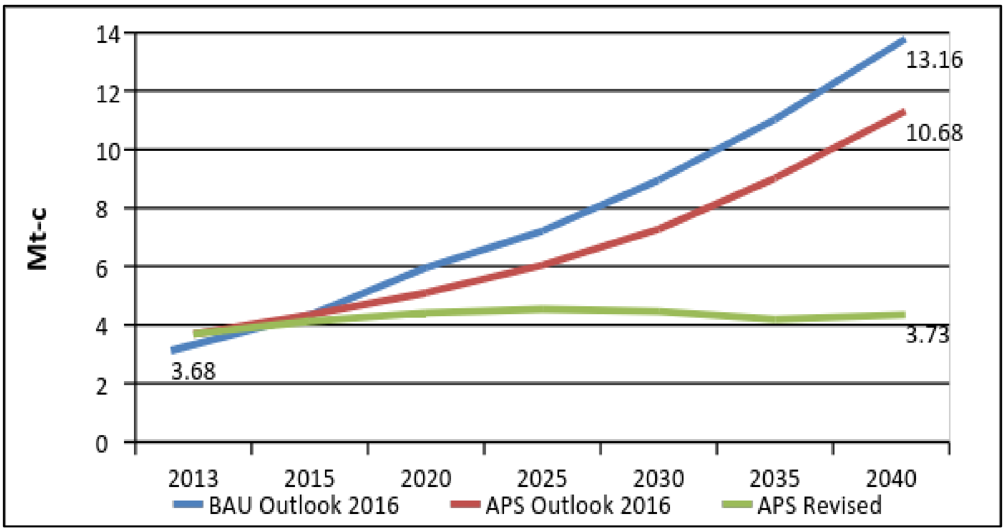
With the implementation of more efficient technology in the final and supply sector and with higher penetration of renewable energy (APS), the total CO_2 emissions will only increase to around 10.7 Mt-C by 2040. Thus, implementing APS will result in an 18.8-% reduction of CO_2 emissions in 2040 compared to BAU.

This case study on CO_2 emissions is to identify possible solutions to mitigate CO_2 emissions in 2040 to the 2013 level. Since the APS scenario has the lowest CO_2 emissions, this will be the basis for the case study.

Methodology

APS consists of APS1, APS2, and APS3. Implementing APS results in an increase of CO_2 emissions in 2040 compared to 2013. To ensure that the total CO_2 emissions remain at the 2013 level (Figure 2G.2), more efforts are needed to achieve national development target without increasing CO_2 emissions from its base year level.

Figure 2G.2. CO_2 Emissions Comparisons



APS = Alternative Policy Scenario, CO_2 = carbon dioxide, Mt-C = metric tonne of carbon.
Source: Author's calculations.

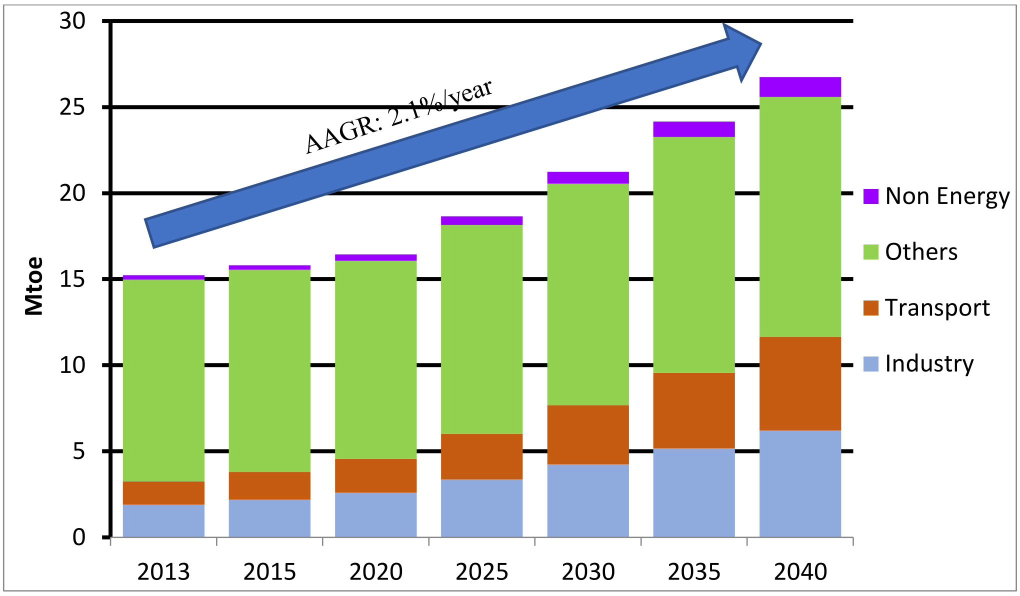
The parameters considered were: energy saving in the final consumption sector, high-efficient thermal power plant, hydropower and geothermal energy, solar/photovoltaic and wind energy, and other renewables.

The approach for the exercise will be: make energy efficiency targets more stringent; use less fossil fuels and more renewables; increase use of biofuels such as biogasoline (bioethanol), biodiesel, and biogas; limit use of fossil fuels in the power sector; and increase use of renewables in power generation.

Final Energy Demand

In ERIA's Energy Outlook and Energy Saving Potential in East Asia 2016*,* (Energy Outlook 2016), the final energy demand of Myanmar under APS will be growing at an average rate of 2.1% over the 2013–2040 period (Figure 2G.3).

Figure 2G.3. Final Energy Demand in ERIA's Energy Outlook 2016 APS

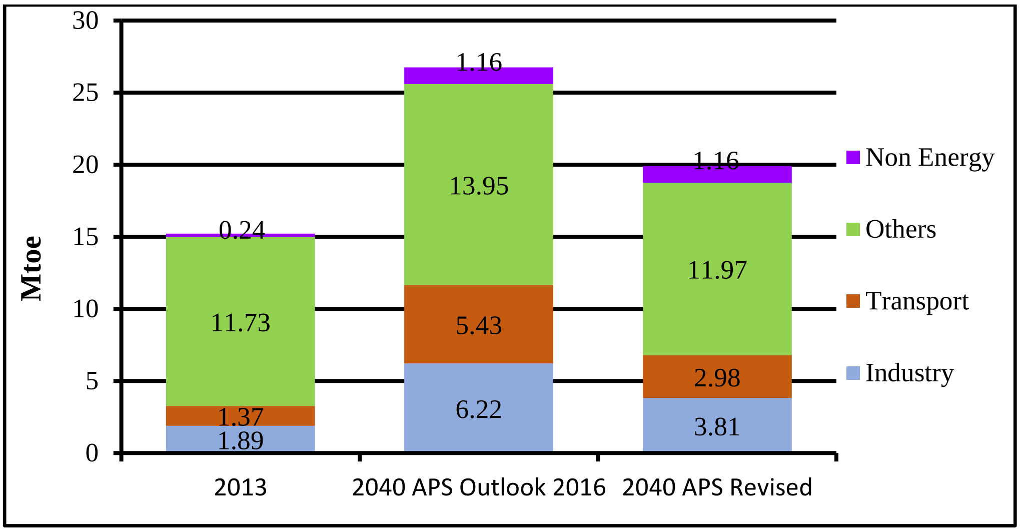


APS = Alternative Policy Scenario, ERIA = Economic Research Institute of ASEAN and East Asia, AAGR = Average Annual Growth Rate, Mtoe = metric tonne of oil equivalent.
Source: Author's calculations.

Revising the assumption for energy efficiency (EE) and increasing the use of biofuels will slow down the increase of the final energy demand. The final energy demand of the revised APS will grow at an average annual rate of 1% per year over the 2013–2040 period. Revising the EE target will reduce the total final energy demand of 2040 by almost 25% the level of APS in ERIA's Energy Outlook 2016 (Figure 2G.4).

The use of biofuels will be increasing since the assumption was revised especially in the transport sector. Biogas for households was assumed in the revised APS, which was excluded in APS of ERIA's Energy Outlook 2016.

Figure 2G.4. Final Energy Demand Comparisons

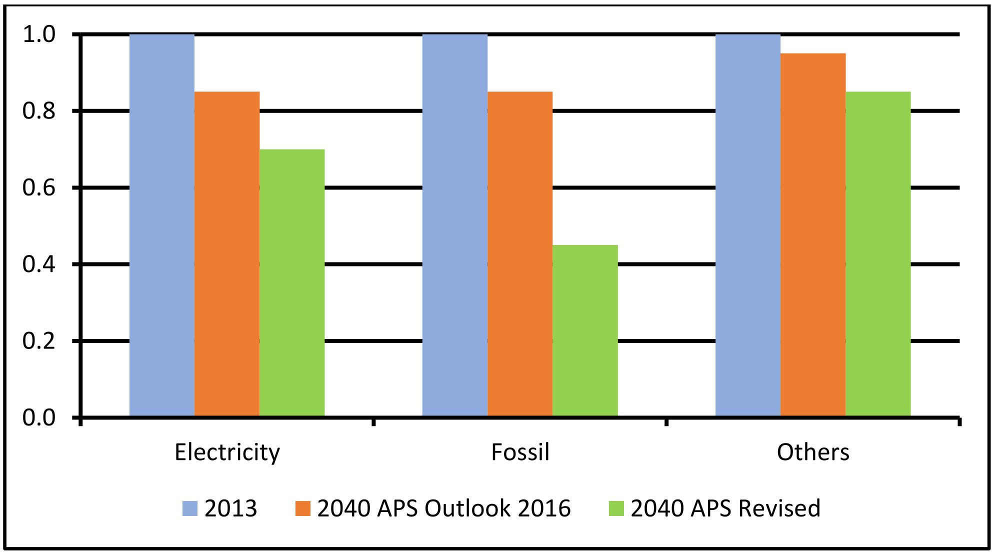


APS = Alternative Policy Scenario, Mtoe = metric tonne of oil equivalent.
Source: Author's calculations.

EE Targets

The EE target in APS of ERIA's Energy Outlook 2016 is assumed to be 10% by 2040 for electricity and fossil fuel. There is no EE target for other fuels. In the revised APS, the target is more stringent. Around 50% saving target is assumed for fossil fuel, a-30% saving target for electricity, and a-10-% saving target for other fuels (Figure 2G.5).

Figure 2G.5. EE Targets

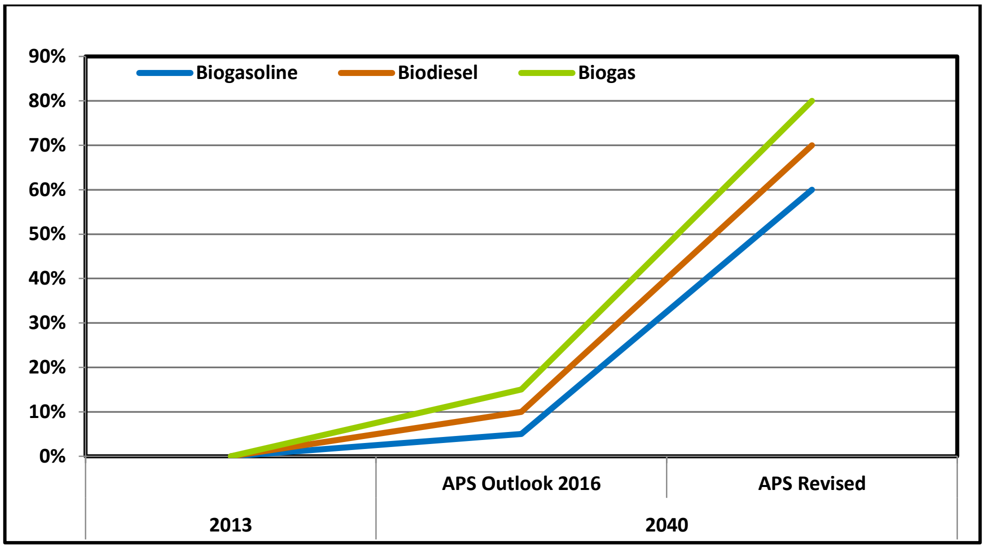


EE = Energy Efficiency.
Source: Author's calculations.

Biofuel Penetration

Beside the EE target, the biofuel penetration rate was also revised. In APS of ERIA's Energy Outlook 2016, penetration of biodiesel is assumed to reach 10% by 2040 and 5% for biogasoline. No penetration of biogas is assumed in APS of ERIA's Energy Outlook 2016. In the revised APS, the penetration of biodiesel increased to 70% by 2040, while biogasoline has a 60-% penetration rate and biogas around 80% (Figure 2G.6).

Figure 2G.6. Biofuel Penetration



APS=Alternative Policy Scenario.
Source: Author's calculations.

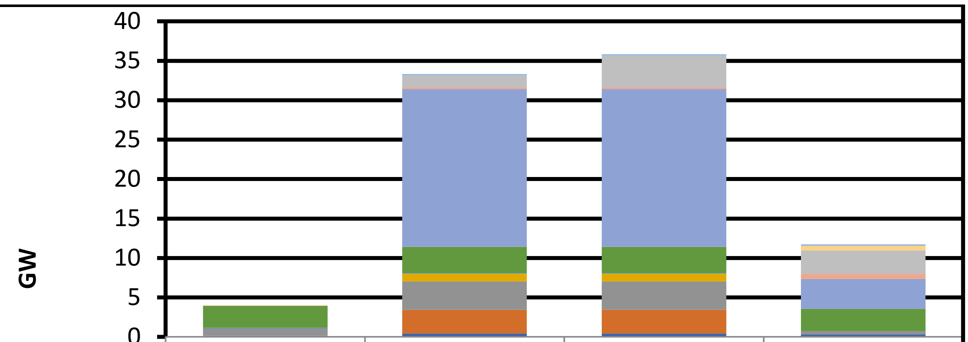
Power Generation

The parameters in the power generation sector of the long-range energy alternatives [lanning model include dispatch rule, merit order, efficiency, maximum availability, exogenous capacity, etc. Most of these technical parameters are like those in APS of ERIA's Energy Outlook 2016. The difference is in the capacity expansion of the various power plants. In the revised APS, there is more renewable energy capacity being assumed for the future.

Capacity

As shown in Figure 2G.7, total capacity in APS of ERIA's Energy Outlook 2016 is around 36 gigawatts (GW) in 2040 while in the revised APS it is 16 GW. An assumption is made on the expansion of fossil fuels in the revised APS to achieve CO_2 emissions of 2040 at the same level of 2013.

Figure 2G.7. Total Capacity (GW)



	2013	REF Outlook 2016 (2040)	APS Outlook2016 (2040)	APS Revised (2040)
Geothermal	-	0.200	0.200	0.200
Biomass	0.000	0.005	0.005	0.600
Wind	0.000	1.500	4.000	3.000
Solar	0.004	0.200	0.200	0.600
New Hydro	-	20.000	20.000	3.800
Hydro	2.813	3.319	3.319	2.813
Diesel	0.087	0.087	0.087	-
New CCGT	-	1.000	1.000	-
Natural Gas	0.931	3.593	3.593	0.431
New Coal	-	3.000	3.000	-
Coal	0.120	0.420	0.420	0.300

GW = gigawatt, APS = Alternative Policy Scenario, REF = Reference, CCGT = Combined Cycle Gas Turbibe.
Source: Author's calculations.

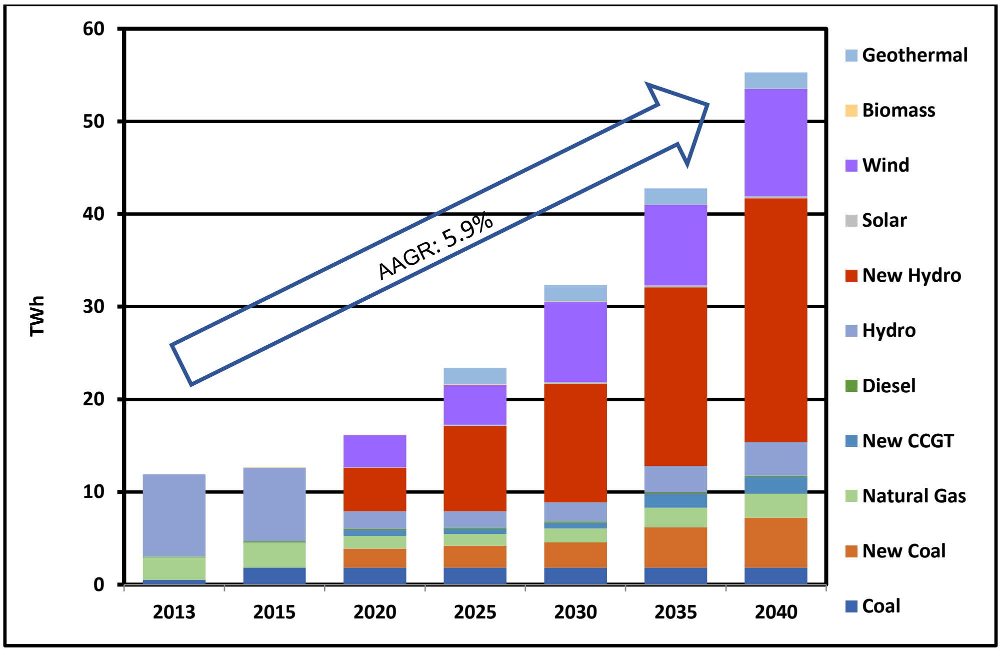
In the case of coal power plants, the assumption for capacity expansion is the one already planned in 2015 (300 MW). The existing 120-MW coal power plant is also assumed to be retired in 2040. No expansion is assumed for natural gas-fuelled plants and that some of the existing plants will be retired gradually by 2040 (300 MW). The existing diesel plants are also assumed to be retired by 2030.

Based on the assumptions for the fossil-fuelled power plants, electricity production will be based mostly from renewable plants. Since there is also reduction in electricity demand as a result of the revised EE targets, the new hydropower capacity is also assumed to be reduced. The existing hydropower capacity remains the same as that of APS in ERIA's Energy Outlook 2016. Similarly, there is also reduction in the new capacity assumption for wind energy plants. The biomass, geothermal, and solar plants have been assumed to expand the same as it is in APS of ERIA's Energy Outlook 2016.

Power Generation

The revised APS generation of electricity will be around 42 terawatt hours (TWh) in 2040, lower than the 55 TWh generated in APS of ERIA's Energy Outlook 2016 (Figure 2G.8 and Figure 2G.9). The average annual growth rate of electricity production in te APS of ERIA's Energy Outlook 2016 is 5.9% while in the revised APS, the rate is slower, at 4.8% per year.

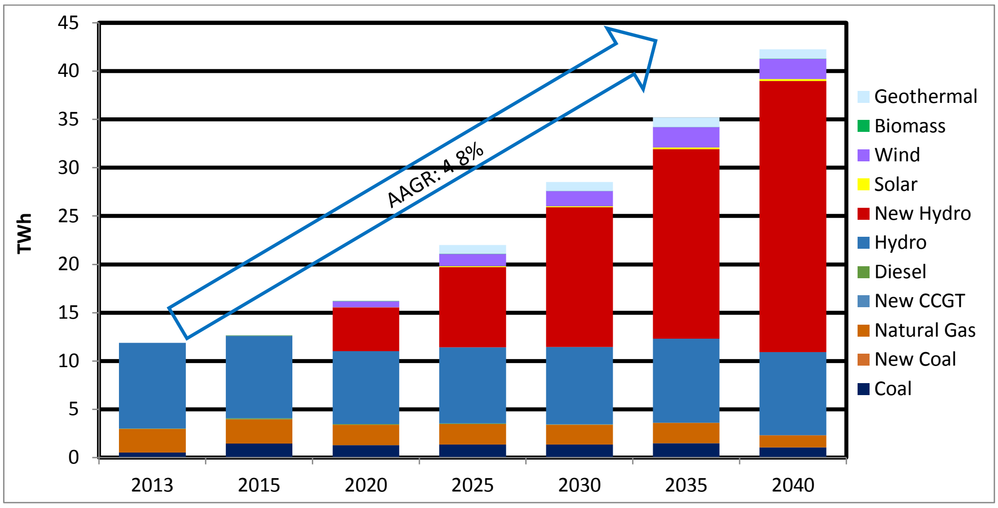
Figure 2G.8. Power Generation in ERIA's Energy Outlook 2016 APS



AAGR = Average Annual Growth Rate, APS = Alternative Policy Scenario, CCGT = Combined Cycle Gas Turbine, ERIA = Economic Research Institute for ASEAN and East Asia, TWh = terawatt hour.Source: Author's calculations.

Around 95% of the total generation comes from renewable energy in the revised APS while the rest will come from the fossil-fuelled power plants. In APS of ERIA's Energy Outlook 2016, the renewable share in total generation is 79%.

Figure 2G.9. Power Generation by Type in the Revised APS

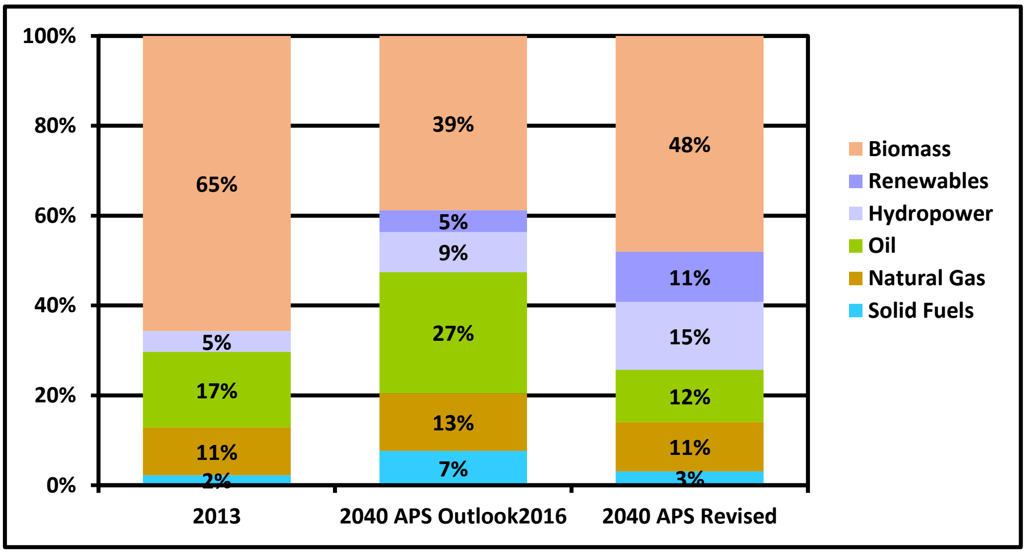


AAGR = Average Annual Growth Rate, APS = Alternative Policy Scenario,
CCGT = Combined Cycle Gas Turbine.
Source: Author's calculations.

Primary Energy Supply

With revised EE target, biofuel penetration, and increased share of renewable energy in the power sector, the total primary energy supply of the revised APS will almost be 21 Mtoe in 2040, around 28% lower than in APS of ERIA's Energy Outlook 2016 (Figure 2G.10). In terms of share in the total energy mix, 74% comes from renewable energy including biomass.

Figure 2G.10. Primary Energy Supply

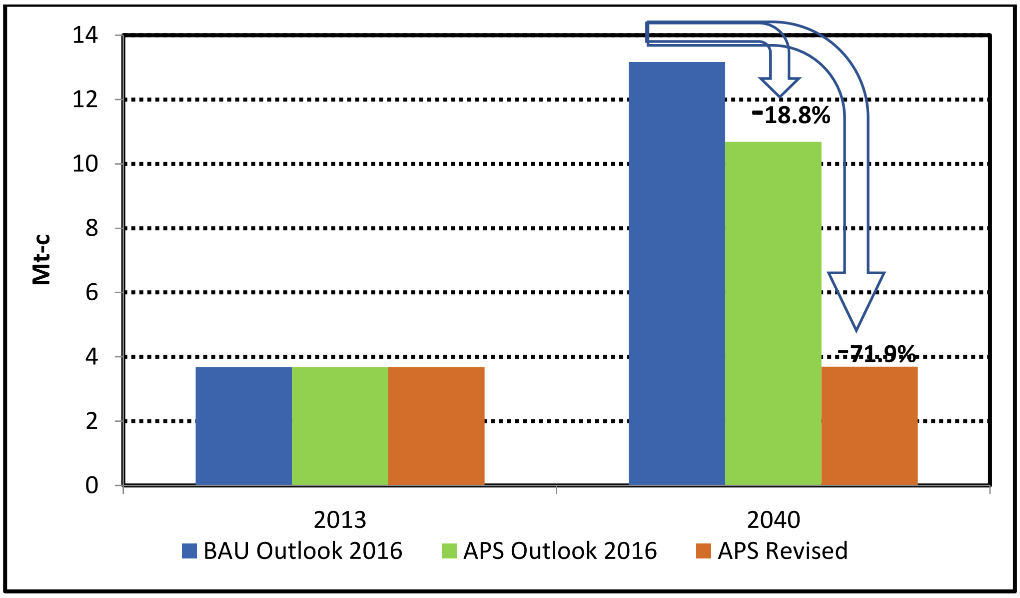


APS = Alternative Policy Scenario.
Source: Author's calculations.

CO_2 Emissions

The resulting carbon dioxide (CO_2) emissions of the revised APS, which are assumed to be the same as the base year value (3.7 Mt-C), are almost 72% lower than the level in APS of ERIA's Energy Outlook 2016, which are 10.7 Mt-C (Figure 2G.11).

Figure 2G.11. CO_2 Emissions Reduction by 2040



APS = Alternative Policy Scenario, BAU = Business as Usual, CO_2 = carbon dioxide, Mt-C = metric tonne of carbon.

Source: Author's calculations.

Conclusion

ERIA's Energy Outlook 2016 results in total CO_2 emissions of almost 13.2 Mt-C by 2040 for the BAU scenario and 10.7 Mt-C for APS. For the total CO_2 emissions in 2040 to be the same as that of 2013 (3.7 Mt-C), efforts in the revised APS have to be more stringent that those in APS of ERIA's Energy Outlook 2016.

Revising the EE target, the biofuel penetration, and increasing the share of renewables in power generation have made it possible for the total CO_2 emissions of the revised APS to be similar to the base year level. The CO_2 emissions reduction in APS of ERIA's Energy outlook 2016 is around 19% by 2040, while the revised APS will result in a 72% reduction compared to the BAU scenario.

2H. The Philippines' Case Study

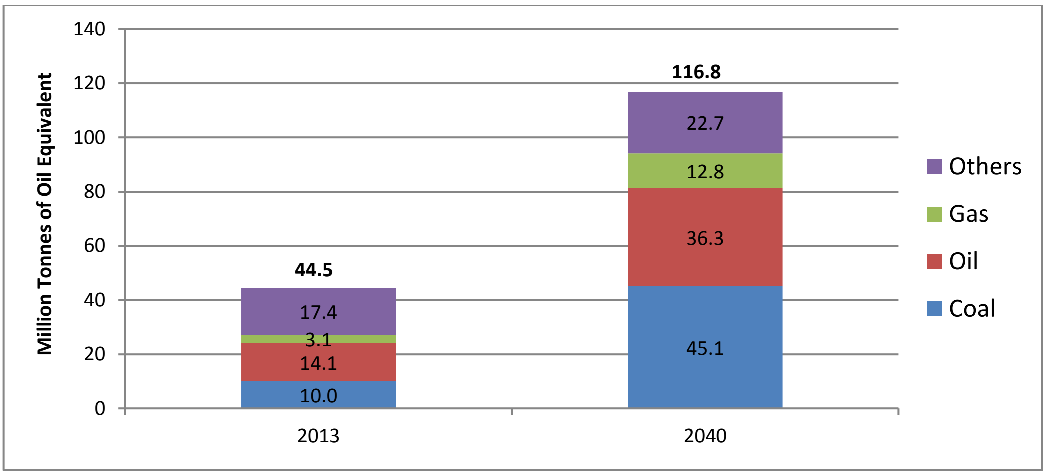
Keeping CO_2 Emissions at 2013 Level by 2040

Introduction

Based on report of the Economic Research Institute for ASEAN and East Asia (ERIA) on the energy supply and demand outlook for the Business as Usual (BAU) scenario for the period 2013–2040, the Philippines' primary energy consumption is expected to increase by 3.6% per year from its 2013 level of 44.5 metric tonnes of oil equivalent (Mtoe) to 116.8 Mtoe in 2040. Consumption for all major energy sources is projected to increase during the period, with coal growing the fastest at 5.7% per year. During the same period, natural gas is also expected to expand with a growth rate of 5.4% per year, while oil growth rate is estimated at 3.6% per year. On the other hand, major renewable energy consumption from geothermal and hydropower will come at an average growth rate of 1.7% and 1.5%, respectively, while the aggregated consumption of other fuels can be expected at a meagre level of 0.1% growth rate.[1]

Coal will account for the largest share in the total energy supply of the country by 2030 up to the end of the period, reaching 38.6% share by 2040. Oil and natural gas, being part of the country's major energy sources, are projected to register the shares of 31.1% and 11.0%, respectively, at the end of the period. Geothermal and hydropower, mainly used for power generation, will register shares of 11.1% and 1.1%, respectively. Meanwhile, the requirements for other fuels in 2040 will comprise the 7.2% share in the supply mix (Figure 2H.1).

Figure 2H.1. Primary Energy Consumption by Source, BAU Scenario, 2013 and 2040



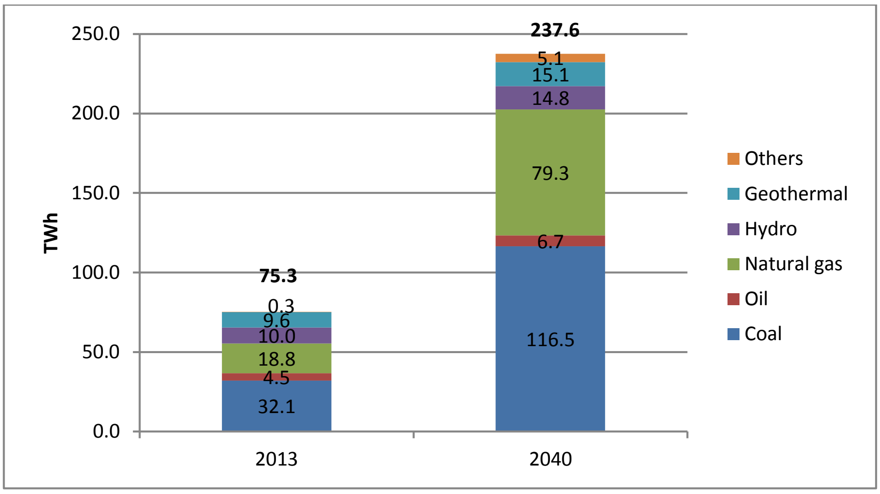
BAU = Business as Usual.
Source: Author's calculations.

The country's total power generation in 2013 reached 75.3 terawatt hours (TWh) and is

[1] ERIA 2015 Energy Supply and Demand Outlook Report - Philippines

expected to increase by 4.3% yearly across the planning period. Coal remained the major source in power generation in 2013, accounting for an average share of 42.6%. At the end of the planning period, the share of coal is expected to be at 49.1%, as its level will increase at an annual average rate of 4.9%, from 32.1 TWh in 2013 to 116.5 TWh in 2040. Natural gas, as the second biggest source of power generation, will increase its output from 18.8 TWh in 2013 to 79.3 TWh in 2040, at an average rate of 5.5% a year. On the other hand, oil's share to generation mix will continue to decline, reaching a measly 2.8% share by 2040. Hydropower and geothermal power generation are expected to grow at a steady rate of 1.4 and 1.7% a year, respectively. Other sources of power generation, an aggregate output from solar, wind, and biomass resources, are expected to increase at an annual average rate of 11.4% (Figure 2H.2).

Figure 2H.2. Power Generation by Source, BAU, 2013 and 2040



BAU = Business as Usual.
Source: Author's calculations.

Sensitivity Analysis on the Level of GDP Growth Rate to the Primary Energy Consumption

The purpose of simulating high and low gross domestic product (GDP) scenarios is to analyse the effect of one unit increase or decrease of GDP growth rate at the level of primary energy consumption. It is somehow related to measuring the energy intensity per unit of economic output. As shown in Table 2H.1, high GDP scenario will increase by 1 percentage point from 2016 to 2040 from the BAU scenario level. By contrast, low GDP scenario will decrease by 1 percentage point from the BAU scenario level during the period.

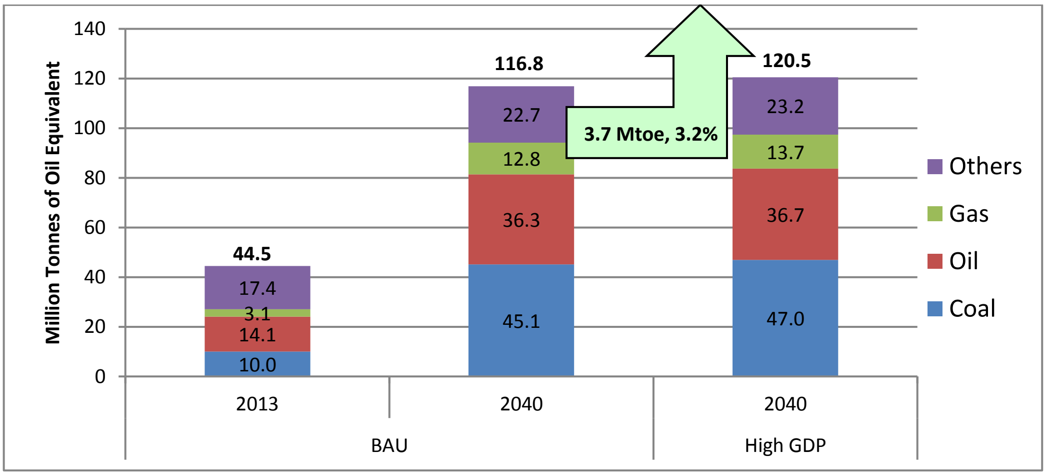
Table 2H.1. GDP Growth Rate (BAU, High GDP and Low GDP), 2013–2040

BAU scenario	Base year: 2013 Growth (2013, 7.1%; 2014, 6.1%; 2015, 5.8%; 2016–2020, 6.2%; 2021–2026, 6%; 2027–2029, 5.8%; 2030–2040, 5.5%)
High GDP scenario	Base year: 2013 Growth (2013, 7.1%; 2014, 6.1%; 2015, 5.8%; 2016–2020, 7.2%; 2021–2026, 7%; 2027–2029, 6.8%; 2030–2040, 6.5%)
Low GDP scenario	Base year: 2013 Growth (2013, 7.1%; 2014, 6.1%; 2015, 5.8%; 2016–2020, 5.2%; 2021–2026, 5%; 2027–2029, 4.8%; 2030, 4.5%)

BAU = Business as Usual, GDP = gross domestic product.
Source: Author's assumptions.

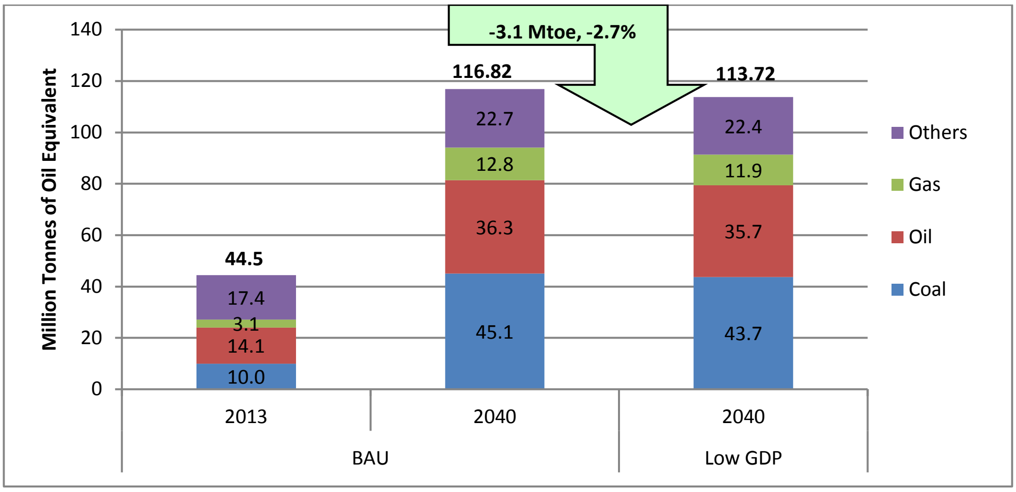
As a result of the simulation made, a percentage point increase of economic output may require additional 3.2% of energy supply in 2040, while a decrease of a percentage point in economic output may defer 2.7% of energy requirement during the period. The effect of 1 percentage point increase or decrease of GDP growth to the primary energy consumption is approximately 3% plus or minus. In high GDP scenario, natural gas will increase the highest at 7.0% in 2040 in comparison with the BAU level of the same period while coal will also increase significantly by 4.2% (Figure 2H.3). Low GDP scenario, on the other hand, has almost the same trend with high GDP scenario but in the opposite direction in such a way that natural gas and coal will decrease by 7.3% and 3.0%, respectively, in 2040 compared with the BAU scenario (Figure 2H.4).

Figure 2H.3. Primary Energy Consumption, BAU and High GDP, 2013 and 2040



BAU = Business as Usual, GDP = gross domestic product.
Source: Author's calculations.

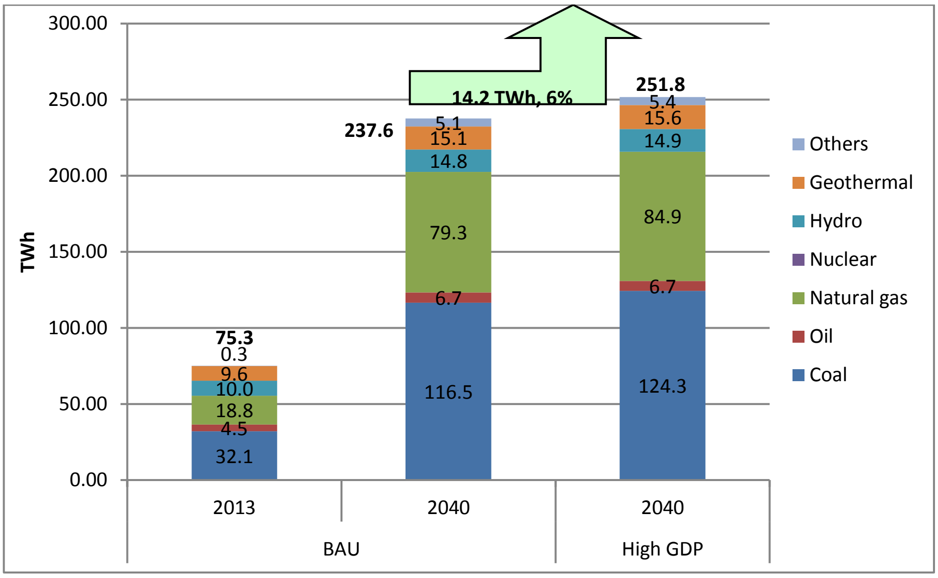
Figure 2H.4. Primary Energy Consumption, BAU and Low GDP, 2013 and 2040



BAU = Business as Usual, GDP = gross domestic product.
Source: Author's calculations

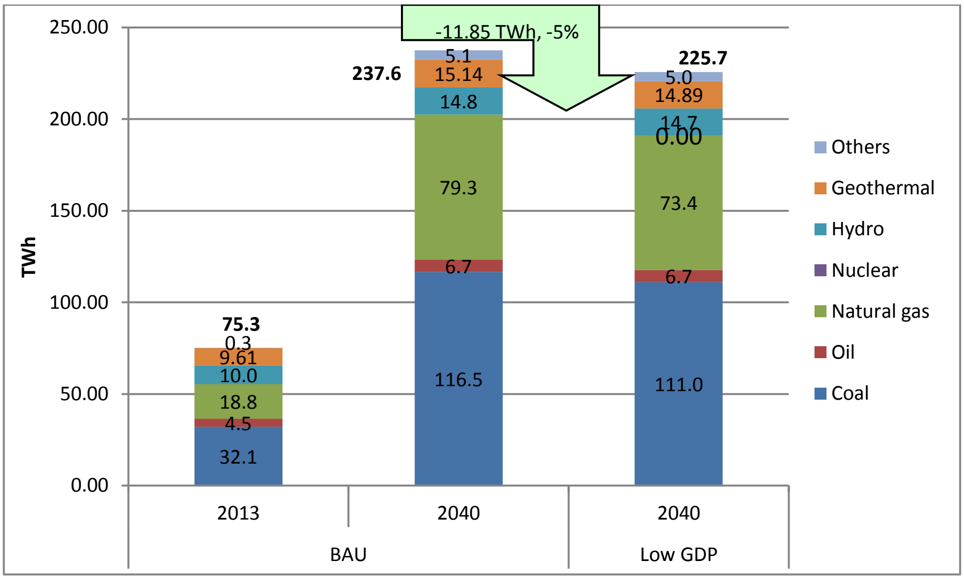
In power generation, the high GDP scenario will register a total generation output of 251.8 terawatt hours (TWh), a 6-% increase from the BAU scenario in 2040 (Figure 2H.5). Majority of increase will come from fossil fuel sources such as coal and natural gas at 6.6% and 7.0%, respectively. A combine generation output from other renewables such as wind, solar, and biomass resources will also increase significantly by 4.8% during the period. On the other hand, the low GDP scenario will account for a total of 225.7 TWh generation output in 2040, a 5-% level of reduction from the BAU scenario during the period (Figure 2H.6). On this account, coal and natural gas will be reduced by 4.7% and 7.4%, respectively, while an aggregate generation output from other renewables will reduce by 2.0%.

Figure 2H.5. Power Generation by Source of Energy, BAU and High GDP, 2013 and 2040



BAU = Business as Usual, GDP = gross domestic product, TWh = terawatt-hour.
Source: Author's calculations.

Figure 2H.6. Power Generation by Source, BAU and Low GDP, 2013 and 2040



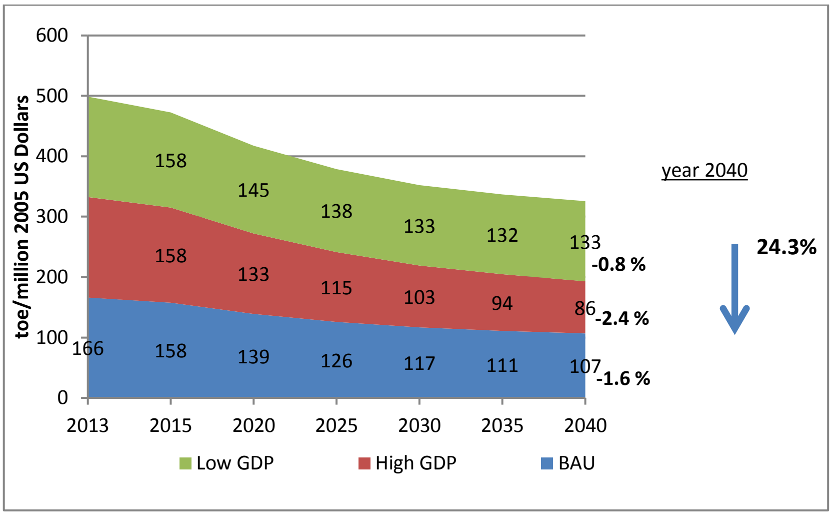
BAU = Business as Usual, GDP = gross domestic product, TWh = terawatt hour.

Source: Author's calculations.

In terms of energy and economic account, the impact of a percentage point increase in GDP growth rate in 2040 is indicated by the 19.3% reduction on energy intensity (ratio of final energy consumption and GDP in toe/million US$ 2005) in comparison with the BAU scenario level. On the other hand, a reduction of a percentage point in GDP growth rate will register a 24.3%

increase in energy intensity from the BAU scenario in 2040. However, considering the annual average growth rate of energy intensity from 2013 to 2040 by scenario, the effect of an increase and decrease by a percentage point in GDP growth rate in energy intensity is plus and minus -0.8% (Figure 2H.7).

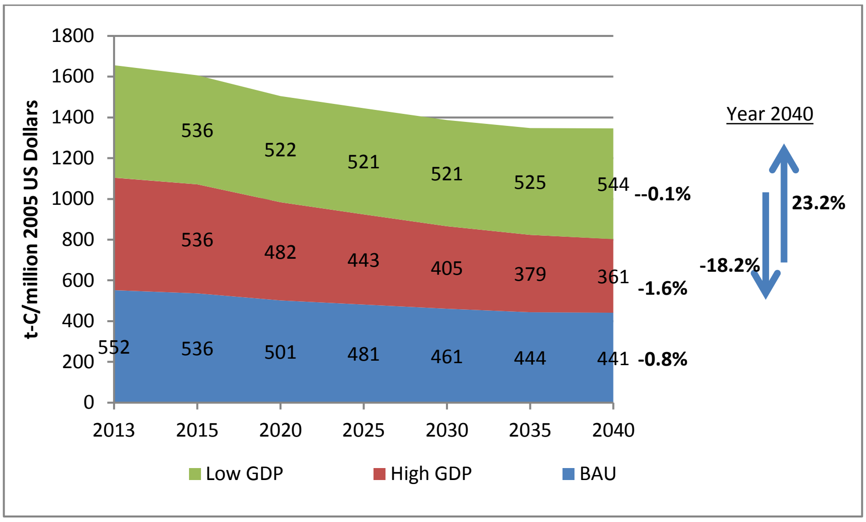
Figure 2H.7. Final Energy Consumption per Unit of GDP, BAU, High and Low GDP, 2013– 2040



BAU = Business as Usual, GDP = gross domestic product, toe = tonne of oil equivalent.
Source: Author's calculations.

For carbon dioxide (CO_2) emission per unit of GDP (t-C/million 2005 US$), the high GDP scenario will register a 19.3-% reduction in 2004 from the BAU scenario level. By contrast, CO_2 emission per unit of GDP in the low GDP scenario will increase significantly by 24.3% during the period (Figure 2H.8). In terms of annual average growth rate for 2013–2040, the impact of a percentage point increase and decrease on GDP growth rate for the CO_2 emission per unit of GDP will be -0.8% and 0.7%, respectively.

Figure 2H.8. CO_2 Emission per Unit of GDP, BAU, and High and Low GDP, 2013 and 2040

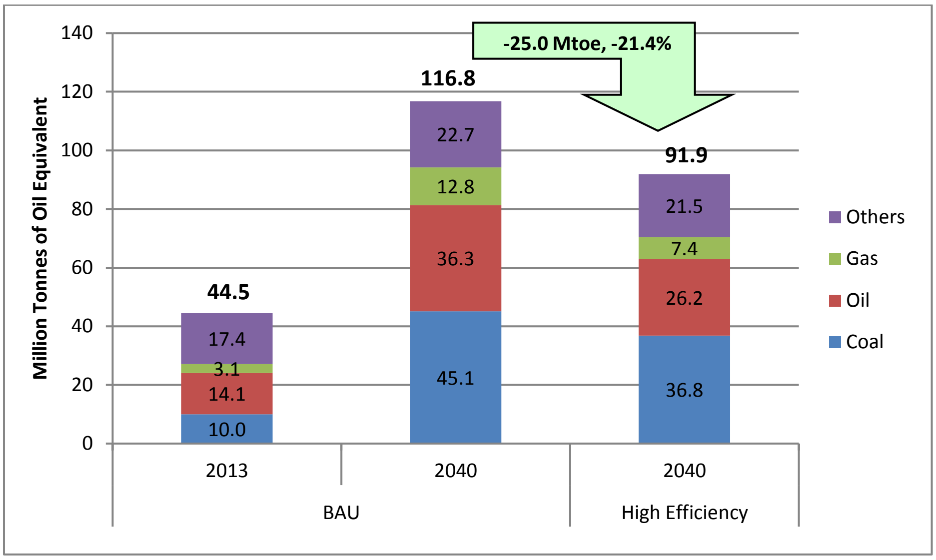


BAU = Business as Usual, CO_2 = carbon dioxide, GDP = gross domestic product, t-C = tonne of coal.
Source: Author's calculations.

Sensitivity Analysis on Setting Higher Energy Efficiency Target in the Demand Sector to the Primary Energy Consumption Level

In the high energy efficiency scenario, the 30-% energy saving target for each of the industry, transport, residential, and commercial sectors is assumed to be realised by the end of the period. This target will reflect a 21.4-% reduction on primary energy consumption in 2040 based on the BAU level for the same period (Figure 2H.9). The reduction on primary energy consumption will be derived mainly from fossil fuel sources such as coal (18.4%), oil (27.7%), and natural gas (42%). At least a 5.4-% reduction on energy requirement from renewables is expected by 2040 under this scenario.

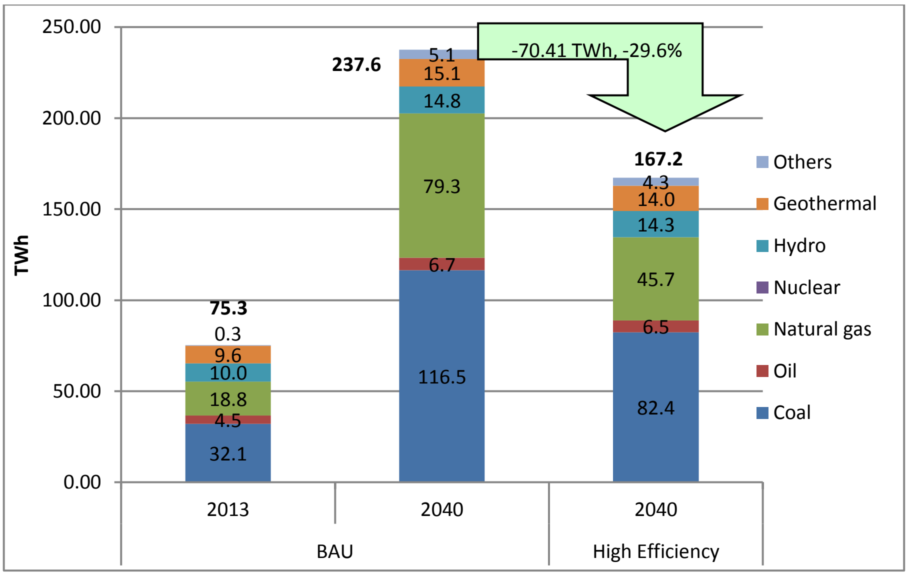
Figure 2H.9. Primary Energy Consumption, BAU and High Energy Efficiency, 2013 and 2040



BAU = Business as Usual, Mtoe = metric tonne of oil equivalent.
Source: Author's calculations.

For the high energy efficiency scenario, there will be a 29.6-% reduction on generation output in 2040 from the BAU level (Figure 2H.10), mostly from coal and natural gas at 29.3% and 42.4%, respectively.

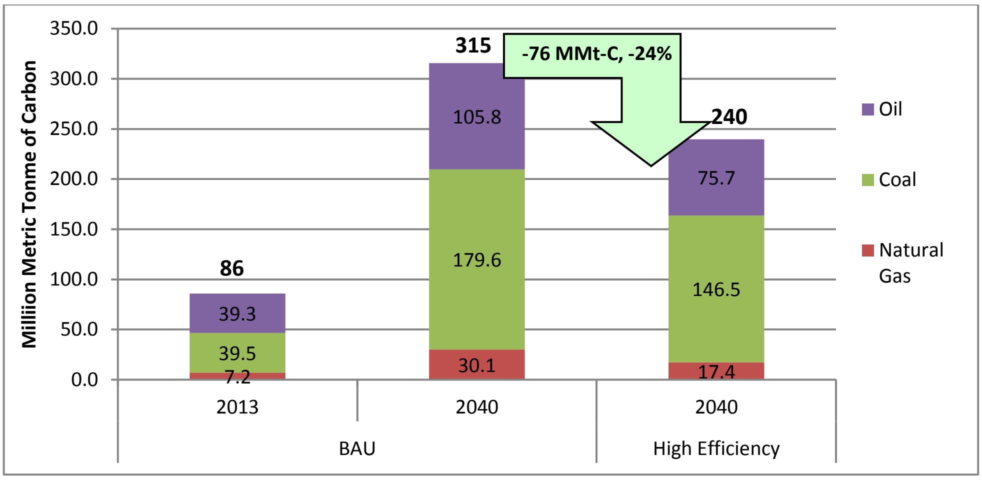
Figure 2G.10. Power Generation by Source, BAU, and High Energy Efficiency, 2013 and 2040



BAU = Business as Usual, TWh = terawatt hour.
Source: Author's calculations.

Achieving a 30-% energy saving target will reflect CO_2 emissions reduction of 24% in 2040 from the BAU scenario level. As the sources of CO_2 (coal, oil, and gas) emissions will be reduced by about 25%, a 24-% reduction on CO_2 emissions is expected in 2040 as compared with the BAU level (Figure 2H.11).

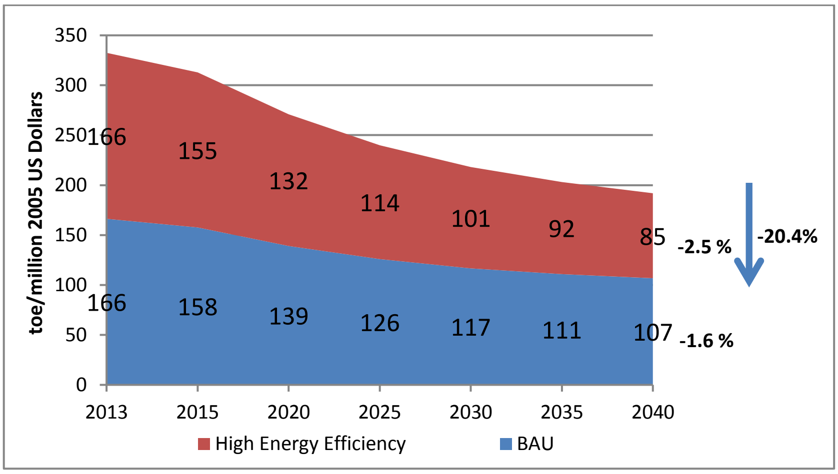
Figure 2H.11. CO_2 Emissions by Source of Energy, BAU, and High Energy Efficiency, 2013 and 2040



BAU = Business as Usual, CO_2 = carbon dioxide, MMt-C = million metric tonne of carbon.
Source: Author's calculations.

Energy intensity for the high energy efficiency scenario will be declined by 20.4% in 2040 in comparison with the BAU scenario level. Considering the annual average growth rate of energy intensity for the entire period, the effect of the 30% energy saving from each major economic sector is the reduction of energy intensity by 0.8% from the BAU scenario level (Figure 2H.12).

Figure 2H.12. Final Energy Consumption per Unit of GDP, BAU and High Energy Efficiency, 2013– 2040

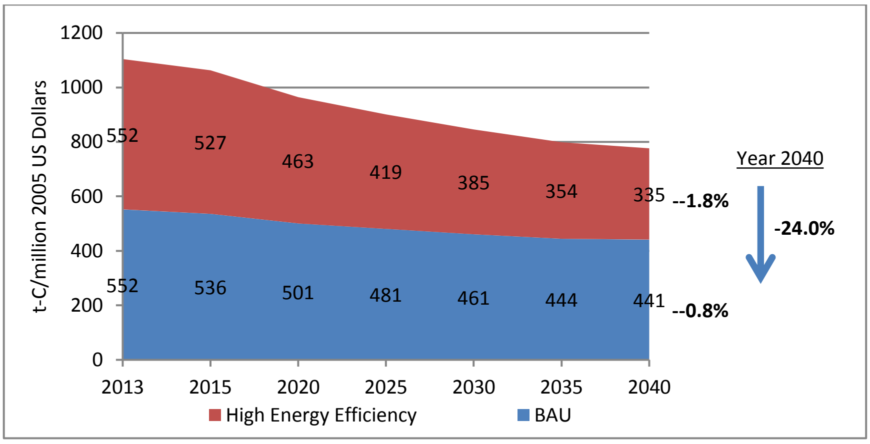


BAU = Business as Usual, GDP =gross domestic product, toe = tonne of oil equivalent.

Source: Author's calculations.

On the other hand, the CO_2 emission per unit of GDP will be declined by 24% in 2040 from the BAU scenario level. In terms of annual average growth rate from 2013 to 2040, the CO_2 emission per unit of GDP is expected a reduction of 1% in comparison with the BAU scenario level (Figure 2H.13).

Figure 2H.13. CO_2 Emission Per Unit of GDP, BAU and High Energy Efficiency, – 2013 and 2040



BAU = Business as Usual, CO_2 = carbon dioxide, GDP = gross domestic product, t-C = tonne of carbon.
Source: Author's calculations.

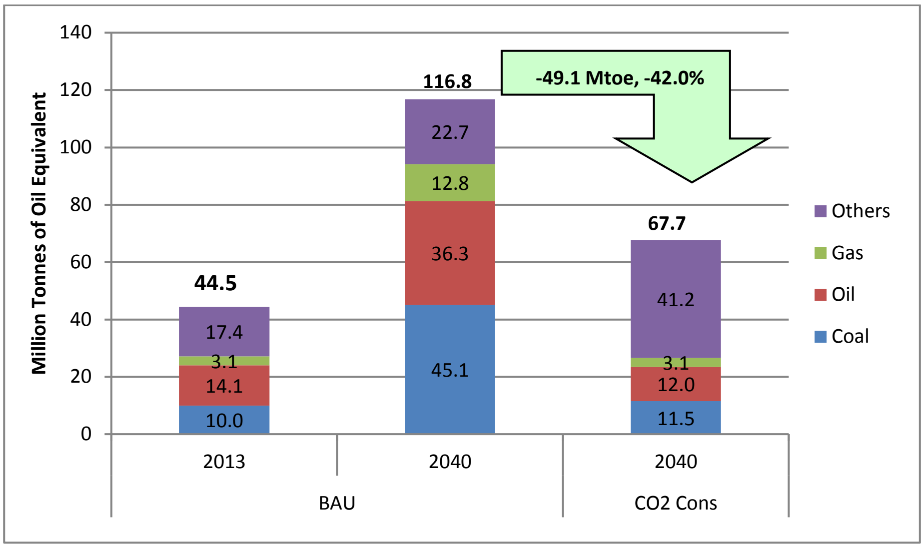
Feasible Solutions on Mitigating CO_2 Emissions in 2040

In the CO_2 constraint scenario, the condition is to limit the CO_2 emissions level in 2040 to be equal to the emissions level of 2013. Trial and error simulations have been made to find out the best solution to satisfy the requirement of this scenario. In the case of the Philippines, it may not be possible to achieve this kind of target since based on the BAU scenario, the share of fossil fuel in the total primary energy consumption in 2040 will be more than 80%. However, to address this condition as part of mitigation measures to constraint the level of emissions in 2040, the following assumptions have been instituted as a result of feasible solution of model simulation:

- Seventy percent energy savings from oil and coal demand for the non-power application and 46% savings from electricity demand.
- Improve thermal efficiency of coal power plant by 2020 from 36% to 44% by prioritising the project for high-efficient coal plant such as supercritical and ultra-supercritical technology (2,200 MW additional capacities).
- Improve thermal efficiency of gas power plant (CCGT) by 2021 up to 60% (2,100 MW additional capacities).
- 1.200 MW additional power capacities from nuclear power plant from 2023 to 2040.
- Additional capacities from wind, solar, and biomass sources from the BAU scenario at 1,927 MW, 2,299 MW, and 198 MW, respectively, from 2015 to 2040.
- Achieving the target of increasing the total installed capacity of hydropower and geothermal power in 2040 at 10,606 MW and 5,856 MW, respectively, from total installed capacity of hydropower at 4,644 MW and geothermal power at 2,109 in the BAU scenario by 2040.

As a result of model simulation for CO_2 constraint scenario in consideration with the specified assumptions, the primary energy consumption in comparison with the BAU scenario will be reduced by 42% in 2040 (Figure 2H.14). The reduction in energy requirements in 2040 will come from fossil fuel sources such as coal (74.6%), oil (67.1%), and gas (75.5%). By contrast, an aggregate supply from other energy sources such as renewables and other new technologies will significantly increase by 81.6% at the end of the planning period.

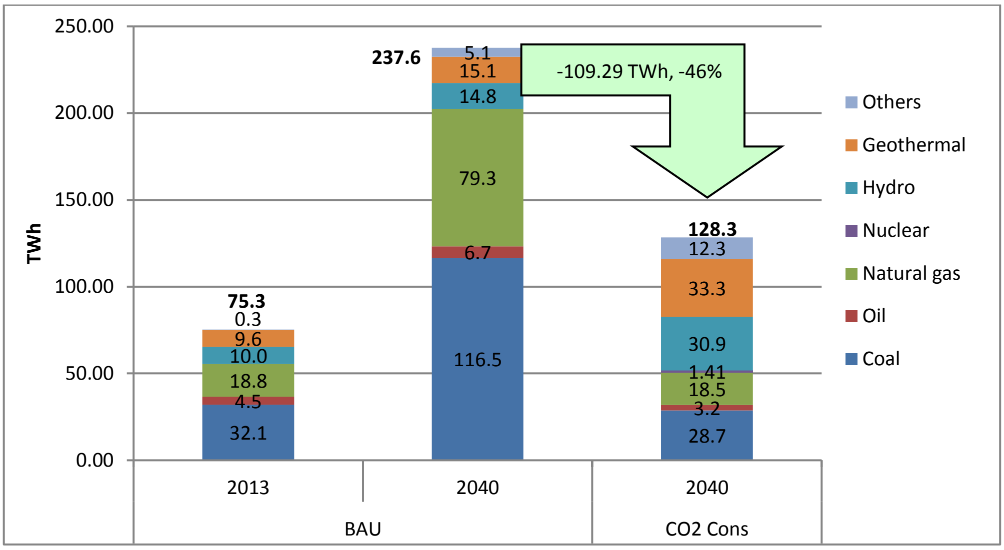
Figure 2H.14. Primary Energy Consumption, BAU, and CO_2 Cons, 2013 and 2040



BAU = Business as Usual, CO_2 = carbon dioxide, Mtoe = metric tonne of oil equivalent.
Source: Author's calculations.

In power generation, the reduction in generation output is expected to be at 46% level in 2040 from the BAU scenario (Figure 2H.15). An aggregate fossil fuel reduction as a source of power generation is anticipated at about 75% while other sources of energy will significantly increase their generation output by around 122% during the period.

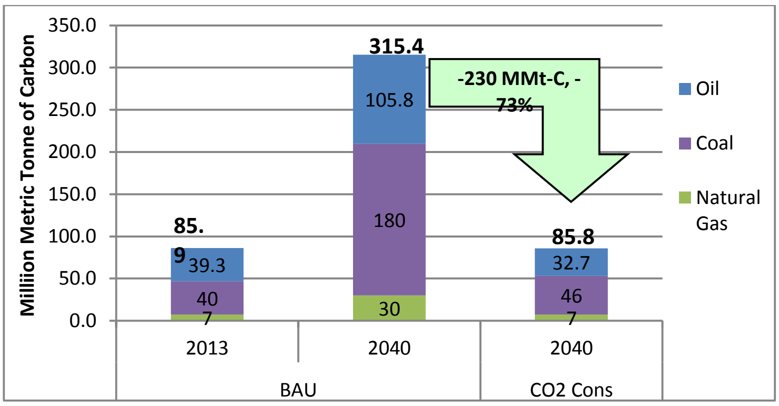
Figure 2H.15. Power Generation by Source, BAU and CO_2 Cons, 2013 and 2040



BAU = Business as Usual, CO_2 = carbon dioxide, TWh = terawatt hour.
Source: Author's calculations.

It can be observed that the CO_2 emissions level in 2040 will be at the same level with 2013 emissions (Figure 2H.16). This can only happen if the CO_2 emissions from the BAU scenario in 2040 at 315.4 metric tonnes of carbon (Mt-C) can be reduced by 230 Mt-C. In the CO_2 constraint scenario, fossil fuel application from transformation to final end-use sector was abruptly reduced to satisfy the given condition of CO_2 mitigation measure at the end of the planning period.

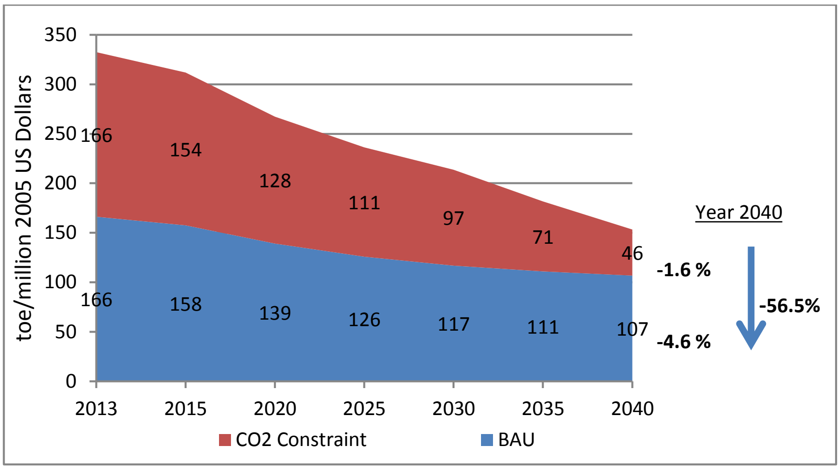
Figure 2H.16. CO_2 Emission by Source of Energy, BAU and CO_2 Cons, 2013 and 2040



BAU = Business as Usual, MMt-C = million metric tonne of carbon.
Source: Author's calculations.

Energy intensity in the CO_2 constraint scenario will be reduced by 56.5% in 2040 compared with the BAU scenario level (Figure 2H.17). Likewise, a decline by 3 percentage point in the annual average growth rate of energy intensity from 2013 to 2040 is expected.

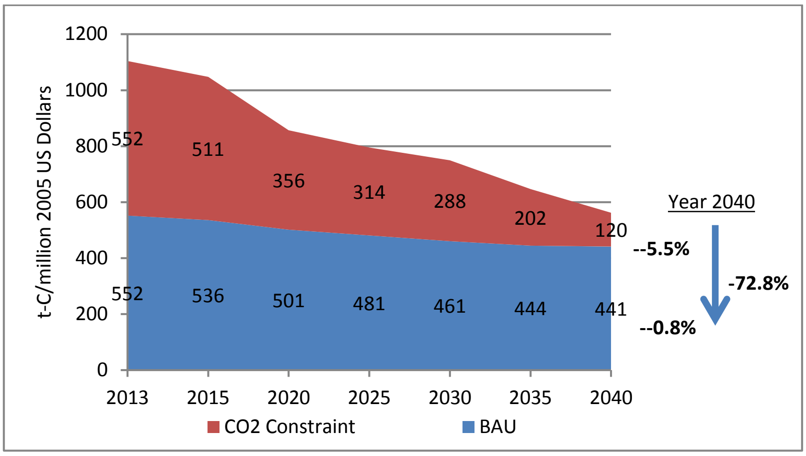
Figure 2H.17. Final Energy Consumption per Unit of GDP, BAU and CO_2 Constraint, 2013–2040



BAU = Business as Usual, CO_2 = carbon dioxide, GDP = gross domestic product, toe = tonne of oil equivalent.
Source: Author's calculations.

As a result of limiting the 2040 emissions level, a 72.8% reduction in CO_2 emission per unit of GDP is anticipated (Figure 2H.18). The level of CO_2 emission per unit of GDP in terms of annual average growth from 2013 to 2040 will register a negative 5.5%, a 4.7 percentage point reduction from the BAU scenario level of negative 0.8%.

Figure 2H.18. CO_2 Emission Per Unit of GDP, BAU and CO_2 Constraint, 2013 and 2040



BAU = Business as Usual, GDP = gross domestic product, t-C = tonne of carbon.
Source: Author's calculations.

Conclusion and Recommendation

In the case of the Philippines, without further policy intervention in mitigating CO_2 emissions, an average growth rate of CO_2 emissions from 2013 to 2040 can be estimated at about 5% yearly. This is because the country is highly dependent on the use of fossil fuel, which is projected to be more than 70% by 2040 in terms of its share in the total primary consumption based on the BAU scenario. Likewise, fossil fuel contribution in power generation will reach more than 80% of the total generation output in 2040. The fact that fossil fuel for power and non-power application are reliable energy sources such as coal in power sector and oil in transport sector, it may not be very possible to change the demand mix sharply to be more leaning to a utilisation of cleaner energy even in the long-term. Achieving high renewable energy utilisation target in power generation may not be enough to reduce the fossil fuel contribution abruptly in the power sector in view of the country's first and foremost challenge which is the stability of power supply. In this regard, the country should also need to be focused on the strict implementation of energy conservation and efficiency programmes and promotion of alternative fuels and technologies. For instance, coal is becoming a very important fuel in the industry sector for non-power demand due to its high utilisation in cement production. In the CO_2 constraint scenario, utilisation of coal in non-power application has been reduced by 70% as part of the solution to satisfy the condition in limiting CO_2 emissions in 2040. In reality, however, there is no strict policy and programme to reduce utilisation of coal for non-power application in the country. If intensive coal utilisation is inevitable, there must be a policy to impose the use of clean coal and efficient technology for its power and non-power application. Likely, it is not possible to reduce oil demand sharply in the transport sector, although its demand level in the CO_2 constraint scenario has been reduced by 70%. However, if there is a policy intervention for massive replacement of oil-fuelled vehicles in the transport sector to be substituted by alternative fuels and technologies like electric and biofuel vehicles, it may be possible to reduce oil demand significantly in the sector.

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2I.Singapore's Case Study

Keeping CO_2 Emissions at 2013 Level by 2040

Study Objectives and Assumptions

This study is a follow-up exercise based on the Business as Usual (BAU) results of primary energy consumption and carbon emissions for Singapore from the 2016 report of the Economic Research Institute for ASEAN and East Asia (ERIA). The main objective is to find out the extent in which Singapore will have to increase its mitigation efforts to reduce carbon emissions to 2013 levels by 2020. An alternative aggressive Alternative Policy Scenario (APS) is set in a hypothetical sense, which does not assume any cost and other resource constraints[1]. The assumptions made for the APS are as follows:

1) All fuel use for final energy demand in the industry sector is reduced by 45% (10% for APS5) in 2040.
2) All fuel use for final energy demand in the residential sector is reduced by 23% (7.5% for APS5) in 2040.
3) For commercial buildings, fuel use for final energy demand is assumed to reduce by 40% (20% for APS5) in 2040.
4) Transport fuel consumption for final energy demand is assumed to decrease by an AAGR of 0.5% from 2018 onwards.
5) Naphtha demand is assumed to experience 0% growth to 2040.
6) For power generation, policy measures are assumed to have the following impact:

i) Solar power gradually increases to 22% of the total electricity generation in 2040 (8% for APS5).

ii) The efficiency of both CCGT and OCGT power plants improve by 15% and 8% from 2013 levels.

Outlook Results

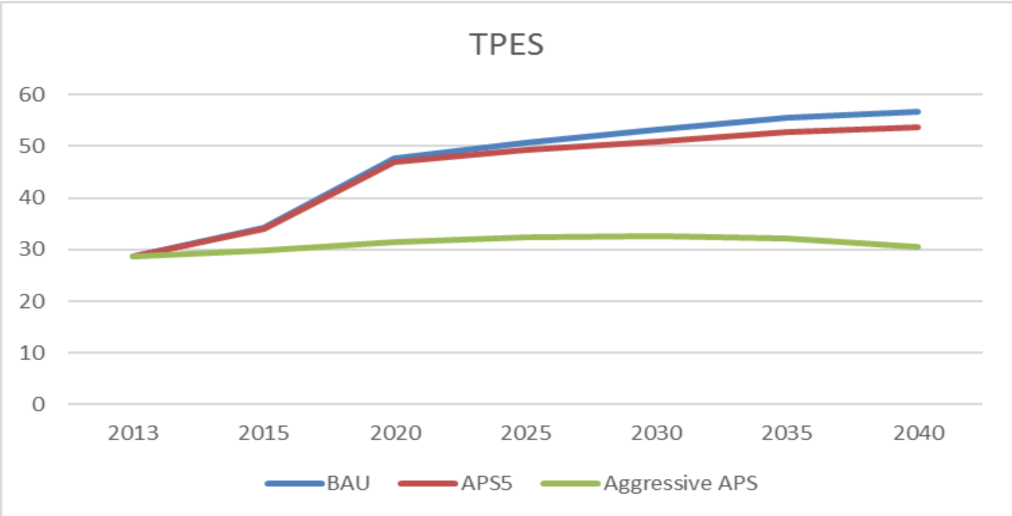
Total primary energy supply

Based on the above assumptions, APS will lead to a 46% reduction relative to BAU, with base year set at 2013, in total primary energy supply (TPES) in 2040. This is much greater than the 5.2% reduction achieved in APS5 (Figure 2I.1). Aggregate TPES in 2040 is 30.6 metric tonnes of oil equivalent (Mtoe), as compared to 56.6 Mtoe for BAU. Oil consumption remains relatively

[1] The APS does not reflect the national position for climate policies, and hence should only be taken as an academic exercise.

stable, increasing at only 5.7% from 19.22 Mtoe in 2013 to 20.32 Mtoe in 2040. Natural gas consumption will peak sometime in 2025–2030, before decreasing to 8.49 Mtoe in 2040. This represents an AAGR of -1.8% from 2030 to 2040. Biomass consumption increases at an AAGR of 0.6% from 2013 to 2040. The largest increase comes from solar power, which will rise by 28% from 0.0014 Mtoe to 1.07 Mtoe in 2040. In terms of proportion, oil will make up two-thirds of the total TPES, with natural gas next at 27.7%. Renewables including solar power will make up 5% of the TPES.

Figure 2I.1. Total Primary Energy Supply (TPES)



BAU = Business as Usual, APS = Alternative Policy Scenario.
Source: Author’s calculations.

Final energy demand

The total final energy demand will increase by an AAGR of 0.6% from 2013 to 2040 if aggressive policies are set to reduce carbon dioxide (CO_2) emissions in the economy. This increase would be largely driven by industry, which increased at an AAGR of 1.5% from 6.92 Mtoe to 8.87 Mtoe. Other sectoral energy use remains largely constant over time, all of which increase only marginally at rates of up to an AAGR of 0.4. In terms of fuel use, natural gas demand will rise the fastest to 2.23 Mtoe in 2040, which is a 71% increase from 2013 levels.

Power generation

Taken separately from final energy demand, electricity demand will be predominantly supplied by natural gas at 43.7 Mtoe, although renewables (solar + biomass energy) will rise at an AAGR of 9% to 14.09 Mtoe in 2040.

CO_2 reduction potential

If emissions are constrained to reach 2013 levels in 2040, the share of natural gas in contributing to this amount would be 60% by 2040, with a slight decline from 2013 levels at 5.4 Mtoe. CO_2 emissions from oil remain largely stable but peak at around 2030. This represents savings of 57% from BAU levels.

Policy Implications

The results highlighted here are driven mainly by aggressively constraining TFEC across all the sectors from 23% to 45%. Such assumptions are very ambitious since such reduction will impact on the economy and are not considered for this scenario. In addition, the assumptions for solar penetration in electricity generation would also be over-achieving at 22% in 2040 since the Solar Research Institute of Singapore predicts only a 10–20% penetration from solar power by 2050 (Tan, 2016).

The results from APS5 are hence still more realistic when it comes to determining further energy savings potential and will require a 'whole-of-government' approach and collaboration by private industries to achieve the emissions reduction associated with it.

References

Tan, A. (2016), 'Cutting emissions by tapping the sun', *The Straits Times.* 18 March

2J.Thailand's Case Study

Keeping CO_2 Emissions at 2013 Level by 2040

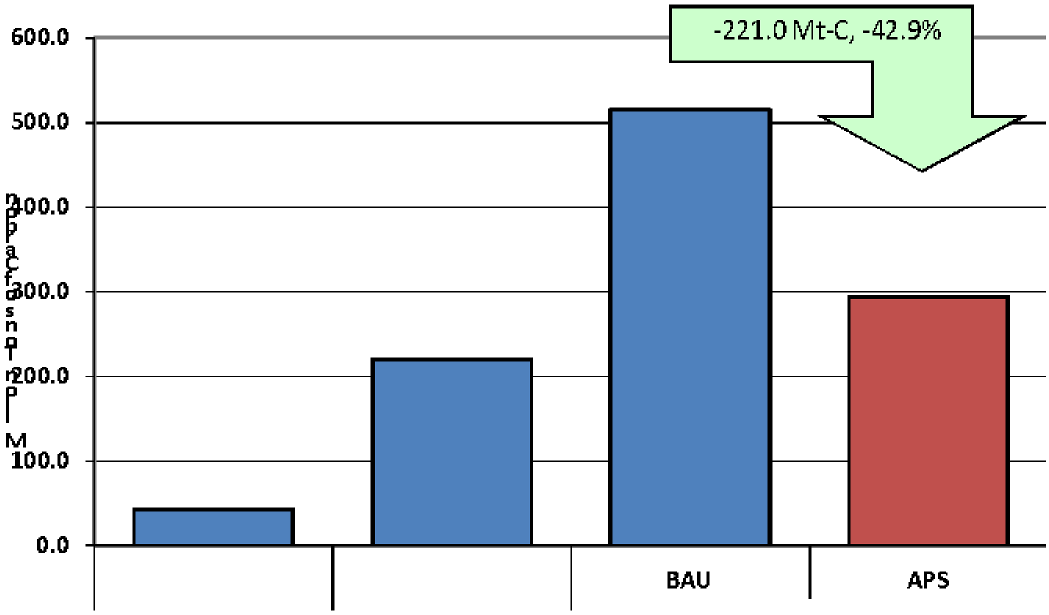
Introduction

This chapter discusses a scenario of Thailand contributing in mitigating carbon dioxide (CO_2) emissions in 2040 to the emissions level of 2013. Through national energy policies and plans, Thailand faces the challenge of a trade-off between greenhouse gases (GHG) and future energy consumption. Achieving energy efficiency and use of non-carbon energy might not be an easy goal for the country. If the national energy plan alone is not adequate, the analysis here might provide additional input to make the target a success.

Energy Consumption and CO_2 Emissions in 2040 BAU and APS

Based on the 2016 energy model, the results in 2040 of Alternative Policy Scenario (APS)-5 (all four APSs combined) could cut down Thailand's primary energy consumption by 91.7 metric tonnes of oil equivalent (Mtoe) from BAU's 2040 level of 301.5 Mtoe to 209.7 Mtoe of APS-5. In the BAU case, CO_2 emissions will increase to around 3.2% per year from 220.5 metric tonnes of carbon dioxide equivalent ($MtCO_2e$) in 2013 to 515.2 $MtCO_2e$ in 2040. When BAU combines national policy and main energy efficiency plan, renewable development plan, and power development plan, it will reduce CO_2 from energy consumption by around 221.0 $MtCO_2e$ or 42.9% reduction compared to BAU (see Figure 2J.1).

Figure 2J.1. Primary Energy and CO_2 Mitigation, APS-5 (combined)



APS = Alternative Policy Scenario, BAU = Business as Usual, Mt-C = metric tonne of carbon, Mtoe = metric tonne of oil equivalent.
Source: Author's calculations.

Even though APS-5 would be able to reduce CO_2 emissions, , efforts to mitigate CO2 emission to the 2013 level will not be achieved because emissionS in APS-5 will be at 290 Mton-CO2eq higher than emissionS at 2013 level (220 Mton-CO_2eq). If CO_2 mitigation to the 2013 level will be applied to such a scenario, Thailand will need to put more efforts to its present policy and plan.

Mitigating CO_2 Emissions in 2040 to the 2013 Level

To mitigate CO_2 emissions to the 2013 level, Thailand would have to go beyond its national energy plans. To achieve the target, several ways have been planned:

- Use LEAP model to simulate more energy efficiency in the industry sector, from 22 up to 44%.

-Increase renewable energy to double the present plan.

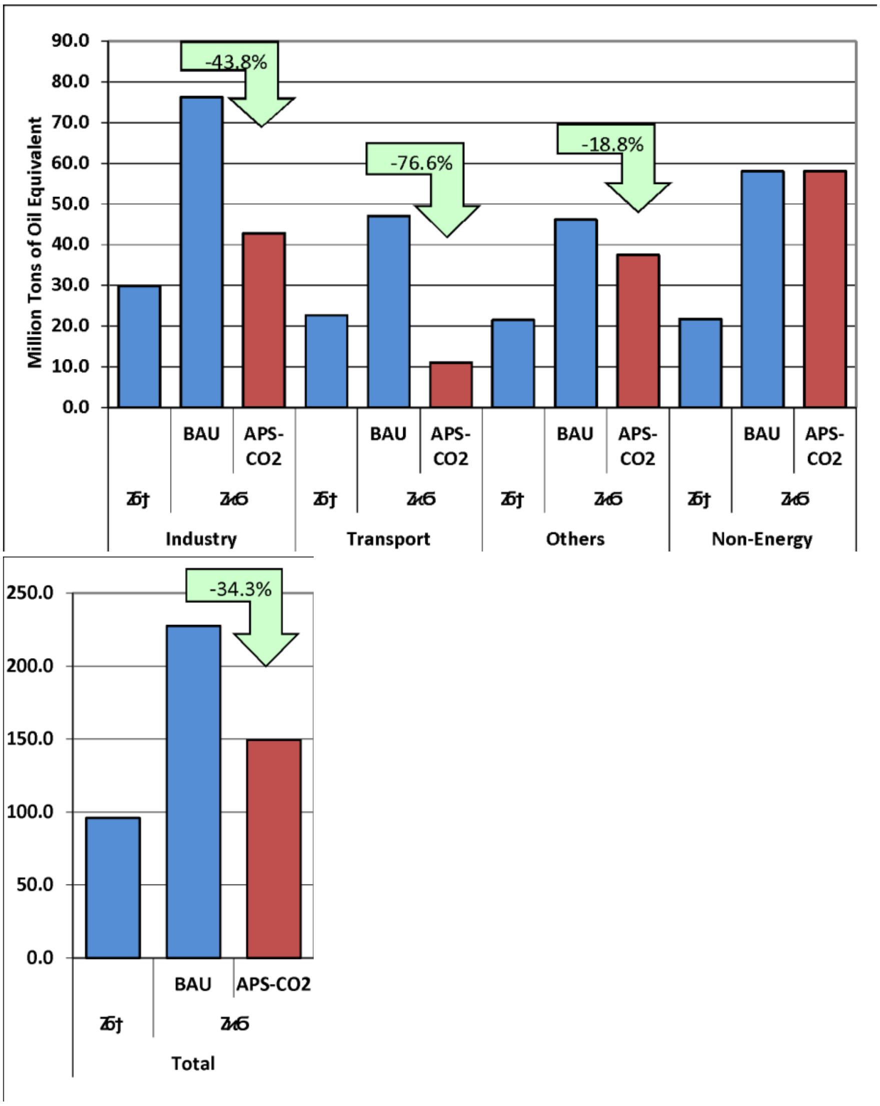
-Add more non-carbon energy in the power fuel mix. Thailand needs to increase nuclear power from 2,000 megawatts (MW) to 4,000 MW by 2036. It should also use to the maximum potential renewable energy as recommended in the PDP.

With Thailand implementing all plans to achieve CO_2 mitigation, a new case called APS-CO_2 will be created, which is APS-5 (combined).

Final Energy Demand with CO_2 Mitigation

Once Thailand implements its plans to CO_2 mitigation, its final energy demand will be impacted by more demand to reduce CO_2 from energy consumption. Final energy demand will probably be reduced by 34.3% from 230 metric tonnes of oil equivalent (Mtoe) to 150 Mtoe in BAU. In this case, consumption in the industry sector will be decreased by 76.3 Mtoe, 59.6 Mtoe, and 42.9 Mtoe in BAU, APS-5, and APS-CO_2, respectively (see Figure 2J.2). However, the rest of the sectors will almost remain the same as APS-5.

Figure 2J.2 Final Energy Consumption by Sector, APS-CO_2



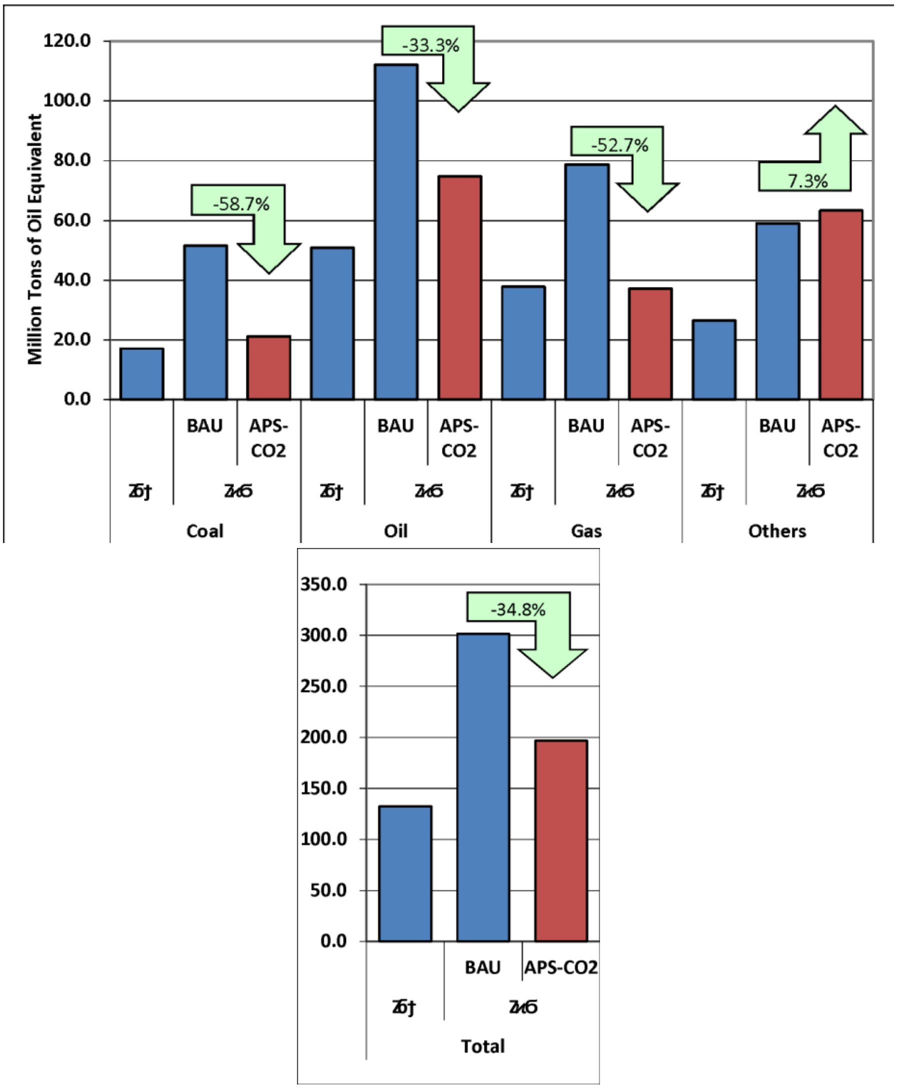
APS = Alternative Policy Scenario, BAU = Business as Usual, CO_2 = carbon dioxide.

Source: Author's calculations.

Primary Energy Under CO_2 Mitigation

Primary energy is also affected by CO_2 mitigation. Primary energy in 2040 will decrease by 34.8% from 301.5 Mtoe in BAU to 196.7 Mtoe in this case. The amount of primary energy under APS-5 does not differ much from that of APS-CO_2: 209.7 Mtoe and 196.7 Mtoe, respectively (see Figure 2J.3). Although natural gas will decrease the most, it will be compensated with an increase in biomass.

Figure 2J.3. Primary Energy Results

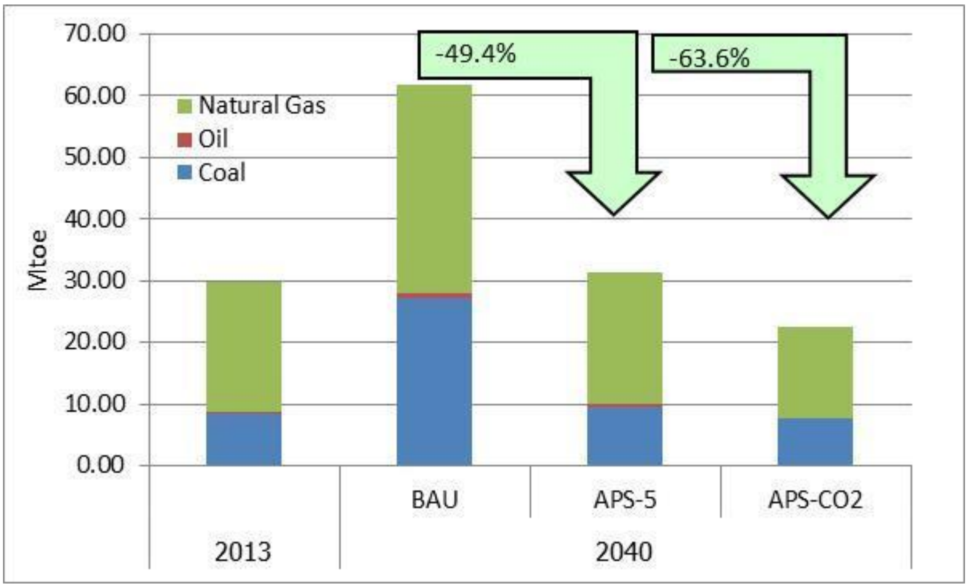


APS = Alternative Policy Scenario, BAU = Business as Usual, CO_2 = carbon dioxide,
Source: Author's calculations.

Fuel Mix

In power generation in 2040, fossil fuels in APS-CO_2 will decline by 63.6% from 61.9 Mtoe in BAU to 22.5 Mtoe, a decline driven by both coal and natural gas, which will grow from 27.3 Mtoe and 33.9 Mtoe in BAU to 7.6 Mtoe and 14.9 Mtoe in APS-CO_2, respectively. (see Figure 2J.4).

Figure 2J.4. Fuel Mix in Power Generation, APS-CO_2

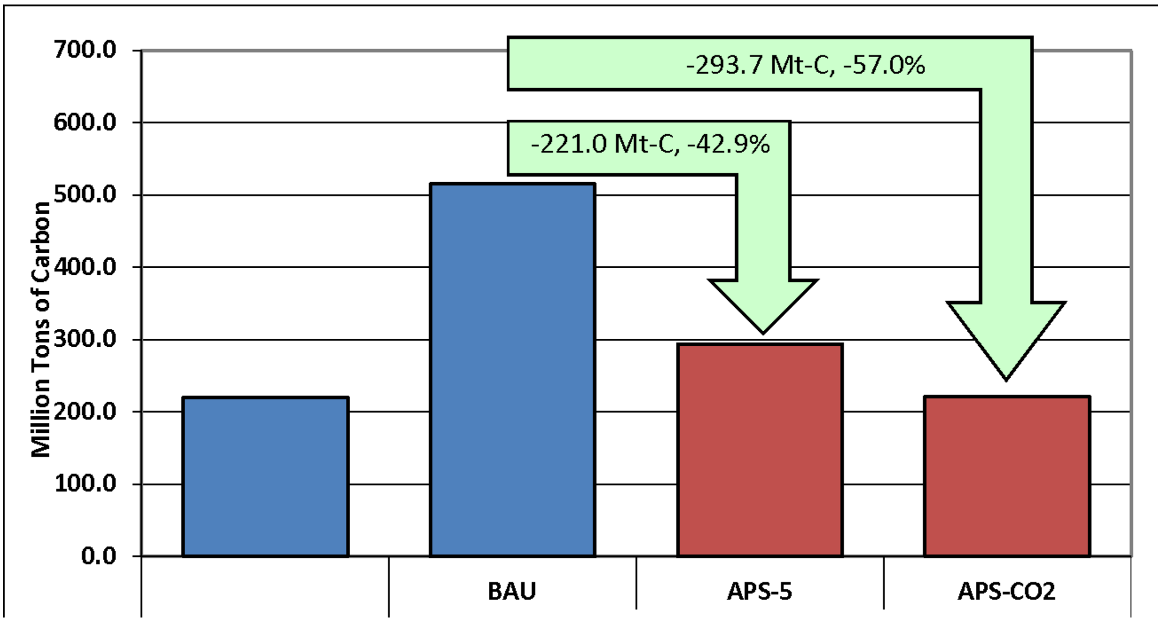


APS = Alternative Power Scenario, BAU = Business as Usual, Mtoe = metric tonne of oil equivalent.
Source: Author's calculations.

CO_2 Mitigation Outcome

In APS-5, CO_2 mitigation cannot be achieved alone with Thailand's national plans but will need APS-CO_2 to meet the target. CO_2 will be reduced from 515.2 MtCO_2e in BAU to 294.2 MtCO_2e in APS-5 and finally to 221.5 MtCO_2e in APS-CO_2, which is close to the 220.5- MtCO_2e 2013 level target. To mitigate CO_2 to the 2013 level, CO_2 must be reduced by around 293.7 MtCO_2e or at least 57% (see Figure 2J.5). In addition, Thailand needs to put more effort in energy efficiency through non-carbon energy sources such as renewables and nuclear power while cutting use of other commercial energy and fossil fuels such as coal and natural gas in power generation.

Figure 2J.5. CO_2 Mitigation at 2013 Level



APS = Alternative Policy Scenario, BAU = Business as Usual, CO_2 = carbon dioxide.

Source: Author's calculations.

2K.Viet Nam's Case Study:

Keeping CO_2 Emissions at 2013 Level by 2040

Introduction

Climate change is one of the most serious challenges to mankind. Each country needs to make a specific contribution to climate change response to protect the Earth's climate system for the current and next generations. As one of the countries severely affected by climate change, Viet Nam is willing to respond to climate change and supports a new post-2020 international agreement to keep the global average temperature increase below 2^{o}C by the end of the century compared to the pre-industrialization period.

Results of the 2015 energy outlook model implemented by a working group under the Economic Research Institute for ASEAN and East Asia (ERIA) show that greenhouse gas (GHG) reduction in the Alternative Policy Scenario(APS) of Viet Nam is around 49.7 metric tonnes of carbon (Mt-C), equal to the 29.6% reduction in 2040, but the annual increase in carbon dioxide (CO_2) emissions between 2013 and 2040 was projected to be 4.5% per year, which is still conservative compared with its potentials. To reduce CO_2more with Viet Nam's maximum efforts to contribute to the international efforts to keep the global average temperature increase below 2^{o}C, this study intends to propose possible solutions for Viet Nam to achieve no-increase of CO_2 emissions by 2040 from the 2013 base year.

Modelling Assumptions

In this outlook, Viet Nam's gross domestic product (GDP) is assumed to grow at an average annual rate of 6% from 2013 to 2040. Growth is projected to be faster in the first outlook period, increasing at 6.8% per year between 2013 and 2020. For the remaining periods of 2020–2030 and 2030–2040, the country's economic growth will be slightly reduced at an annual rate of 6.2% per year and 5.2% per year, respectively. Population growth is projected to increase at a much slower rate, increasing by 0.7% per year between 2013 and 2040.

The share of electricity generated from coal-fired power plants is projected to increase considerably at the expense of other energy types (thermal power and hydropower). Viet Nam is expected to increase its imports of electricity, particularly from the Lao PDR and China.

Nuclear power plants were abandoned through the decision of Viet Nam's National Assembly in November 2016,the main reason for which is economic issue due to increasing investment cost of nuclear power while that of oil is decreasing. The suggestedsolution is to develop renewable energy, gas, and coal power plants. In this study, it is assumed that imported coal power plants would be substituted for nuclear power plants in the Business as Usual (BAU) scenario, and then in APS, renewable energy technologies would be strongly developed to replace the imported and domestic coals for power generation.

Viet Nam's energy saving goal is assumed to be between 60% and 65% of total energy consumption by each sector, based on the potential by each sector. The energy-saving goals are expected to be attained through the implementation of energy efficiency programmes in industry, transport, residential, and commercial sectors on the demand side.

On the supply side, energy efficiency improvement in power generation, development of renewable energy technologies, particularly solar photovoltaic system, hydropower, wind power, and biomass are expected to come online intensively from 2017 in line with the renewable energy development strategy.

From the above analysis, proposed APSs consist of scenarios such as EEC scenarios (APS1), improvement of energy efficiencies in power generation (APS2), and development of renewable energy (APS3).

- APS1: EEC measures on the demand side

Based on energy-saving potential by each sector, it is assumed that EEC measures would be implemented in the industry, transport, agriculture and commercial sectors, and residential sector to achieve 60%–65%energy reduction by 2040.

- APS2: Improvement of energy efficiency in thermal power plants

It assumes that efficiencies of coal, natural gas, and residue fuel oil thermal power plants will increase to 45%, 45%, and 40%, respectively, by 2040 compared with 37%, 40%, and 32%, respectively, in BAU, while natural gas with CCGT technologies will increase to 60% by 2040 compared with 52% in BAU.

- APS3: Development of renewable energy technologies

Installed electricity-generating capacity from renewable energy sources is assumed to reach 58,100 megawatts (MW) in 2040 with solar photovoltaic system contributing 30,000 MW; wind, 14,500 MW; biomass, 7,500 MW; small hydropower, 5,900 MW; and biogas, 200 MW.

- APS4: Combining all APSs from APS1 to APS3.

Outlook Results

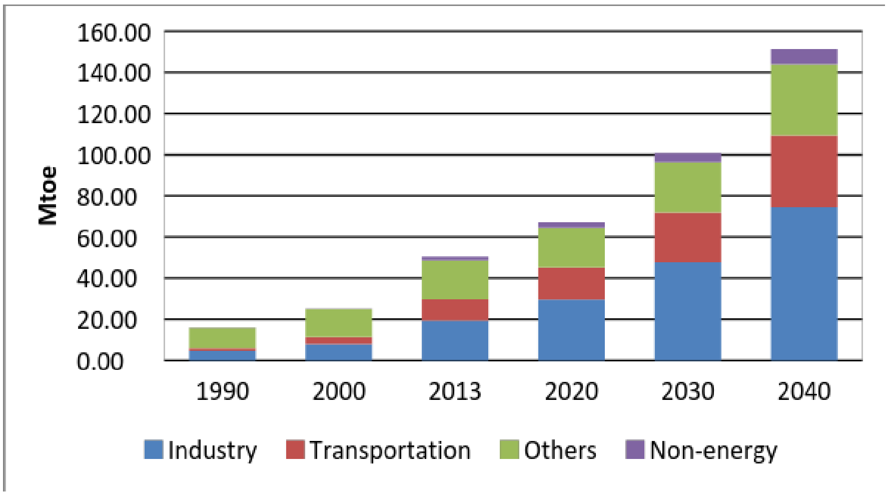
BusinessasUsual (BAU) scenario

Total final energy consumption

Viet Nam's total final energy consumption (TFEC) in 2013 was 50.5 metric tonnes of oil equivalent (Mtoe), increased 5.1% per year, which was 3.1 times more than its 1990 level of 16.1 Mtoe (see Figure 2K.1).

For 2013–2040, TFEC is projected to increase at an average rate of 4.2% per year under BAU. The growth is driven by strong economic growth which is assumed to be at an average annual growth of 6% and the rising population an average annual growth of 0.7%. On a per sector basis, the strongest growth in consumption is projected to occur in the industry sector, increasing by 5.1% per year. This is followed by the transportation sector (4.6% per year) and the residential/commercial (others) sector (2.3% per year). The non-energy use is expected to increase at growth rate of 5.7% per year.

Figure 2K.1. Final Energy Demand by Sectors, BAU



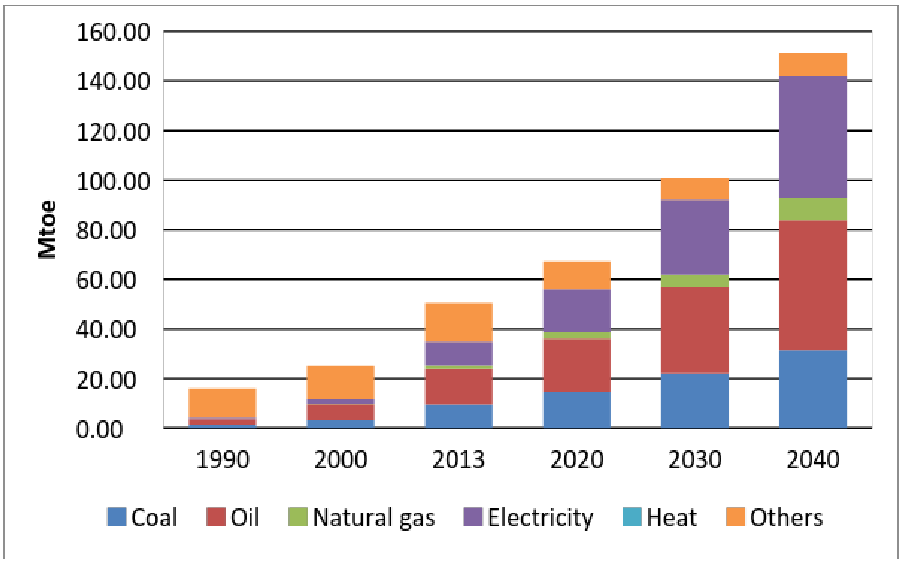
Mtoe = metric tonne of oil equivalent.
Source: Author's calculations.

The bulk of the country's energy consumption or more than 63% in 1990 came from the residential/commercial (others) sector, where biomass fuel used for residential cooking took the dominant share. This share will have a trend of decreasing strongly to 37.5% by 2013 and 22.8% by 2040 due to the substitution of biomass fuels by commercial fuels with higher efficient use. The decreasing share of the sector is due to the impact of the growing economy. The impact of economic growth will translate to improvement of standard of living, thus increasing the transition from biomass fuels to the model fuels.

On a per fuel basis, other fuels (mostly biomass) were the most consumed product, accounting for 73.9% of total final energy consumption in 1990 but this declined to 30.8% in 2013. Oil was the second most consumed product, accounting for 14.5% of total final energy consumption in 1990 and increasing to 28.2% in 2013. The share of coal consumed from 1990 to 2013 had an increasing trend from 8.3% to 18.9%. Electricity took a small share of 3.3% in 1990 but increased significantly to 19.4% in 2013 (see Figure 2K.2).

Under BAU, natural gas is projected to exhibit the fastest growth in final energy consumption, increasing at 7.4% per year between 2013 and 2040. Electricity is projected to have the second highest growth rate of 6.1% per year, followed by oil at 4.9% and coal at 4.5%. Other fuels (mostly biomass) are projected to reduce at an annual rate of 1.7% due to transition from biomass fuels to modern fuels.

Figure 2K.2. Final Energy Demand by Fuel, BAU



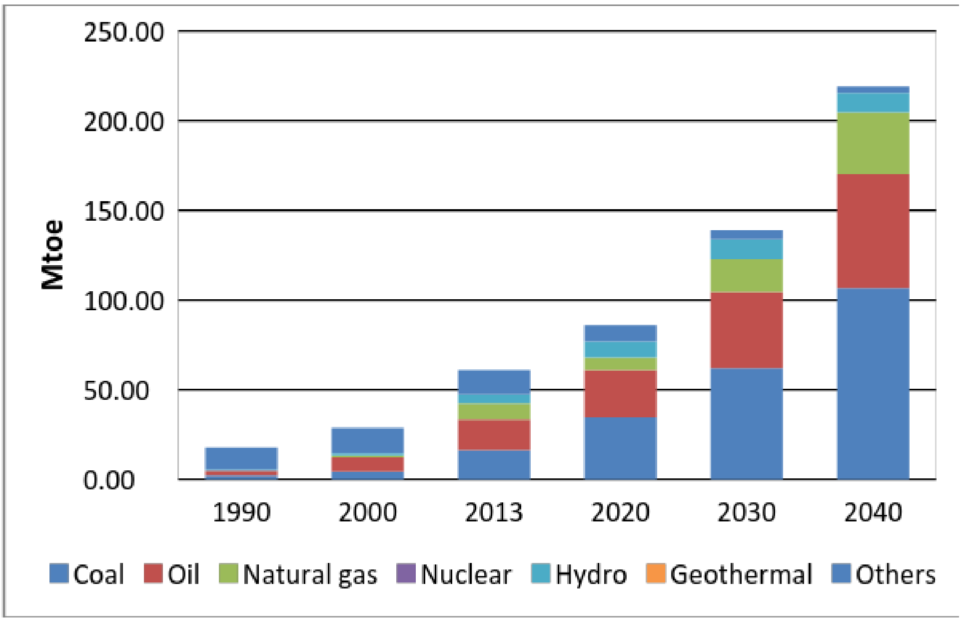
Source: Author's calculations.

Total primary energy consumption

The total primary energy consumption (TPEC) in Viet Nam grew at a higher rate than the final energy consumption, increasing at 5.5% per year or 3.4 times from 17.9 Mtoe in 1990 to 60.1 Mtoe in 2013. Among the major energy sources, the fastest growing were natural gas, hydropower, coal, and oil. Natural gas consumption grew at an average annual rate of 41.6% between 1990 and 2013 while hydropower, coal, and oil consumptions grew at 10.8%, 9.0%, and 8.4% per year, respectively (see Figure 2K.3).

In BAU, Viet Nam's TPEC is projected to increase at an annual rate of 4.9% per year or 3.6 times from 60.1 Mtoe in 2013 to 219.2 Mtoe in 2040. The fastest growth is expected in coal, increasing at an annual average rate of 7.2% between 2013 and 2040, followed by natural gas, oil, and hydropower at 5.1%, 5.0%, and 3.0%, respectively, while other fuels (mostly biomass) will decrease strongly at 4.7% per year.

Figure 2K.3. Primary Energy Demand, BAU



Mtoe = metric tonne of oil equivalent.
Source: Author's calculations.

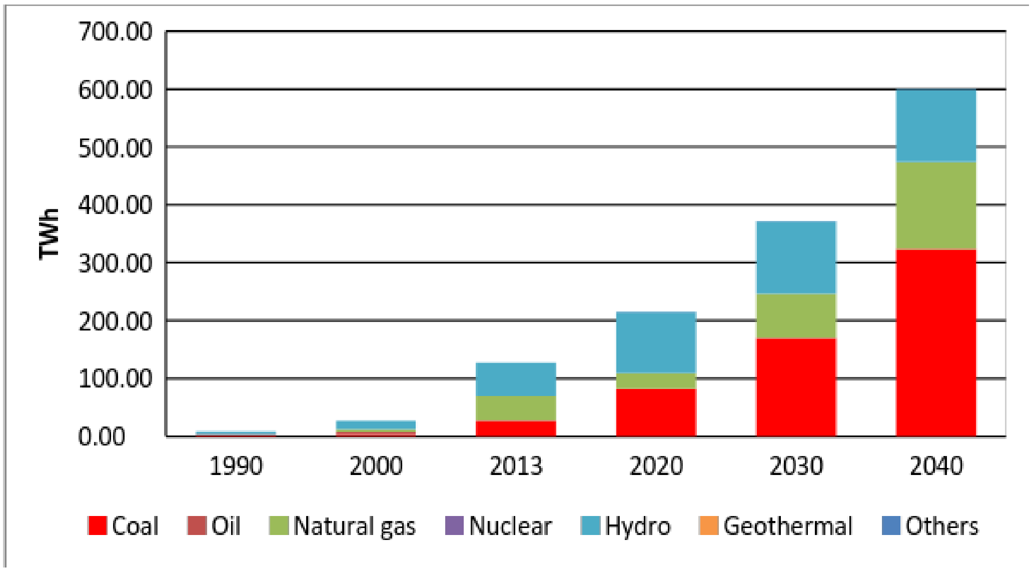
Oil accounted for the largest share of 28.2% of TPEC in 2013 and will increase slightly to 29% in 2040. The share of coal was 26.5% in 2013 and will increase strongly to 48.6% in 2040. Natural gas accounted for a share of 14.7% in 2013 and is projected to increase to 15.7% in 2040. These growths are due to the projected decline from hydropower and others whose shares are projected to decline from 8% to 4.9% and from 22.4% to 1.7%, respectively.

Power generation

Power generation output increased at 12.4% per year or 14.7 times from 8.7 terawatt hours (TWh) in 1990 to 127.3 TWh in 2013. The fastest growth occurred in the natural gas power generation (47.1% per year) followed by coal (12.0%), and hydropower (10.8% per year). These fast growths were due to the decrease of oil at 3.8% (see Figure 2K.4).

To meet the demand of electricity under BAU, power generation is projected to increase at an average rate of 5.9% per year or 4.7 times between 2013 and 2040. The fastest growth will be in coal power generation (9.7% per year) followed by the other (wind and biomass power) generation (7.0% per year), natural gas (4.8% per year), and hydropower generation (3.0% per year).

Figure 2K.4: Power Generation by Type of Fuel, BAU



Source: Author's calculations.

By end of 2013, majority of the country's power requirement came from hydropower, which comprised about 44.7% of the total power generation mix. The share of natural gas power generation was around 33.7% while the rest were from coal and oil power generation.

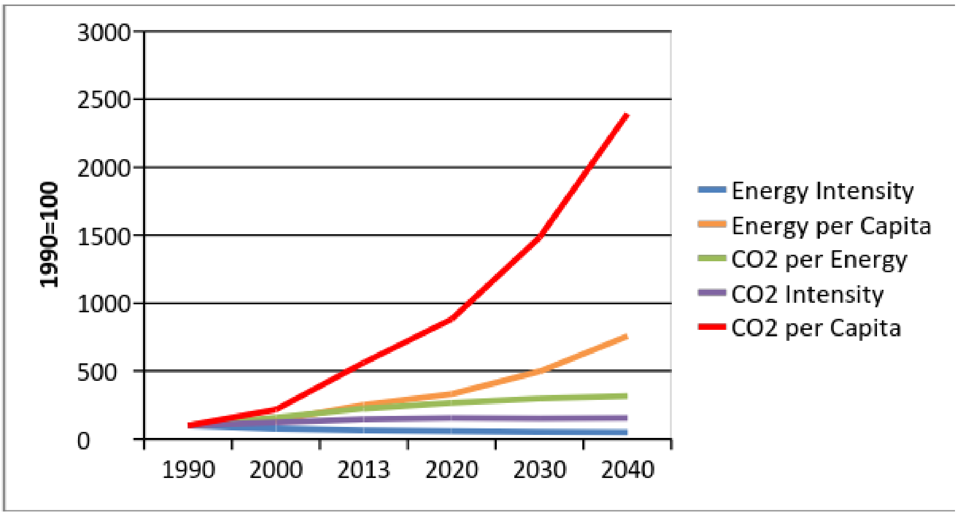
In BAU, coal will be the major fuel for power generation for 2030–2040, with its share increasing from 45.3% in 2030 to 53.9% in 2040. On the other hand, the share of hydropower in the total power generation will decline from 33.7% in 2030 to 20.9% in 2040.

Energy indicators

For 1990–2013, Viet Nam's energy intensity showed a decreasing trend. Both primary and final energy intensities of the country decreased from 1,006 tonnes of oil equivalent (toe)/million 2005 US$ and 905 toe/million 2005 US$, respectively, in 1990 to 660 toe/million 2005 US$ and 547 toe/million 2005 US$, respectively, in 2013. The major reason was the high economic growth rate which resulted in significant reduction in biomass fuels used for cooking in the residential sector, although the energy requirement in the industry sector and transport sector was increasing fast in recent years. The final energy intensity under BAU is estimated to continue the decreasing trend from 547 toe/million 2005 US$ to 338 toe/million 2005 US$ by 2040. This decreasing trend is a good indication that energy will be used efficiently in the future for economic development.

Meanwhile, primary energy per capita had an increasing trend that was 0.27 toe/person in 1990 to 0.68 toe/person in 2013 and will also have trend of increasing to 2.05 toe/person in 2040.This indicates that in the future, the living standards and people's income will increase resulting in increase in total primary energy consumption per capita (Figure 2K.5).

Figure 2K.5. Energy Indicators



CO_2 = carbon dioxide.
Source: Author's calculations.

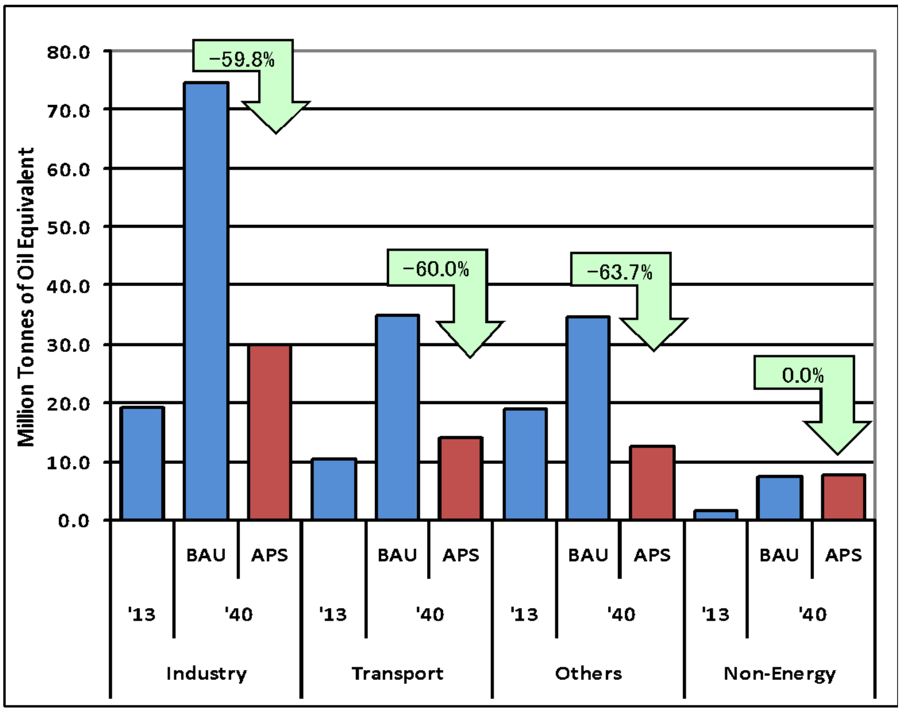
As regards GHG emissions, CO_2 intensity and CO_2 per energy had an increasing trend in 1990–2013, from 265 tonnes of carbon (t-C)/million 2005 US$and 0.26 t-C/toe in 1990 to 389 t-C/million 2005 US$and 0.59 t-C/toe in 2013, respectively. In BAU, CO_2 intensity and CO_2 per energy will also have trend of slightly increasing up to 2020 with 413 t-C/million 2005 US$and 0.70 t-C/toe, respectively. Beyond 2020, CO_2 intensity will slightly decline up to 2040 with 407 t-C/million 2005 US$ while CO_2 per energy will maintain a slight increase at around 0.83 t-C/toe. However, CO_2 per capita has an increasing trend continuously due to energy demand increasing faster than population growth rate.

Energy saving and CO_2emissions reduction potential

Total final energy consumption

In APS4, TFEC is projected to increase at a slower rate of 0.9% per year (compared with 4.2% in BAU) from 50.5 Mtoe in 2013 to 64.0 Mtoe in 2040 because of strong measures on EEC (APS1) in industry, transport, and other sectors such as agriculture, residential, and commercial sectors (see Figure 2K.6).

Figure 2K.6. Total Final Energy Consumption, BAU vs. APS



APS = Alternative Policy Scenario, BAU = Business as Usual,
Source: Author’s calculations.

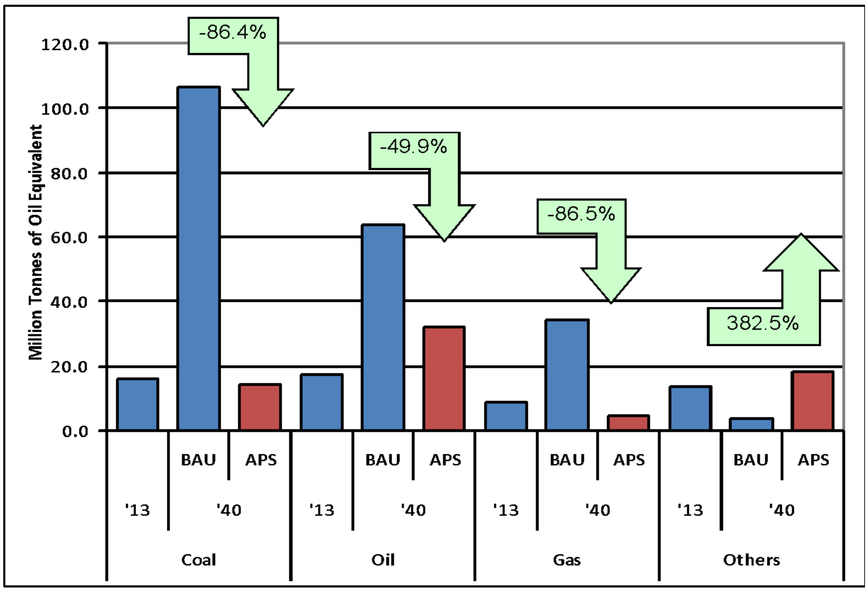
The bulk of the savings are expected to occur in the others sector with 22.0 Mtoe, equivalent to 63.7% reduction, followed by the transportation sector with 20.9 Mtoe, equivalent to 60% reduction, and the industry sector with 44.5 Mtoe, equivalent to 59.8% reduction.

Total primary energy consumption

In APS4, TPEC is projected to increase at a slower rate of 1% per year from 60.9 Mtoe in 2013 to 78.8 Mtoe in 2040. Hydropower is projected to grow at highest average annual rate of 2.6% compared with 3% in BAU, followed by oil with 2% (compared with 5% in BAU) over the same period. Meanwhile, coal and natural gas are projected to decrease at average annual rate of 0.4% and 2.4%, respectively (see Figure 2K.7).

The reduction in the primary energy consumption, relative to the BAU scenario, stems mainly from strong EEC measures on the demand side (APS1), the more aggressive uptake of energy efficiency in thermal power plants (APS2), and strongly developed renewables (APS3) on the supply side.

Figure 2K.7. Primary Energy Saving Potential by Fuel, BAU vs. APS

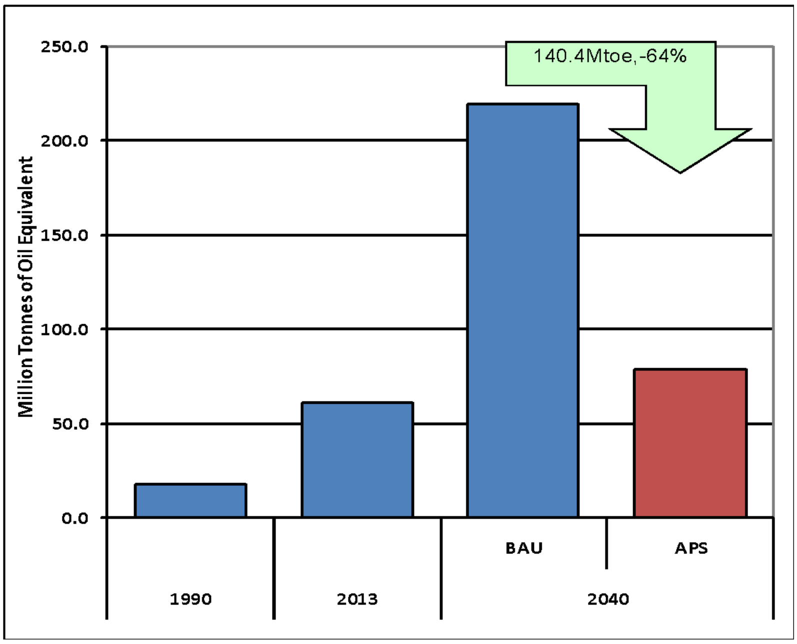


Source: Author's calculations.

In aspect of energy saving, coal is expected to achieve the highest amount of energy saving with 92.1 Mtoe, equivalent to 86.4% reduction, followed by oil and natural gas with 31.7 Mtoe and 29.8 Mtoe, equivalent to 49.9% and 86.5% reduction, respectively. These great reductions are due to the rapidly increased exploitation of others (renewable energy sources) at 382.5% to substitute for fossil fuels in power generation (on the supply side) and especially the strong energy saving measures on the demand side.

The total savings are equal to 140.4 Mtoe or equivalent to 64% of Viet Nam's total primary energy consumption in 2040 (Figure 2K.8).

Figure 2K.8: Evolution of Primary Energy Demand, BAU and APS



Source: Author's calculations

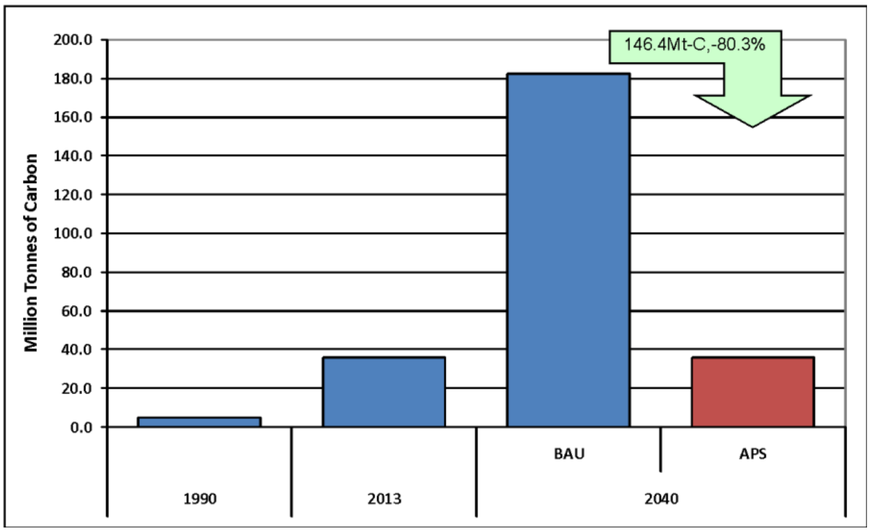
CO_2 reduction potential

CO_2 emissions from energy consumption under the BAU scenario are projected to increase by 6.2% per year from 35.9 metric tonnes of carbon (Mt-C) in 2013 to 182.3 Mt-C in 2040. Meanwhile, under APS4, the annual increase in CO_2 emissions between 2013 and 2040 is projected to be 0% yearly, which means that Viet Nam could achieve no-increase of CO_2 emissions by 2040 from the base year.

No-increase of CO_2 emissions from the base year is mostly due to EEC measures on the demand side (APS1), improvement of energy efficiency in thermal power plants (APS2), and development of renewable energy technologies (APS3).

Improvement on CO_2 emissions under APSs will be around 146.4 Mt-C lower, equal to 80.3% reduction in 2040, indicating the extreme efforts of Viet Nam in reducing CO_2 emissions (see Figure 2K.9).

Figure 2K.9: Evolution of CO_2 Emissions, BAU and APS



Source: Author's calculations

Key Findings and Solutions for GHG Mitigation

Key findings

From the results of study, some keys findings can be recognised as follows:

- Energy demand by 2040 is projected to highly increase at three times over the next 25 years as population and economic activity increase.
- Coal thermal power plants will be the major power generation in Viet Nam in coming years. Its share in the total of power generation output is increasing continuously from 21.1% in 2013 to 53.9% in 2040 in BAU. This is the area with the largest energy-saving as well as GHG mitigation potential in Viet Nam.
- EEC scenarios on the demand side are most effective compared with other proposed scenarios on energy saving as well as GHG emissions reduction.

The above findings showed that the effort of Viet Nam to achieve no-increase of CO_2 emissions by 2040 from base year is extremely difficult.

Solutions for GHG mitigation

From the above findings, the following solutions are recommended to implement the efforts for GHG mitigation at 2013 level in Viet Nam:

1) Improve effectiveness and efficiency of energy use to reduce energy consumption.

- Innovate technologies and apply advanced management and operation procedures for efficient and effective use of energy in production, transmission, and consumption, especially in large production facilities where energy consumption is high;
- Apply energy efficiency and renewable energy technologies in energy consumption sectors and power generation sector;
- Develop public passenger transport to replace private transport means in large cities. Restructure freight transport towards a reduction in the share of road transport in exchange for an increase in the share of transportation via rail and inland waterways;
- Establish standards on fuel consumption and develop a roadmap to remove obsolete and energy-consuming technologies in energy production and consumption systems.

2) Change the fuel structure in industry and transportation

- Change the energy structure towards a reduced share of fossil fuel, encouraging the exploitation and use of renewable and low-GHG emission energy sources;
- Encourage buses and taxis to use compressed natural gas and liquefied petroleum gas; implement management solutions for fuel quality, emissions standards, and vehicle maintenance;
- Apply market instruments to promote structural change and improve energy efficiency; encourage the use of clean fuels; support the development of renewable energy; implement the roadmap to phase out subsidies for fossil fuels;
- Label energy-saving equipment and issue national standards for the quality of equipment.

3) Promote effective exploitation and increase the proportion of renewable energy sources in energy production and consumption.

- Develop and implement financial and technical mechanisms and policies to support research and the application of appropriate advanced technologies; exploit and optimise the use of both on-grid and off-grid renewable energy sources;
- Develop a renewable energy technology market, domestic industries, and local service providers.

4) Enhance international cooperation.

- Enhance cooperation in scientific research, in information exchange on the formulation and implementation of policies, and in the basic content of climate change strategies and policies;
- Enlist the support of other countries and international organisations in finance, capacity building, and technology in the implementation of climate change strategies and policies;
- Facilitate international cooperation to implement foreign direct investment on climate change-

related projects.

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Chapter 3

Nationally Determined Contributions of EAS Countries

This chapter reviews the Nationally Intended Contributions (NDC) of countries to the Conference of Parties (COP 21). It shows how countries lay out targets or programmes aimed at reducing carbon dioxide (CO_2) emissions. Some countries have clear policies and targets while some have none. Thus, it is very important for countries to lay out their road maps on how to concretely contribute to COP 21 through clear actions and programmes with timeframe.

Finally, this chapter serves as an exercise for the working group to improve its national data by practising intellectual scenarios of keeping CO_2 emissions at the 2013 level until 2040 and reviewing their countries' NDC commitments. This will improve the capacity of national experts on the energy outlook.

3A. Review of Nationally Determined Contributions of Australia

Australia submitted its Intended Nationally Determined Contributions (INDC) in August 2015, which later became Australia's first Nationally Determined Contributions (NDC). Australia's NDC includes a target of reducing greenhouse gas (GHG) emissions by 26%–28% against the 2005 level by 2030. It represents a progression beyond the 2020 target of reducing emissions by 5% below 2000 levels, or a reduction of 13% below 2005 levels. Australia's NDC target is nearly double the rate of emissions reduction target in 2020. Compared to the amount of emissions in 2005, this NDC target is equivalent to 50%–52% of emissions reduction per capita and to 64%–65% per unit of gross domestic product (GDP) by 2030. This ambitious target would mean significant emissions reduction per capita and per GDP unit. Having this background in mind, Australia's NDC clearly demonstrates an ambitious commitment to mitigate future emissions. The mitigation target set out in NDC incorporates national circumstances, such as economic and population growth, current energy infrastructure, high abatement costs, and the country's position as global resource provider (UNFCCC, 2015). Table 3A.1 presents the scope and coverage of Australia's NDC.

Table 3A.1. Scope and Coverage of Australia's NDC

Target	Emissions reduction of 26%–28% by 2030 against the 2005 level
Target type	Absolute economy-wide emissions reduction
Gases covered	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6), nitrogen trifluoride (NF_3)
Sectors covered	Energy; industrial processes and product use; agriculture; land-use, land-use change, and forestry; waste
Base year emissions covered	100% of GHG emissions and removals in the national GHG inventory

GHG = greenhouse gas, NDC = Nationally Determined Contributions.
Source: United Nations Framework Convention on Climate Change (2015).

Prior to Australia's submission of its NDC in 2015, attempts to mitigate GHG emissions have been pursued since 1992 when Australia signed the Rio Declaration on Environment and Development (Agenda 21). In 1997, the government signed the Kyoto Protocol even if its ratification is not in country's national economic interest, particularly for investment and industrial development. Despite this, Australia ratified the Kyoto Protocol in 2007, demonstrating its commitment to tackling climate change. In the first commitment period (2008–2012), the target was to limit emissions increase (excluding land use, land-use change, and forestry [LULUCF]) to 8% above the 1990 levels. In the second commitment period (2013–2020), Australia has committed to 5% reduction of GHG emissions below 2000 levels. Under the Copenhagen Accord (2010), Australia's pledge includes a reduction of 25% below 2000 levels depending on the commitments of other countries. However, since the Copenhagen Accord lacks compliance provisions, this pledge is not legally binding. Finally, Australia ratified, in November 2016, the Paris Agreement formalizing its commitment to climate change mitigation efforts.

Australia's total GHG emissions (including LULUCF) were estimated to be 565 metric tonnes of carbon dioxide equivalent ($MtCO_2e$) in 1990 and remained lower than 600 $MtCO_2e$ until 2004. In 2006, the country's emissions started to increase and peaked at 613 $MtCO_2e$. This amount was a 9% increase against the 1990 level. However, total emissions have steadily declined thereafter as a result of government policies and energy efficiency measures. The country's emissions were lowest during the implementation of carbon pricing scheme introduced in 2011 and came into effect the following year (Wijesekere and Syed, 2017).

Despite its small contribution to the global GHG emissions (about 1.5%), Australia's per capita emissions rank the highest among OECD countries as well as globally. Such high amount is largely due to high emissions intensity for energy use as a result of the country's reliance on coal for electricity. Emissions from the transport sector in Australia are similar to those of other developed countries (Garnaut, 2008). In addition to that, export income in Australia is mainly derived from energy-intensive products (Wijesekere and Syed, 2016).

Recognising the urgent need to systematically address the climate change challenges, the Australian government formulated a set of policies to create an enabling environment while at the same time supplementing the ongoing actions at national or state levels. The central policy for emissions reduction in Australia is the direct action plan whereby Emissions Reduction Fund become the central component. The fund implements a long-term framework that provides incentives to adopt technologies to further improve productivity or energy efficiency. This programme has three elements: crediting emissions reductions, purchasing emissions reductions, and safeguarding emissions reductions (Commonwealth of Australia, 2014). A safeguard mechanism is currently being finalised to guarantee that emissions reductions bought under this scheme are not offset by increased emissions elsewhere in the economy. Furthermore, this programme is expected to reduce the country's GHG emissions by 5% by 2020 (against the 2000 level). The first auction (April 2015) successfully bought over 47 million tonnes of abatement at an average rate of AU$13.95 (UNFCCC, 2015). The first three auctions generated AU$194 million for land sector income as reported by the Australian Farm Institute in 2016. Revenue from projects is being reinvested to improve farms and help indigenous communities secure their land (Commonwealth of Australia, 2014).

The key component of future energy policy in Australia is the Energy White Paper 2015. The document lays out the priority for energy market reforms to encourage reliable supply and competitive energy prices for households and businesses. The paper provides policies that encourage investments in new energy sources and technologies through the right market settings. It is expected that the policy directions and future decision-making would give certainty for industry and consumers. Australia has also introduced the Renewable Energy Target (RET) as an additional policy measure. The desire to promote deployment of renewable energy as substitute for fossil fuels is one reason for having this scheme. Aligned with the Energy White Paper 2015, the RET scheme includes actions to encourage investments in renewable energy, provide certainty to industry, and improve the market condition. Under RET, the government sets to have over 23% (33,000 gigawatts [GW]) of electricity sourced from renewables by 2020. RET is operated in two different scales: the small-scale renewable energy scheme (SRES) and the large-scale renewable energy target (LRET). The former provides financial incentives to install small-scale renewable energy system in households, small businesses, or communities. The large-scale renewable target, on the other hand, provides financial incentives to establish or expand renewable energy power stations such as solar farms and wind or hydroelectric power stations (Commonwealth of Australia, 2015).

To complement policy measures, the Australian government is developing post-2020 mitigation commitments that target improved energy productivity around 40% between 2015 and 2030. In addition, the government will start the formulation of post-2020 emissions reduction policies that are appropriately calibrated towards achieving the 2030 target (UNFCCC, 2015).

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3B.Review of Nationally Determined Contributions of Brunei Darussalam

In November 2015, Brunei Darussalam submitted its Intended Nationally Determined Contributions (INDC) to the United Nations Framework Convention on Climate Change, reaffirming its commitment to combat future climate change and limit global warming to 2°C above the pre-industrial levels. Brunei Darussalam's INDC concerns are primarily on the energy sector, the largest sector contributing to the country's economic growth and greenhouse gas (GHG) emissions. Although much emphasis is given to the energy sector, Brunei Darussalam's INDC considers emissions reduction from other sectors as equally important. The INDC pledge is focused on GHG mitigation from transportation, forestry, and other sectors that are anticipated to generate significant mitigation impacts in the near future. Under the INDC framework, Brunei Darussalam targets to reduce its total energy consumption by 63% by 2035 against the Business as Usual (BAU) scenario. Furthermore, the country aims to achieve a 10% total share of renewable energy in the power generation by 2035. With regards to the transport sector, the target is to reduce carbon dioxide (CO_2) emissions from morning peak-hour vehicle use by 40% by 2035 compared to the BAU scenario. Another target in the INDC is to enhance the stocks of carbon sinks by increasing the total forest reserves from the present 41%–55% of the country's total area.

The estimated total emissions in Brunei Darussalam represent a small fraction relative to the global emissions, which accounts for only 0.016% of the global emissions in 2010. According to the Initial National Communication draft, Brunei Darussalam's GHG emissions in 2010 were estimated to be 10.02 metric tonnes of carbon dioxide equivalent ($MtCO_2e$) with the net GHG of 7.40 $MtCO_2e$. At the same time, land-use change and forestry contributed 2.63 $MtCO_2e$ of emissions.

Brunei Darussalam's GHG profile is long dominated by emissions from the energy sector, where electricity generation is the largest source of emissions. At present, natural gas represents 99% of Brunei Darussalam's electricity mix, largely generated from open cycle power plants. By 2020, it is estimated that emissions generated from these plants will be around 4.18 $MtCO_2e$. Another considerable source of emissions is the production of oil and gas for both domestic and international markets. As presented in Table 3B.1, emissions from oil and gas production reached 3.31 $MtCO_2e$ in 2010. Apart from that, Brunei Darussalam's emissions also come from direct combustion of fossil fuels in end-use sectors such as transport, industry, and residential sectors. Other emissions sources are considered small compared to the emissions from the energy sector.

Table 3B.1. Estimated Emissions in Brunei Darussalam, 2010

Emissions source	Emissions ($MtCO_2e$)
- Energy production (including oil and gas production for domestic and export markets)	3.31
- Fuel consumption in transport	1.17
- Industrial energy consumption	0.45
- Combustion from residential and other sectors	Below 0.39
- Waste management, agriculture, and industrial processes	Below 0.53

$MtCO_2e$ = metric tonne of carbon dioxide equivalent.
Source: United Nations Framework Convention on Climate Change (2015).

The energy sector is a central element of Brunei Darussalam's economy as it holds a significant share to its gross domestic product (over 60%). The energy sector generates benefits through revenues from oil and gas extraction, refining, and export. Being highly reliant on the oil and gas sector, the government has recognised the need to promote sustainability within the current economy, particularly in the energy sector. The overarching goals include achieving energy security, supply diversification, and energy efficiency and conservation. To this end, the government has introduced the Energy White Paper in 2014. The paper sets out policy framework which will deliver concerted efforts to diversify the energy mix by promoting the use of renewable and alternative energy sources for power generation.

In its INDC pledge, Brunei Darussalam intends to reduce its total energy consumption by 63% by 2035 relative to the BAU scenario. As of 2013, the country was able to reduce energy consumption by 13.9%. To achieve greater reduction in energy consumption, the government has formulated policies and actions in several areas as outlined in Table 3B.2. Apart from actions on the energy sector, the government has developed guidelines requiring all buildings, including industrial, commercial, and housing, and government buildings, to maintain at least 10% of the land for green area.

The government acknowledges the critical importance of promoting the growth of other sectors, in addition to the energy sector, to balance the economy. With this aspiration, the government is working with the hydrocarbon industry to limit its direct impacts and maximise its environmental benefits. The hydrocarbon industry is perceived as one of the major sources of GHG emissions. Under this mechanism, the industry provides funding for forestry projects such as forestry protection initiatives, increasing tree plantations for carbon sequestration, and campaign for raising awareness. At the same time, the government also actively promotes integrated approaches with other departments. For example, it provides top-down approaches in many facets of the economy that are further bolstered by bottom-up support for activities at the community level like raising awareness about climate change.

Table 3B.2. Policies and Actions in the Energy Sector, Brunei Darussalam

Mitigation Measures	Implementation Strategies
Energy intensity reduction across all sectors Target: reduction in energy intensity by 45% against 2005 level	- Energy efficiency and conservation (until 2035): 1. Electricity tariff reform 2. Energy efficiency and conservation building guidelines for non-residential sector 3. Standards and energy labelling for products and appliances 4. Energy management policy 5. Fuel economy regulation 6. Financial incentives 7. Awareness rising - Project-based energy efficiency measures: 1. Increase the use of energy-efficient streetlights 2. Replace existing high-pressure sodium vapour street lighting to increase the standards nationwide
Increase the share of renewable energy in power generation Target: 10% of total power is from renewable energy by 2035	- Increase the use of solar power - Utilise the 10–15 MW potential of waste to energy resource
Emissions reduction from land transport Target: 40% reduction in the morning peak hour CO_2 emissions against BAU in 2035	

BAU = Business as Usual, CO_2 = carbon dioxide, MW = megawatt.
Source: United Nations Framework Convention on Climate Change (2015).

The Brunei Vision 2035, known as 'Wawasan Brunei 2035', highlights the importance of the environment to support future development. The document lists strategies aimed to minimise environmental pollution, mitigate the deterioration of natural ecosystem, and maintain biodiversity.

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3C.Review of Nationally Determined Contributions of Cambodia

Introduction

Cambodia respects the principles of the United Nations Framework Convention on Climate Change, particularly that of 'common but differentiated responsibilities and respective capabilities' along with the right to the sustainable development of developing countries.

Cambodia presented its Intended Nationally Determined Contributions (INDC) to the convention in December 2015, ahead of the Conference of Parties or COP 21 in Paris. The INDC is subject to revisions to meet national circumstances as the country continues along its development pathway.

As Cambodia is a low emitter of greenhouse gases (GHG) and highly vulnerable to the negative effects of climate change, its contributions are therefore necessarily aligned with its development priorities. The country's INDC includes both adaptation and mitigation actions based on national circumstances. It is composed of five sections:

- National context, presenting national circumstances relevant to INDC;
- Adaptation, covering Cambodia's vulnerability to climate change and prioritised adaptation actions;
- Mitigation, including Cambodia's intended contributions to reduce GHG emissions, with information to ensure clarity, transparency, and understanding, and consideration of fairness and ambition;
- Planning and implementation processes, with indications of the institutions, policies, strategies, and plans that will support the implementation of INDC; and
- Means of implementation, with information on the support needed for the implementation of INDC.

Adaptation

Adapting to current and future effects of climate change is a priority for Cambodia. The country firmly believes that climate change adaptation actions require an integrated, multi-sectoral approach to be effective and to be able to support national development objectives. Cambodia has therefore selected the following priority actions, giving prominence to ones with climate change impact mitigation co-benefits:

- Promoting and improving the adaptive capacity of communities, especially through community-based adaptation actions, and restoring the natural ecology system to respond to climate change;
- Promoting climate resilience through improved food, water, and energy security;

- Promoting low-carbon planning and technologies to support sustainable development;
- Improving capacities, knowledge, and awareness for climate change responses;
- Strengthening institutions and coordination frameworks for national climate change responses; and
- Strengthening collaboration and active participation in regional and global climate change processes.

Mitigation

Cambodia proposes a GHG-mitigation contribution for the period 2020–2030, conditional upon the availability of support from the international community, particularly in accordance with Article 4.3 of the United Nations Framework Convention on Climate Change. Significantly, despite Cambodia's status as a least developed country, it is implementing actions in accordance with its sustainable development needs that also address climate change as shown in Table 3C.1.

(i) **Energy industries, manufacturing industries, transport, and other sectors**: Cambodia intends to undertake actions as listed in Table 1, the impact of which is expected to be a maximum reduction of 3,100 gigatonnes of carbon dioxide equivalent ($GgCO^2eq$) compared to the baseline emissions of 11,600 Gg CO_2eq by 2030.

Table 3C.1. Mitigation Actions in Key Sectors – Aggregate Reductions by 2030

Sector	Priority Actions	Reduction as Gg CO_2e and % in 2030 compared to the baseline.
Energy Industry	National grid-connected renewable energy generation (solar energy, hydropower, biomass, and biogas) and connecting decentralised renewable generation to the grid. Off-grid electricity such as solar home systems, hydropower (pico, mini, and micro). Promoting energy efficiency by end users.	1,800 (16%)
Manufacturing Industry	Promoting use of renewable energy and adopting energy efficiency for garment factories, rice mills, and brick kilns.	727 (7%)
Transport	Promoting mass public transport. Improving operation and maintenance of vehicles through motor vehicle inspection and eco-driving, and increased use of hybrid cars, electric vehicles, and bicycles.	390 (3%)

Others	Promoting energy efficiency for buildings and more efficient cooking stoves. Reducing emissions from waste through use of biodigesters and water filters. Use of renewable energy for irrigation and solar lamps.	155 (1%)
Total		**3,100 (27%)**

(ii) **Land Use, Land Use Change, and Forestry (LULUCF)**: Cambodia intends to undertake voluntary and conditional actions to achieve the target of increasing forest cover to 60 percent of national land area by 2030. In the absence of any actions, the net sequestration from land use, land use change, and forestry is expected to reduce to 7,897 $GgCO_2$ in 2030 compared to projected sequestration of 18,492 $GgCO_2$ in 2010.

Cambodia requires support in the form of financing, capacity building, and technology transfer to implement the actions set out in its INDC. Based on the assessment of financial needs for priority activities up to 2018 as included in the sectoral climate change action plans, Cambodia would require US$1.27 billion to support the implementation of these activities. The assessment also took into account the climate finance absorption capacity of Cambodia to ensure that the proposed investments are effective.

3D.Review of Nationally Determined Contributions of India[1]

Introduction

Global climate change due to rising levels of greenhouse gases (GHGs) in the atmosphere is one of the most serious environmental challenges at present. In its fifth assessment report, the Intergovernmental Panel on Climate Change states that 'warming of the climate is unequivocal and, since the 1950s, many of the observed changes are unprecedented over decades to millennia'. The atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased to unprecedented levels and 'carbon dioxide concentrations have increased by 40% since pre-industrial times, primarily due to fossil fuel emissions'. This necessitates 'substantial and sustained' efforts to reduce GHG emissions to limit climate change.

Glaring inequities exist in the distribution of the causes of climate change and the distribution of its impacts among the nations and peoples of the world. While the developed countries are predominantly responsible for climate change due to their historic contribution to the build-up of GHG concentration in the atmosphere, the effect of global warming is perceived to be more adverse on the developing countries as their resources and capacity to adapt to impact of climate change are very limited.

India is in a particularly difficult position vis-à-vis the climate change problem. It accounts for 2.4% of the world surface area but supports around 17.5% of the world population. It houses the largest proportion of global poor (30%), around 24% of the global population without access to electricity, about 30% of the global population relying on solid biomass for cooking, and about 90 million without access to safe drinking water. The adverse impacts of climate change on the developmental prospects of the country are amplified enormously by dependence of a large proportion of the population on climate-sensitive sectors for livelihood. India has an enormous task in hand to secure their futures through economic development. Hence, adaptation is inevitable and an imperative for the development process. Although India is at present the third largest emitter of GHGs globally, its per capita emissions are a mere 1.6 tonnes of CO_2 equivalent (tCO_2e).

India's Response to Climate Change

India's broad policy framework on environment and climate change is laid down by its National Environment Policy 2006 which promotes sustainable development along with respect for ecological constraints and the imperatives of social justice. The National Action Plan on Climate Change (NAPCC) was launched in 2008 and a concerted effort was put in place to draw strategies that would help India align its development with low-carbon actions. NAPCC is implemented through eight national missions, outlining

[1] Full version is available at http://www4.unfccc.int/submissions/INDC/Published%20Documents/India/1/INDIA%20INDC%20TO%20UNFCCC.pdf

priorities for mitigation and adaptation to combat climate change. Carrying the vision of NAPCC forward, all states and union territories are in the process of formulating State Action Plans on Climate Change. The action plans are aligned with the eight national missions. In 2009, under the Copenhagen Accord, India made a voluntary pledge to reduce by 2020 the GHG emissions intensity of its gross domestic product by 20%–25% over the 2005 level.

Adaptation strategies

Five of the eight missions of NAPCC concentrate on adaptation measures in sectors such as water, agriculture, Himalayan ecosystem, capacity building, and knowledge management. The policy framework catering to adaptation in some crucial areas is briefly described below.

To target the various threats that the agriculture sector is facing, the government of India has implemented several policies and missions. For instance, the National Mission on Sustainable Agriculture aims at food security; protecting resources such as land, water, and genetics; early warning systems and weather forecasting systems; and newer and more environment-friendly technologies and practices. Among other programmes are the National Initiative on Climate Resilient Agriculture for National Resources and the National Agroforestry Policy. Another government scheme involves the provision of 'soil health cards' to farmers, along with the facility of mobile soil testing laboratories.

As water is the most critical component of the life support system, various adaptation strategies that focus on enhancing efficient use of water, securing its access, and combating adverse climate change impacts are implemented. India has launched the National Water Mission with the key objectives of conservation, enhancing efficient usage, and equitable distribution of water through integrated water resources development and management. Further, in its adaptation strategies, the government has prioritised groundwater management and replenishment through rainwater harvesting and watershed development programme to give additional impetus to watershed development in the country. Additionally, the government has taken up initiatives such as the National Mission for Clean Ganga and the setting up of the National River Conservation Directorate for conservation of rivers and other water bodies as well as improving their water quality.

Climate change can adversely impact human health. Keeping in mind the various health consequences, India is formulating a health mission under the ambit of NAPCC which would present strategies on mitigation, containment, and management of adverse health impacts of climate change. The objectives of the mission are the analysis of epidemiological data; identification of vulnerable population; and increasing expertise, awareness, and community participation. In addition to the general efforts of the government in public health infrastructure are several specific programmes such as the Integrated Disease Surveillance Programme and the National Vector Borne Disease Control Programme.

Considering the accentuated vulnerability to rising sea levels faced by India's 7,517-km long coastline, its island territories, India has implemented several programmes to tackle these adverse effects. It has identified and demarcated vulnerable areas as the coastal regulation zone, restricting development of industries and operations in such areas. Further, through programmes such as the Integrated Coastal Zone Management and the Island Protection Zone, the government has attempted to conserve habitat, biodiversity, provide livelihood security to the locals, as well as reduce disaster risks. Another effort, in collaboration with the International Union for Conservation of Nature, to protect coastal livelihood is the Mangroves for the Future initiative.

With over 85% of its geographical area vulnerable to one or multiple hazards, the Indian subcontinent is one of the world's areas most prone to disasters. Through strategies such as early warning systems, development and maintenance of multipurpose cyclone shelters, improved access and evacuation, and strengthened response capability of vulnerable local communities, the government has tried to fortify disaster risk mitigation and adaptation capacity at central, state, and local levels. Further, the Sendai Framework for disaster risk management has drawn up roadmaps for adequate response to calamities. India has put in place the National Disaster Relief Fund which is financed through the levy of a cess to create a fund pool to help achieve disaster management and risk-reduction goals.

To protect its strong biodiversity, the country has developed a biogeographic classification for conservation planning and has mapped biodiversity-rich areas. Recognising the grave importance of the Himalayan ecosystem and its extreme vulnerability to climate change, India launched the National Mission for Sustaining the Himalayan Ecosystem and the complementary National Mission on Himalayan Studies. These programmes seek to address threats and issues faced by Himalayan Glaciers, their associated hydrological consequences, protect biodiversity and local livelihoods, along with building a strong traditional and scientific knowledge base that demonstrate replicable solutions to relevant problems.

Mitigation strategies

India has demonstrated its commitment to fast track GHGs-mitigation measures that align well with its development priorities. Many national strategies and policies supplement this. The Energy Conservation Act encourages efficient use of energy and its conservation. The National Electricity Policy underscores the focus on universalising access to electricity and promoting renewable sources of energy, as does the Integrated Energy Policy.

India has adopted several measures for clean and renewable energy, energy efficiency in various sectors of industries, lower emission intensity in the automobile and transport sector, non-fossil-based electricity generation, and building sector based on energy conservation. Thrust on renewable energy, promotion of clean energy, enhancing energy efficiency, developing climate resilient urban centres, and sustainable green transportation network are some of the measures for achieving this goal.

With the National Solar Mission as a major initiative of the government, contributing solar energy to the country's energy mix is expected to grow significantly. Main schemes, under varying levels of development, include establishment of 25 solar parks, ultra-mega solar power projects, canal top solar projects, and 100,000 solar pumps for farmers. To accelerate development and deployment of renewable energy in the country, the government has scaled targets for renewable-based power generation to 175 gigawatts (GW) by 2021–2022 out of which 100 GW will be from solar energy.

The energy efficiency of thermal power plants will be improved systematically and mandatory over the time. The Performance Achieve and Trade mechanism will be broadened as a market-based energy efficiency trading mechanism which at present involves 478 large energy consumers in the industrial sector. Additionally, more than 1 million medium and small-scale enterprises will be involved in the Zero Defect, Zero Effect scheme to improve their quality and energy efficiency, enhance resource efficiency, control pollution, manages wastes, and use renewable energy.

Every day, the Indian railways handle 3 million tonnes of freight and 23 million passengers. Although over the time, the volume of freight and passengers carried by rail in India has increased significantly, there has been a decline of share of traffic by railways compared to traffic by roads which is more energy intensive. Efforts are being made to check this declining trend of railways.

India's urban transport policy envisages encouraging moving people rather than vehicles with a major focus on Mass Rapid Transit Systems. India already has to 236 km of metro rail in place and about 1150 km metro projects are being planned for other cities.

India is one of the few countries where forests and tree covers have increased in recent years, transforming the country's forests into net sinks. Per the latest assessment, forests and tree covers have increased from 23.4% of the geographical area in 2005 to 24% in 2013. The government's long-term goal is to bring 33% of the country's geographical area under forest cover.

India's Intended Nationally Determined Contribution

Although ambitious, India's Intended Nationally Determined Contributions (INDC), submitted to the United Nations Framework Convention on Climate Change on 2 October 2015, clearly embarks upon the fact that the country has come a long way towards developing low-carbon solutions and strategies. India's INDC has eight elements:.

1. **Promote sustainable lifestyles.** To put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation.
2. **Achieve cleaner economic development.** To adopt a climate-friendly and a cleaner path than the one followed hitherto by others at corresponding levels of economic development.
3. **Reduce emissions intensity of GDP.** To reduce the emissions intensity of its GDP by 33%–35% by 2030 from the 2005 level.
4. **Increase share of electricity generated from non-fossil fuel sources.** To achieve about 40% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030 with the help of transfer of technology and low-cost international finance including from the Green Climate Fund.
5. **Create additional carbon sinks through afforestation.** To create an additional carbon sinks of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forests and tree covers by 2030.
6. **Improve adaptation measures.** To better adapt to climate change by enhancing investments in development programmes in sectors vulnerable to climate change, particularly agriculture, water resources, Himalayan region, coastal regions, health, and disaster management.

7. **Mobilize finance.** To mobilise domestic and new and additional funds from developed countries to implement the above mitigation and adaptation actions in view of the resources required and the resource gap.
8. **Build capacity, develop and transfer technology.** To build capacities, create domestic framework and international architecture for quick diffusion of cutting edge climate technology in India, and for joint collaborative research and development for such future technologies.

Means of Implementation of India's Intended Nationally Determined Contributions

Implementing the NDCs will require India to develop innovative policies, institutional frameworks, mobilize the required resources and find solutions to promote newer, cleaner technologies. India is working on developing a roadmap for implementation of its NDC and has constituted a committee and six thematic sub-committees involving key ministries and departments. The six thematic sub-committees include: Mitigation; Adaptation; Finance; Forestry; Technology and Capacity Building; Transparency Compliance and Legal aspects.

Climate change finance

Finance is a key enabler of climate change action. A wide range of studies providing different estimates of the financial requirement to combat the adverse effects of climate change all tend to demonstrate the enormity of funds that would be needed for this task.

Estimates for India's finance requirements to combat climate change

Preliminary estimates peg India's financial requirements for adaptation actions in agriculture, forestry, infrastructure, water, and ecosystems in the order of US$ 206 billion (at 2014–2015 prices). Further investments would be required to strengthen resilience and disaster management. Additionally, NITI Aayog of Government of India estimates expenditure on mitigation activities for moderate low-carbon development for India to be around US$834 billion till 2030 (at 2011 prices).

Sources of climate change finance for India

India's actions tackling climate change have primarily been funded from domestic sources in the form of budgetary allocations under various schemes that have adaptation and mitigation components built into them. Apart from this, India sources the required funds from a careful mix of market mechanisms, fiscal instruments, and regulatory interventions to mobilise finance for climate change. To augment the availability of assured targeted resources, the government has set up two dedicated funds at the national level for mobilising finance for mitigation and adaptation actions, respectively. These are the cess on coal production and the National Adaptation Fund. India imposes a cess of INR 200 per tonne of coal production[2], which is equivalent to a carbon tax. The cess on coal primarily drives the National Clean Energy Fund which is used to finance clean energy and related projects. The National Clean Energy Fund, of its total funds of INR 170.84 billion till 2014–2015, is being used to finance 46 energy projects worth INR 165.11 billion.

Other fiscal instruments and incentives employed by the government to achieve a low- carbon economy and a sustainable growth trajectory include a reduction in subsidies and an increase in taxes on fossil fuels such as petrol and diesel. Among other strategies, the government is issuing Tax Free Infrastructure Bonds of INR 50 billion for funding renewable energy projects during 2015–2016, and following up on the 14th Finance Commission recommendation of setting up an incentive for creation of carbon sinks through forestry. Per the Finance Commission's recommendation, the devolution of funds to states from the federal pool would be based on a formula that would attach 7.5% weight to areas under forests, thus conditioning about US$6.9 billion of transfers to states based on their forest covers.

Technology transfer, knowledge sharing, and international cooperation

Finally, the pursuit of a low-carbon growth path cannot be achieved through domestic means alone. A significant reason behind the reduction of carbon intensity in India's economy is the adoption of new and innovative international technologies that address climate mitigation and adaptation. Thus, in order to pursue its path to low-carbon sustainable development, India vitally depends upon international collaborations both in terms of financial aid, technology transfer, knowledge sharing, and capacity building efforts.

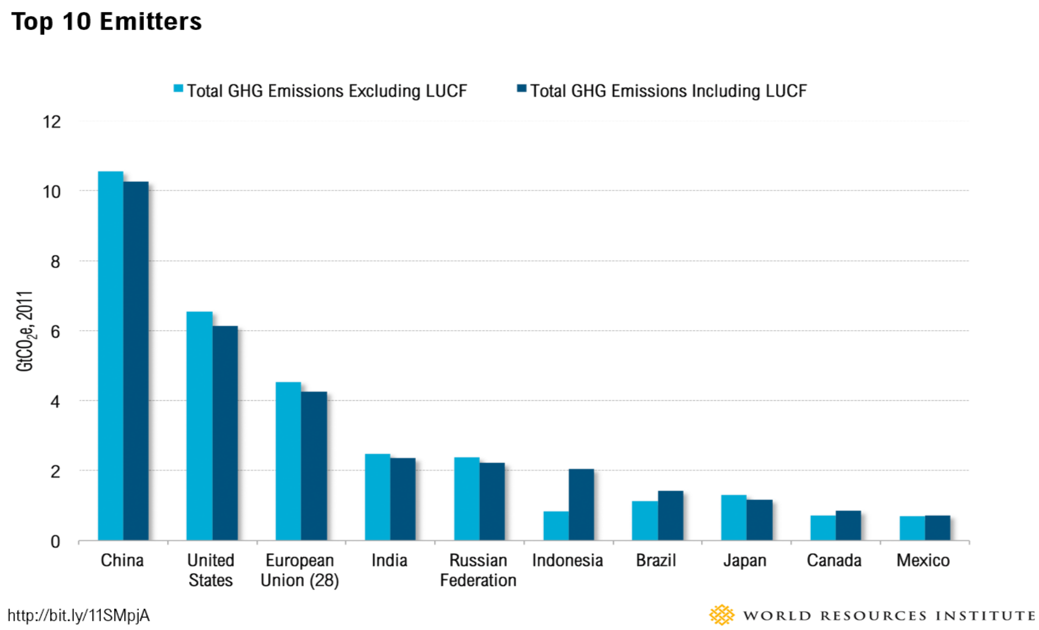
[2] With effect from 1April 2016 cess on coal production increased to INR400 per tonne

3E.Review of Nationally Determined Contributions of Indonesia

Indonesia's GHG Emissions

According to the World Resource Institute (2014), 10 countries produce around 70% of global greenhouse gas (GHG) emissions (Figure 3E.1). Indonesia's total GHG emissions rank the sixth largest if land use change and forestry are included.

Figure 3E.1. World's Top 10 GHG Emitters



GHG = greenhouse gas, GtoCO_2e = gigatonne of carbon dioxide equivalent, LUCF = land use change and forestry.
Source: Mengpin Ge, Johannes Friedrich, and Thomas Damassa (2014**)**.

A later analysis by the World Research Institute (2015) indicated that Indonesia's fires crisis in 2015 released more GHG emissions, reaching a total of 1.62 billion metric tonnes of carbon dioxide (MtCO_2). This surpassed Russia's total annual emissions and marked Indonesia as the world's fourth-largest emitter of GHGs. Excluding land use change, Indonesia's current total emissions are nearly 760 MtCO_2. Considering its impact to the global emissions, Indonesia's climate commitment is an important piece of the global response to climate change.

Indonesia's emissions reduction

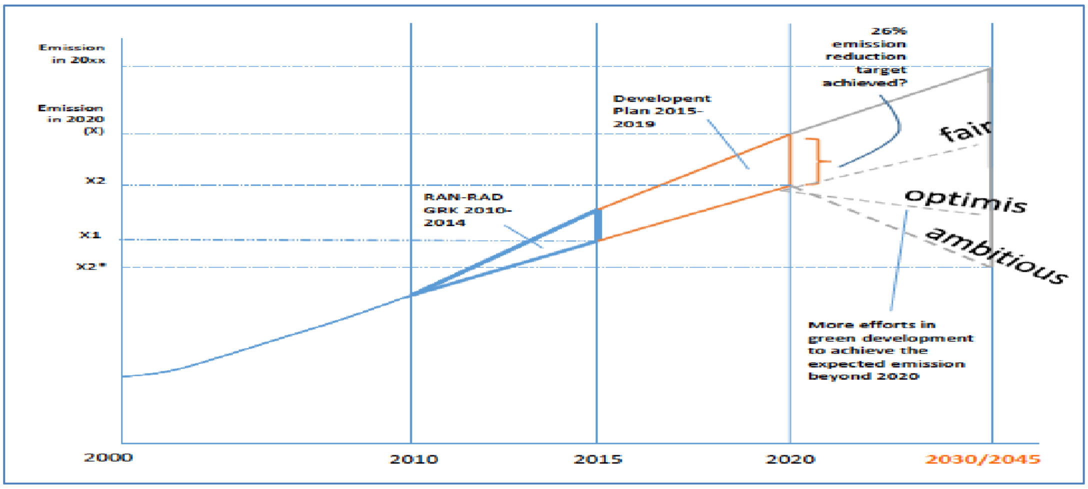
According to Indonesia's Second National Communication of 2010, national GHG emissions were estimated at 1.8 gigatonnes of carbon dioxide equivalent (Gt CO_2e) in 2005. Most emissions (63%) were the result of land use change, peat and forest fires, with combustion of fossil fuels contributing approximately 19% of total emissions.

In 2009, Indonesia voluntarily committed to reduce emissions by 26% by 2020 with its own effort and 41% with international support against the Business as Usual (BAU) scenario. This target is nationally implemented through the Presidential Regulation of the Republic of Indonesia No. 61 Year 2011, otherwise known as the National Action Plan for Greenhouse Gas Emissions Reduction.

The commitment to mitigation and adaptation has been included in the national mid-term development plan 2015–2019, thus mainstreaming the climate change commitment into the development plan as well as other global commitments such as Not Allowing Clearing Primary Forest and Prohibiting Open Peatland Areas.

As a continuing commitment, Indonesia has set in its Intended Nationally Determined Contributions (INDC) the 29% target of emissions reduction relative to the BAU scenario in 2030. Three mitigation scenarios were modelled for the National Action Plan for Greenhouse Gas Emissions Reduction review and INDC. The 'fair' scenario corresponds to the 29% unconditional reduction and the 'ambitious' scenario corresponds to the 41% reduction conditional on international support. The 'optimis' scenario is in between where more efforts have been pursued in green development to achieve the expected emissions beyond 2020 (Figure 3E.2).

Figure 3E.2. Reduction Scenarios

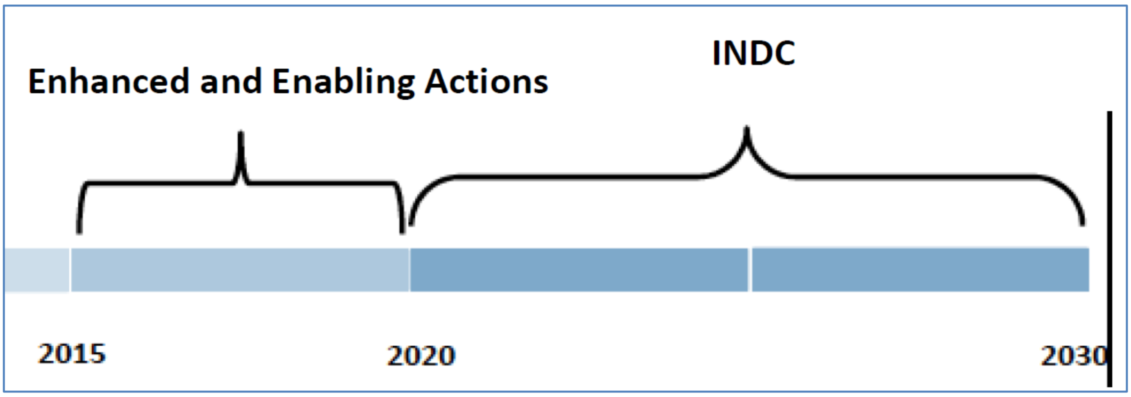


Source: Presentation at the Session 5: Synergies on land-use/REDD+ in countries' INDCs submitted to the United Nations Framework Convention on Climate Change and national strategy documents and REDD+ programmes; Joint FCPF/UN-REDD Programme Knowledge Exchange San Jose, Costa Rica, 8 November 2015.

Indonesia’s INDC

Indonesia’s INDC sets the path of the country’s transition towards a low-carbon future by outlining enhanced actions and putting in place the necessary enabling environments for 2015–2019 that will lay the foundation for more ambitious goals beyond 2020 (see Figure 3E.3).

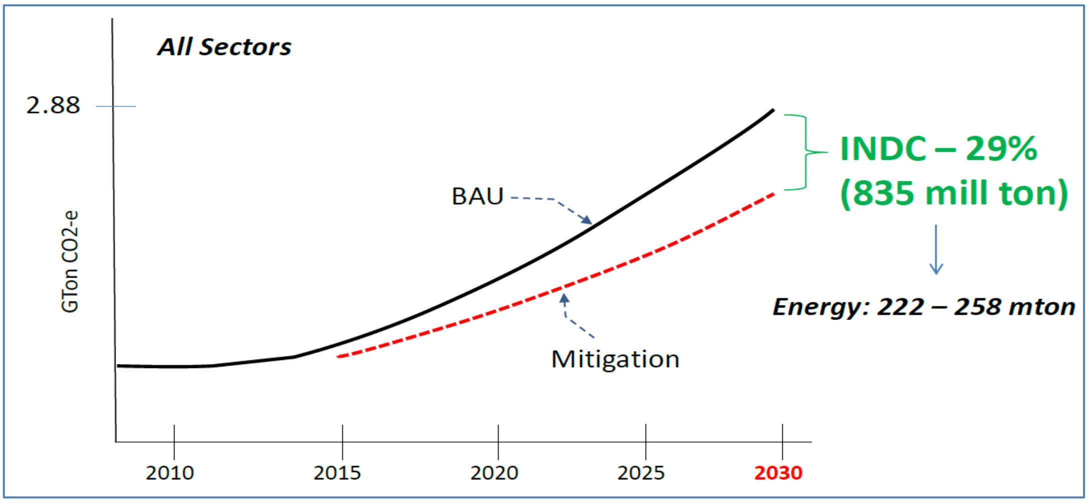
Figure 3E.3. INDC Transitional Strategy



Source: Presentation at the Session 5: Synergies on land-use/REDD+ in countries’ INDCs submitted to the United Nations Framework Convention on Climate Change and national strategy documents and REDD+ programmes; Joint FCPF/UN-REDD Programme Knowledge Exchange San Jose, Costa Rica, 8 November 2015.

Indonesia’s INDC is a continuing commitment to reduce the country’s GHG emissions. Indonesia submitted its INDC in September 2015 to the United Nations Framework Convention on Climate Change. The BAU scenario projection puts Indonesia’s GHG emission at 2,881 $GtCO_2eq$ in 2030. The reduction of up to 29% relative to the BAU scenario in 2030 will be equivalent to a reduction of around 835 metric tonnes of CO_2 equivalent ($MtCO_2e$) (Figure 3E.4). Around 222–258 $MtCO_2e$ will be the reduction from the energy sector. With international support, this target can be extended up to 41%, equivalent to a reduction versus BAU of 1,192 $MtCO_2e$ in 2030.

Figure 3E.4. Indonesia's INDC



BAU = Business as Usual, GTCO2e = gigatonne of carbon dioxide equivalent, INDC = intended nationally determined contributions.
Source: Siagian, et al. (2015)

Reduction level

Indonesia's INDC states conditional and unconditional mitigation targets. It would reduce 29% of the emissions against the BAU scenario by 2030 as unconditional scenario. If there is additional international support, Indonesia intends to reduce additional 12% of the emissions. The intended contributions cover five sectors: energy (including transportation), industrial processes and product use, agriculture, land use, land-use change and forestry, and waste sector, with three greenhouse gases: carbon dioxide, methane, and nitrous oxide. The amount of emissions under the 29% and 41% reduction targets would be 0.848 $GtCO_2eq$ and 1.119 $GtCO_2eq$, respectively.

Unconditional reduction level

The commitment to reduce GHG emissions unconditionally by 26% against BAU by 2020, and by 29% by 2030 will be implemented through:

- Effective land use and spatial planning;
- Sustainable forest management including social forestry programmes;
- Restoring functions of degraded ecosystem;
- Improved agriculture and fisheries productivity;
- Energy conservation and the promotion of clean and renewable energy sources (the 23% EBT share in the energy mix in 2025, as stated in the Ministerial Decree No 79/2014, will encourage plantations for energy); and
- Improved waste management.

This is a fair reduction target scenario based on the 2010 National Action Plan on GHG Reduction which was estimated at 2.881 $GtCO_2e$ at BAU scenario in 2030.

Conditional reduction

Support from international cooperation is expected to help increase Indonesia's contribution up to 41% emissions reduction by 2030. The additional 12% is subject to provisions in the global agreement through bilateral cooperation: technology development and transfer, capacity building, payment for performance mechanisms, technical cooperation, and access to financial resources to support mitigation and adaptation efforts.

Content of the INDC document

The INDC document consists of six parts: the national context (including the mitigation and adaptation situation), planning process, strategic approach, information to facilitate clarity, transparency and understanding, key assumptions, and review and adjustment.

An annex to elaborate salient items particularly on adaptation has been included.

Coordination and mainstreaming of Indonesia's INDC

Indonesia's NDC has been well mainstreamed into the National Development Plan. The National Coordination Team (through the Secretariat of the National Action Plan for Greenhouse Gas Emissions Reduction) has been established since 2010 and it will continue to implement actions and provide data and information on GHG emissions reduction results. Involvement of non-governmental organisations and the private sector has been accommodated in the NDC measures.

Supports required

- Improving quality of monitoring, evaluation, and reporting;
- Improving capacity of regional and local governments; and
- Enhancing government and private sectors capacity to access Climate Change (CC) Funds

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3F.Review of Nationally Determined Contributions of Japan

Having faced a drastic change in its energy circumstances as a result of the Great East Japan earthquake and the accident at the Tokyo Electric Power Company's Fukushima Dai-ichi Nuclear Power Station, Japan decided to use the new Strategic Energy Plan in 2015 as starting point for reviewing and rebuilding from scratch its energy strategy.

Japan's intended nationally determined contribution towards post-2020 greenhouse gas (GHG) emissions reduction is at 26.0% by fiscal year (FY) 2030 compared to FY2013 (25.4% reduction compared to FY2005, approximately 1.042 billion tonnes of carbon dioxide equivalent as 2030 emissions). This is consistent with Japan's energy mix, set as a feasible reduction target by bottom-up calculation with concrete policies, measures, and individual technologies, and taking into adequate consideration, inter alia, technological and cost constraints, and set based on the amount of domestic emissions reductions and removals assumed to be obtained.

GHG Emissions Reductions

Energy-originated carbon dioxide (CO_2)

Approximately 90% of GHG emissions in Japan is covered by energy-originated CO_2. Emissions of energy-originated CO_2 will be reduced by 25% by FY2030 compared to FY2013 level (24% reduction compared to FY2005 level or approximately 927 $MtCO_2$). The estimated emissions in FY2030 in each sector are shown in Table 3F.1.

Table 3F.1. Estimated Emissions of Energy-originated CO_2 in Each Sector

	Estimated Emissions of Each Sector in 2030	2013 (2005)
Energy-originated CO_2	927	1,235 (1,219)
Industry	401	429 (457)
Commercial and other	168	279 (239)
Residential	122	201 (180)
Transport	163	225 (240)
Energy conversion	73	101 (104)

[Value: $MtCO_2$]

CO_2 = carbon dioxide, $MtCO_2$ = metric tonne of carbon dioxide.
Source: Author's calculation.

Non-energy originated CO_2

The target reduction is 6.7% compared to FY2013 level (17.0% reduction compared to FY2005 level or approximately 70.8 $MtCO_2$). See Table 3F.2.

Methane

The target reduction is 12.3% compared to FY2013 level (18.8% reduction compared to FY2005 level or approximately 31.6 metric tonnes of carbon dioxide equivalent ($MtCO_2e$). See Table 3F.2.

Nitrous oxide

The target reduction is 6.1% compared to FY2013 level (17.4% reduction compared to FY2005 level or approximately 21.1 $MtCO_2e$). See Table 3F.2.

Table 3F.2. Estimated Emissions of Non-energy-originated CO_2, Methane, and Nitrous Oxide

	Estimated Emissions of Each Gas in 2030	2013 (2005)
Non-energy originated carbon dioxide (CO_2)	70.8	75.9 (85.4)
Methane (CH_4)	31.6	36.0 (39.0)
Nitrous oxide (N_2O)	21.1	22.5 (25.5)

[Value: $MtCO_2e$]

Source: Author's calculation.

Fluorinated gases (hydrofluorocarbon, PEC_S, sulphur hexafluoride, and nitrogen trifluoride)

The target reduction is 25.1% compared to Calendar Year (CY) 2013 level (4.5% increase compared to CY 2005 level or approximately 28.9 $MtCO_2e$). See Table 3F.3.

Table 3F.3. Estimated Emissions of Fluorinated Gases

	Estimated emissions in CY 2030	FCY2013 (CY2005)
Fluorinated gases	28.9	38.6 (27.7)
Hydrofluorocarbons (HFC_S)	21.6	31.8 (12.7)
PFC_S	4.2	3.3 (8.6)
Sulphur hexafluoride (SF_6)	2.7	2.2 (5.1)
Nitrogen trifluoride (NF_3)	0.5	1.4 (1.2)

[Value: $MtCO_2e$]

Source: Author's calculation.

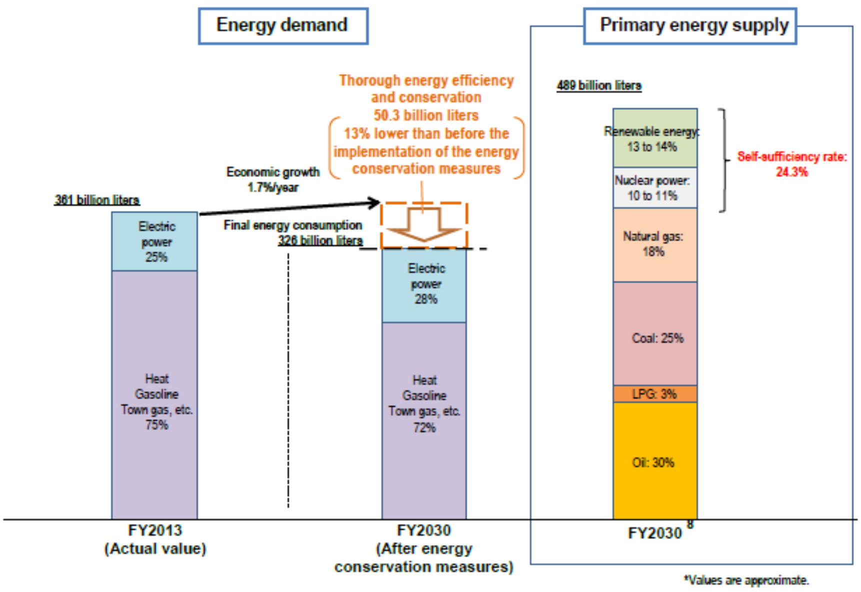
Energy Mix Used for the Emission Reduction Target

Energy demand and primary energy supply structure

The average annual economic growth is assumed at 1.7%, and estimated real gross domestic product (GDP) in 2030 will be ¥711 trillion. The population projection is assumed by the National Institute of Population and Social Security Research (Medium-Mortality Assumption) to be 117 million in 2030.

Energy saving of approximately 50.3 billion litres (crude oil equivalent) is set to be achieved in terms of final energy consumption, resulting in the final energy consumption of 326 billion litres in FY2030. See details in Figure 3F.1.

Figure 3F.1. Energy Supply and Demand

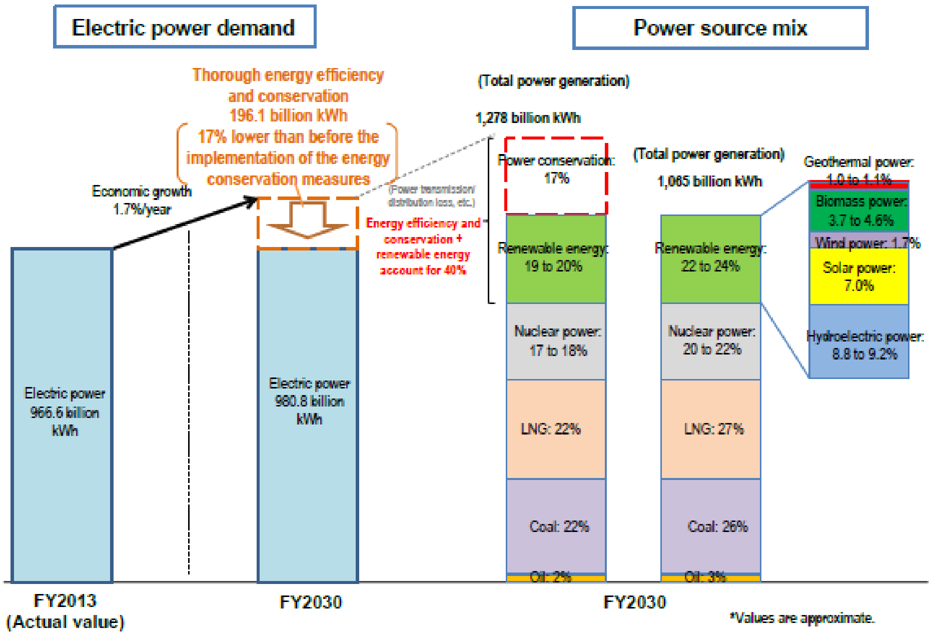


Source: METI.

Power Generation

The electric power supply-demand structure in 2030 will greatly reduce the dependence on the nuclear power plants, which was approximately 30% before the Great East Japan earthquake, to approximately 20%–22%. Also, renewable energy is expected to be introduced to the maximum extent possible, which will be 22%– 24%. See details in Figure 3F.2.

Figure 3F.2. Power Generation



Source: Ministry of Economy, Trade and Industry.

Trend of GHG emissions per GDP and GHG emissions per capita

Japan's GHG emissions per GDP are 0.29 kgCO_2e/US$ in 2013 and per capita are 11 t-CO_2e/person in 2013, all of which are already at the leading levels among developed countries.

The indicators noted above are projected to improve by around 20%–40% by 2030 with further measures to reduce emissions.

3G.Review of Nationally Determined Contributions of the Lao PDR

National Context

With around 70% of the Lao population relying on subsistence agriculture for livelihood, effects of climate change, such as unpredictable rains and extended dry seasons, will have a significant impact on their lives across the country.

The Lao People's Democratic Republic (Lao PDR) is not a major contributor to climate change but is likely to be disproportionably affected by it. The country is concerned about the serious consequences of climate change to its economic development, human capacity, poverty reduction, and environmental sustainability.

The government of the Lao PDR ratified the United Nations Framework Convention on Climate Change in 1995 and the Kyoto Protocol in 2003. This strategy builds on the country's commitment to its climate change adaptation efforts.

To date, only limited assessment, analysis, or projections have been made on the potential climate change impacts to the physical and social environment in the Lao PDR due to the lack of long-term climate data to support projections of climate trends.

The Lao PDR has a long-term goal for national development as set out in its 8th Five-Year National Socio-economic Plan (2016–2020), with a vision for 2030. The goal is for the Lao PDR to make the transition of its status from a least developed country to a middle-income country by 2030 and supported by inclusive, stable, and sustainable economic growth while alleviating poverty. The country recognizes the strong link between economic development, sustainability, and the need to mainstream environmental considerations, including action on climate change, into its development plans.

The Lao PDR hasdeveloped the Climate Change and Disaster Law and the overarching legal framework for climate change and disaster management was provided in the law.

The National Strategy on Climate Change (NSCC) of Lao PDR was approved in early 2010 and states a vision '[to] secure a future where Lao PDR is capable of mitigating and adapting to changing climatic conditions in a way that promotes sustainable economic development, reduces poverty, protects public health and safety, enhances the quality of Lao PDR's natural environment, and advances the quality of life for all Lao People.'

In addition to the overarching strategy set out in NCCS, the climate-change action plans for 2013–2020 define mitigation and adaptation actions in the sectors of agriculture, forestry, land use change, water resources, energy, transportation, industry, and public health. The Lao PDR is a highly climate-vulnerable country and its greenhouse gas (GHG) emissions were only 51,000 giga cubic grams in 2000, which was negligible compared to total global emissions. Despite this, the Lao PDR has ambitious plans to reduce its GHG emissions while at the same time increasing its resilience to the negative impacts of climate change. Examples of such plans include the following:

- An ambitious target set out in the National Forestry Strategy to the Year 2020 to increase forest cover to a total of 70% of land area by 2020, and maintain it at that level going forward. This will reduce the risk of floods and prevent land degradation. At the same time, the GHG mitigation potential of such a target is substantial and long lasting.
- In terms of the country's large-scale electricity generation, its electricity grid draws on renewable resources for almost 100% of output. The Lao PDR also aims at utilizing unexploited hydropower resources to export clean electricity to its neighbours. By supplying neighbouring countries such as Cambodia, Viet Nam, Thailand, and Singapore with hydroelectricity, the Lao PDR is enabling other countries in Southeast Asia to develop and industrialize in a sustainable manner.
- The government has also laid the foundations for implementing a renewable energy strategy that aims to increase the share of small-scale renewable energy to 30% of total energy consumption by 2030.

Climate change is already causing economic loss and affecting the livelihoods, food security, water supply, and health of much of the country's population. As the frequency and intensity of climate-related hazards such as droughts and floods are expected to increase, the Lao PDR must urgently take steps to build resilience by enhancing its adaptation efforts across all sectors. A more detailed summary of the country's vulnerabilities to climate change and the adaptation actions proposed to address them are discussed further in Section 3 of its Intended Nationally Determined Contributions (INDC).

The Lao PDR is committed to implement its NCCS and sectoral climate change action plans for the national, regional, and global benefit. However, technical and financial support are required to deliver its mitigation and adaptation actions. With such support, the NCCS will be most efficiently implemented, the potential GHG reductions will be optimized, and the country can most effectively adapt to the negative and immediate effects of climate change.

Mitigation

Mitigation contribution

The Lao PDR has identified several actions which it intends to undertake to reduce its future GHG emissions, subject to the provision of international support. These are outlined in Table 3G.1 together with preliminary estimates of the projected emissions reductions.

These estimates have been drawn from various sources and need to be reviewed and updated to address consistency and accuracy in analytical methods once more reliable data and information are available.

Table 3G.1. Intended Mitigation Activities to be Implemented by the Lao PDR in 2015–2030

No.	Name of Activity	Objective of the Activity	Estimated CO_2e Reduction
1	Implementation of the 'Forestry Strategy to the Year 2020' of the Lao PDR	To increase forest cover to 70% of land area (i.e. to 16.58 million hectares) by 2020. Once the target is achieved, emissions reductions will carry on beyond 2020	60,000–69,000 $ktCO_2e$ (once the target has been met by 2020 onwards)
2	Implementation of the Renewable Energy Development Strategy	To increase the share of renewable energy to 30% of energy consumption by 2025	1,468,000 $ktCO_2e$ (by 2025)
3	Implementation of the Rural Electrification Programme	To make electricity available to 90% of households in rural area by 2020. This will offset the combustion of fossil fuels to produce power where there is no access to the electricity grid.	63 $ktCO_2$/per annum (pa) (once the target is met in 2020)
4	Implementation of transport-focused Nationally	In one NAMA feasibility study, road network development is identified as a first objective which will reduce the number of kilometres travelled by all	Road network development is 33 $ktCO_2$/pa, and 158 $ktCO_2$/pa for public transport

	Appropriate Mitigation Actions (NAMAs)	vehicles. The second objective is to increase the use of public transport compared to the business as usual (BAU) scenario.	development
5	Expansion of the use of large-scale hydroelectricity	The objective of this activity is to build large-scale (>15 MW) hydropower plants to provide clean electricity to neighbouring countries	16,284 ktCO_2 per annum (2020–2030)
6	Implementation of climate change action plans	To build capacity to monitor and evaluate policy implementation success, with a view to producing new policy, guidance, and data. The objective is to develop and implement effective, efficient, and economically viable climate change mitigation and adaptation measures	To be estimated as part of the implementation plan

CO_2 = carbon dioxide, ktCO_2e = kilotonne of carbon dioxide equivalent, MW = megawatt.
Source: UNFCCC.

Ambitious and fair

The Lao PDR's GHG emissions are very low in the global context and the country's historic contribution to climate change has been minimal. Despite this and its status as a least developed country, the government of the Lao PDR intends to implement policies that support the long-term goal of limiting global GHG emissions in line with the objectives of the United Nations Framework Convention on Climate Change and the findings of the Intergovernmental Panel of Climate Change's 5th Assessment Report. These represent the first time that the Lao PDR has made an international undertaking to act on mitigation and therefore fulfil the requirements of the Lima Call for Climate Action to go beyond existing efforts.

To maximize the ambition of its mitigation contribution while considering the need for economic development, the Lao PDR has prioritized mitigation actions that both address the main causes of future increases in emissions and have significant development co-benefits. This is a fair approach to the nation's first INDC. Forestry-based actions will not only increase the amount of GHG sinks in the Lao PDR but will also provide adaptation co-benefits contributing to prevention of flooding, soil erosion, and landslides, and protection of biodiversity and ecosystem services. Improving public transport will not only lessen GHG emissions as a result of travel but will also improve air quality and support more sustainable economic growth. The rural electrification programme will reduce

GHG emissions, promote rural development, and reduce poverty. Finally, exporting hydropower to other countries in the region will allow their economies to grow in a more sustainable manner by replacing consumption of fossil fuels.

The Lao PDR's INDC includes a mix of plans by the government, including those supported by overseas development assistance. The Lao PDR is also implementing other national and local plans such as the allocation of approximately US$12 million annually for disaster emergency response plans. This demonstrates that the Lao PDR is not content to wait for international support to take action on climate change. Reforestation and maintenance of forests, for example, is a major challenge for the country, so achieving success with international programmes and assistance such as REDD+ and FLEGT is strongly desired.

Overall, to achieve maximum mitigation potential, further international support is required by the Lao PDR. The main support needs are set out in Section 4 and Annex 1 of the Lao PDR's INDC.

Adaptation

As set out in the vision for NSCC referred to earlier, the Lao PDR intends to balance its need for development without compromising its environment. For climate change adaptation, this translates into the following goals as articulated in the NSCC:

- Increase resilience of key economic sectors and natural resources to climate change and its impacts.
- Enhance cooperation, strong alliances, and partnerships with national stakeholders and international partners to achieve national development goals.
- Improve public awareness and understanding of various stakeholders about climate change, vulnerabilities, and impacts to increase willingness of stakeholders to take actions.

The Lao PDR's economy is already experiencing the impacts of climate change and most of the population remains highly vulnerable to climate hazards, particularly floods and droughts. This is because the Lao PDR's economy and over 70% of population depend on natural resources for livelihoods and ensuring food security. The agriculture sector is responsible for 29.9% of GDP and approximately 70% of the population are dependent on the sector for

livelihoods. Increasing climate resilience with respect to agriculture, especially food security, is therefore a high priority. Another high priority is the provision and management of water resources as this contributes to social well-being, economic productivity, and water supply for agriculture, industrial processes, and energy production.

Flooding is a major climate risk in the country, threatening livelihoods almost every year. Fourteen out of 17 provinces as well as Vientiane, the country's capital, have experienced floods since 1995. The country's annual rainfall is expected to increase its variability which, accompanied with increase in temperature, could have significant impact on water resources, ecosystems, and agricultural production. In addition, floods have an adverse impact on housing, health, education, industrial activities, and infrastructure (transportation, water, and sanitation). As an example, the flooding in 2005 caused widespread disruption with estimated economic costs of US$29 million.

The Lao PDR is also experiencing increasingly frequent episodes of drought. Severe droughts occurred in 1996, 1998, and 2003. About 6 out of 17 provinces are already at high risk of droughts. Droughts adversely affect water resources, hydro-electric generation, and agricultural production resulting in widespread economic losses.

The National Adaptation Programme of Action (2009) maps out a country-driven programme to address immediate and projected climate change adaptation requirements in the agriculture, forestry, water resources, and public health sectors. The adaptation programme, intended for implementation by 2020, was further developed in NSCC to cover the main sectors of the economy, which are identified as agriculture and food security, forestry and land use change, water, energy and transport, urban development, industry, and public health sectors.

One guiding principle of the NSCC is to develop and implement integrated adaptation and mitigation solutions, i.e. provide low-cost measures, improve energy efficiency, promote cleaner production, and provide adaptation/mitigation synergies as well as economic, environmental, and socio-economic benefits. Hydroelectricity has great potential in the Lao PDR in providing clean energy, an opportunity to reduce GHG emissions and meet other objectives such as flood, irrigation, and water supply management. The forestry sector, for example, contributes to both national economy and livelihoods of many Laotians. Sustainable forest management therefore improves the resilience of communities and ecosystems and at the same time reduces GHG emissions by absorbing carbon dioxide.

To work towards achieving NSCC's vision and goals and effectively implement the climate change action plans for all sectors, development of a monitoring and evaluation system is an immediate need for the Lao PDR. Table 3G.2 reflects the nation's adaptation priorities given the current understanding of expected climate impacts. These actions will be continuously assessed and improved when monitoring and evaluation data and new information about climate change and impacts become available.

Table 3G.2. Focus of Adaptation Projects in Key Sectors

No.	Sector	Focus of Projects and Programmes
1	Agriculture	- Promoting climate resilience in farming systems and agriculture infrastructure - Promoting appropriate technologies for climate change adaptation
2	Forestry and land use change	- Promoting climate resilience in forestry production and forest ecosystems - Promoting technical capacity in the forestry sector for managing forest for climate change adaptation
3	Water resources	- Strengthening water resource information systems for climate change adaption - Managing watersheds and wetlands for climate change resilience - Increasing water resource infrastructure resilience to climate change - Promoting climate change capacity in the water resource sector
4	Transport and urban development	- Increasing the resilience of urban development and infrastructure to climate change
5	Public health	- Increasing the resilience of public health infrastructure and water supply system to climate change - Improving public health services for climate change adaptation and coping with climate-change-induced impacts.

INDC Development Process and Implementation Plan

The Lao PDR's INDC has been prepared through an inclusive stakeholder consultation process involving line ministries, research institutions, civil organisations, provincial governments, private sector, and international development partners. The main sources of information in preparing this document were the 7th and 8th five-year National Socio-Economic Development Plan 2011–2015 and 2016–2020, with a Vision to 2030 (2011 and 2015); National Climate Change Strategy (2010); Forestry Strategy to the Year 2020 of the Lao PDR (2005); Renewable Energy Development Strategy (2011); Sustainable Transport Development Strategy (2010); Climate Change Action Plan of Lao PDR for 2013–2020 (2013); National Adaptation Programme of Action (2009); Second National Communication to the UNFCCC (2013); and Investment and Financial Flows to Address Climate Change in Energy, Agriculture and Water Sector (2015).

The cross-ministerial National Disaster Management Committee will oversee the overall implementation of INDC. Using the committee's existing structure, the Ministry of Natural Resources and Environment will act as the Secretariat. This will involve coordination with relevant ministries and cooperation with international stakeholders to access finance and capacity building for the implementation of INDC, including the establishment and implementation of a monitoring, reporting, and verification (MRV) system.

The Ministry of Natural Resources and Environment will disseminate INDC and, later, the results of the COP 21 to relevant ministries in the central and line agencies at the local levels. INDC will also be incorporated in the 8th National Socio-Economic Development Plan to ensure the continued mainstreaming of climate-related policy in overall national plans.

INDC will be implemented in a coordinated manner with NCCS, climate change action plans, and sectoral plans. The current climate change action plans run until 2020 and the Lao PDR will start devising the next set of action plans to continue to implement NCCS before the end of 2020. Details of implementation of the mitigation and adaptation actions identified in Sections 2 and 3 of this INDC are set out in Annexes 1 and 2, respectively.

To facilitate implementation of INDC and ensure that climate change action plans are executed in the most effective, efficient, and economic manner, the Ministry of Natural Resources and Environment will carry out four elements as follows:

1. **Overall strategy, coordination of INDC implementation, and regulatory framework.** This will be established by the ministry. Effective arrangements for liaison with line ministries responsible for aspects of INDC, international stakeholders, and development partners at national and local levels to facilitate implementation of INDC will be put in place. This will also include strengthening the policy and regulatory framework specially to continue development and promulgation of the Climate Change and Disaster Law, which is expected to be in effect in 2017. This law will be a continuum of earlier achievements on climate change policies and plans such as the Environmental Protection Law, the Revised Urban Planning Law, the Strategic Plan on Disaster Management 2020 (2003), and the National Strategy on Climate Change (2010).
2. **Capacity building**. One of the biggest requirements is to instigate the development of technical capacity not just across sectors but at all levels of engagement from central government decision-makers through to local levels and technical staff. In mitigation, capacity building is needed, for example, in feasibility studies, mitigation analysis, and policy development. Regarding adaptation, capacity building is needed in understanding the climate change impacts, adaptation measures (including technical requirements such as drought- and flood-resistant varieties of crops, research into new crops and climate-resilient technologies), and how the adaptation measures will impact on communities and environments.
3. **Finance.** In summary, broadly eight main steps need to be followed to ensure that domestic and international finance is successfully acquired, utilized, and accounted for:
    a. Assess needs, define priorities, and identify barriers to investment
    b. Identify policy mix and sources of financing
    c. Identify access routes to multilateral finance

d. Blend and combine resources
e. Formulate projects, programmes, and sector-wide approaches to access finance
f. Implement and execute planned action
g. Implement and manage project coordination systems
h. Monitor, report, and verify / monitor and evaluate climate finance

With respect to domestic resources for climate action, the Lao PDR has apportioned US$12.5 million for climate change, which represents approximately 0.14% of GDP in 2012. To implement the mitigation actions and address adaptation needs, international support in the form of financial, technology transfer, and capacity building is needed. An initial estimate of the financial needs for implementing identified mitigation and adaptation policies and actions is US$1.4 billion and US$0.97 billion, respectively. Details are provided in Annex 1 (mitigation) and Annex 2 (adaptation).

4. **Monitoring, reporting, and verification (MRV).** An MRV system is the cornerstone of effective national implementation as it allows progress against implementation plans to be demonstrated and provides data for learning for future project development. The Lao PDR recognizes that its capacity with respect to MRV requires development if the climate change goals set out in its INDC are to be realized. Specifically, a GHG inventory system, nationally appropriate mitigation actions,MRV framework, adaptation evaluation indicators, and tracking systems for climate finance need to be developed. In the immediate term, to develop an MRV system, the Lao PDR intends to carry out the following:
    - Readiness assessments. These will identify the current state and barriers on data, organizational arrangements, personnel capacity, national policies, and any existing domestic MRV systems.
    - Capacity building. Once the readiness assessment is complete, a capacity development plan will be produced and implemented, and tools will be provided to carry out MRV inclusively.

References

UNFCCC (2015) Lao PDR report on Intended Nationally Determined Contribution, 30 September 2015.

3H.Review of Nationally Determined Contributions of Malaysia

Introduction

In 2013, parties to the United Nations Framework Convention on Climate Change (UNFCCC) were invited to initiate domestic preparations for and submit their intended Nationally Determined Contributions (INDC) by 2015. The INDC submission aimed to facilitate the UNFCCC negotiations for adopting relevant instrument under the convention applicable to all parties towards achieving the objective of the convention as set out in its Article 2. Countries were expected to outline in their INDCs the post-2020 climate actions they intend to take under an international agreement. During the 21st Conference of the Parties (COP21) of UNFCCC in Paris in December 2015, the parties adopted the Paris Agreement, a historic international climate agreement aimed to hold increase of global average temperature to well below 2°C, to pursue efforts to limit the increase to 1.5°C, and to achieve net zero emissions in the second half of this century.

Malaysia submitted its INDC to UNFCCC in November 2015. It stipulates that Malaysia intends to reduce its greenhouse gas (GHG) emissions intensity of gross domestic product (GDP) by 45% by 2030 relative to the emissions intensity of GDP in 2005. This consist of 35% on an unconditional basis and a further 10% conditional upon receipt of climate finance, technology transfer, and capacity building from developed countries. Malaysia's INDC was developed by a participatory process through an inter-ministerial/agencies working group. Stakeholder consultations were conducted in 2015 to obtain inputs on possible measures to reduce GHG emissions.

Major GHG-Emitting Sources

In 2005, Malaysia emitted about 288 metric tonnes of carbon dioxide equivalent ($MtCO_2e$), including emissions from the land-use change and forestry sector. With the country's GDP in 2005 of RM543.578 billion (US$ 143.534 billion), the emissions intensity of GDP in the base year was 0.531 tonnes CO_2 eq per thousand RM. The GHGs to be covered were carbon dioxide, methane, and nitrous dioxide. The sectors to be addressed were the energy, industrial processes, waste, agriculture and land use, and land-use change and forestry.

Table 3H.1. Level of Emissions in the Energy Sector, 2005 and 2011

Source of Emissions	Historical Emissions ($ktCO_2e$)	
	2005	2011
Energy industries	91,308.04	113,885.95
Transport	45,608.51	44,310.00
Industry	35,636.30	23,094.82
Oil and gas	27,106.17	29,535.66

CO_2 = carbon dioxide, $ktCO_2e$ = kilotonne of carbon dioxide equivalent.
Source: Malaysia's First Biennial Update Report submitted to the United Nations Framework Convention on Climate Change in December 2015 (MNRE, 2016).

In the context of the Intergovernmental Panel on Climate Change's categorization of GHG inventory, the energy sector consists of six sub-sectors. Four of these sub-sectors alone – energy industries, transport, manufacturing, and oil and gas – emitted about three-quarters of total national emissions in 2005 and 2011. Table 3H.1 summarizes the level of emissions from these four energy sub-sectors.

Mitigation Actions

Power sector

Feed-in tariff mechanism

A feed-in tariff (FiT) mechanism has been implemented in Peninsular Malaysia and Sabah since 2011 to increase proportion of renewable energy in the fuel mix for grid electricity generation. The aim is to enhance national electricity supply security and sustainable socio-economic development. Indigenous renewable energy sources targeted for generation of power for supply to the grid network include biogas (e.g. agro-industrial waste and landfill gas), biomass (e.g. agro-waste and municipal solid waste), small hydropower, and solar photovoltaic. The mechanism obliges distribution licensees to buy from feed-in approval holders the electricity produced from renewable energy sources and supplied to the electricity grid for a specific duration. By guaranteeing access to the grid and setting a favourable price, it ensures that renewable energy becomes a viable and sound long-term investment for company's industries and for individuals. Renewable energy generation is based on statements of claims on sales by all approval holders submitted by distribution licensees for recovery from the Renewable Energy Fund.

Net energy metering scheme

The net energy metering scheme was initiated as one of the two programmes to continue effort of the feed-in tariff mechanism – which would end by 2017 – in developing renewable energy projects in Peninsular Malaysia and Sabah. The scheme was agreed by the Implementation Committee for Electricity Supply and Tariff in 2015 with a total capacity of 500 megawatts (MW) from 2016 to 2020. As announced in the 2016 budget, the Sustainable Energy Development Authority will offer a quota of 100 MW per year to encourage the use of solar photovoltaic (PV) system. It is an instrument implemented under the Eleventh Malaysia Plan to enable consumers to use their own generating facilities to offset their consumption of electricity over a billing period. Its implementation will provide savings on electricity bills to consumers by allowing renewable energy generators to use the electricity first and feed surplus electricity to the grid.

Solar PV is the only technology applicable under the net energy metering scheme, mainly because of its feasibility for the public at large to address climate change by generating clean energy. Furthermore, based on feed-in tariff experience, solar PV is a technology that requires minimal construction and with high take-up rate compared to other renewable energy technologies, mostly due to the declining cost of solar PV systems in recent years.

The concept of net energy metering is that the energy produced from the solar PV system installed will be consumed first and any excess will be exported and sold to the distribution licensees (such as the Tenaga Nasional Berhad [TNB] and the Sabah Electricity Sdn Bhd [SESB]) at the prevailing displaced cost prescribed by the Energy Commission. This scheme is applicable to all domestic, commercial, and industrial sectors if they are customers of TNB (Peninsular Malaysia) or SESB (Sabah and FT Labuan).

Large-scale solar photovoltaic plants

Together with the net energy metering scheme, the large-scale solar photovoltaic plants programme has been initiated by the government to encourage and increase the contribution of renewable resources in the fuel mix for national electricity generation after the feed-in tariff mechanism is ended by 2017. The large-scale solar photovoltaic plants programme (LSS) aims for large-scale solar projects with minimum 1 MW and maximum 50 MW of power generation. The electricity generated from LSS will be connected to either the transmission network or distribution network in Peninsular Malaysia, Sabah, or Labuan.

In accordance to the decision by the Planning and Implementation Committee of Electricity Supply and Tariff in August 2015, LSS will be implemented by the Energy Commission from 2017 to 2020 with a total 1,000-MW generation from Peninsular Malaysia and Sabah. For each year of the 4-year implementation, 200 MW will be installed in Peninsular Malaysia and 50 MW in Sabah. Besides the 1,000 MW through a competitive bidding framework, additional LSS projects will also be directly awarded in 2017, which include 150 MW in Peninsular Malaysia and 50 MW in Sabah.

Public and private licensees (non-feed-in tariff) for renewable energy generation

The Electricity Supply Act 1990 (amended in 2001) requires that any activity related to the supply of electricity be licensed. In accordance to the Electricity Regulations 1994 (amended in 2003), public and private licences may be granted. ST grants licences for the operation of such facilities in Peninsular Malaysia and Sabah.

Public licence is for the licensee to operate a public installation to supply energy to others; private licence is for the licensee to operate a private installation to generate electricity for its own use or at its property. In terms of renewable energy, the licences allow public licensees to sell electricity generated from renewable energy sources to utilities. The private licensee can manage electricity generation for own use using efficient technologies such as co-generation or power generation using renewable energy sources.

During operation, the licensee is required to monitor and submit information on monthly performance to ST. The electricity generation and installed capacity of renewable energy by public and private licensees are published by ST in its annual National Energy Balance. This mitigation effort excludes renewable energy generated from feed-in tariff mechanism.

Transport sector

Development of energy-efficient vehicles

The development of energy-efficient vehicles (EEVs) is one main objective of the National Automotive Policy 2014, including making Malaysia the regional hub for EEVs in ASEAN. By 2020, it was projected that some 85% of vehicles produced in the country will be EEVs. The key agencies for driving EEV development include the Ministry of International Trade and Industry and the Malaysian Automotive Institute.

EEVs are vehicles that meet a set of defined specifications in terms of carbon emissions level (gCO_2e/km) and fuel consumption (L/100 km). EEVs include fuel-efficient internal combustion engine vehicles, hybrid and electric vehicles, and alternative-fuelled vehicles.

The government has implemented several programmes to drive the EEV development forward, including several roadmaps to support the implementation of the National Automotive Policy 2014. Fiscal incentives of 100% tax exemption for both import duty and excise duty for hybrid electric vehicles were provided in 2011–2013. Tax exemption was also extended for models assembled in Malaysia for hybrids and EVs until 2015 and 2017, respectively. Beyond these dates, the exemptions will be determined based on the strategic value of these completely knocked-down assembly investments.

Use of compressed natural gas in motor vehicles

In Malaysia, the utilization of natural gas is diversified, including natural gas for vehicles. Natural gas is more environmentally attractive than other fossil fuels because it is composed chiefly of methane that releases carbon dioxide and water vapour when burned completely. In comparison, oil and coal compounds have much more complicated molecular structures that do not burn as cleanly. As such, the use of compressed natural gas (CNG) as an alternative fuel in automobiles has been promoted to enhance environmental quality and reduce carbon emissions.

CNG is mostly used in public transport vehicles which run on both natural gas and gasoline. The use of CNG was originally introduced for taxis during the late-1990s. New taxis were launched with NGV engines while operators were encouraged to install CNG tanks in existing taxis to minimize operational costs. To date, the use of CNG still predominantly occurs in the main cities, including Klang Valley and Penang. As fuel subsidies have been gradually removed in Malaysia since 2008, the subsequent price hike on petrol and diesel has led to a significant increase in the number of new CNG tanks installed. To date, no incentives have been offered to users of CNG engines other than taxi owners, while government subsidies on petrol and diesel have made conventional road vehicles cheaper to use in the eyes of the consumers.

Urban rail-based public transport

The Land Public Transport Master Plan underpins the development and operation of rail-based transportation in the country, especially in the urban areas. The rail network continues to be the backbone of Malaysia's existing and future public transport system. The government is injecting substantial investments to improve the rail network across major cities in the country. Rail usage is the fastest-growing among all modes of urban public transportation per ridership data from rail operators.

Public investment in rail-based urban mass transit infrastructure in the Klang Valley is taking place in the form of the light rail transit, the mass rapid transit, and the monorail networks. It aims to upgrade and integrate the urban public transport system and to promote reduced use of private transport and demand on-road infrastructure through increasing public transport modal share. The initiatives include construction of new rail-based mass rapid transit networks to integrate with the existing networks, and extension of existing networks to increase coverage and enhance efficiency.

Palm oil-based biodiesel in blended petroleum diesel for the transport sector

Palm oil biodiesel is an alternative fuel derived from palm oil and can be used as fuel in diesel engines without any engine modifications. It can also be blended in any proportion with petroleum diesel. The biodiesel-blended petroleum diesel can increase the use of palm oil-based biodiesel as a renewable clean-burning petroleum diesel replacement to contribute towards reducing Malaysia's dependence on fossil fuels and enhancing sustainable socio-economic development.

The B5 biodiesel is a blend of 5% palm oil or palm methyl ester and diesel, the use of which has been implemented in phases in the country since 2011. Depots nationwide with in-line blending facilities have been set up by the government together with participating petroleum companies. Since 2015, the programme has increased to 7% palm biodiesel blended with 93% petroleum diesel under the B7 programme.

Industry sector

Energy efficiency measures by large and medium-size industries

An energy audit maps the energy consumption of a facility. It aims to identify areas where energy efficiency can be implemented including, for example, energy wastage from equipment that is left on but not being used, or improvements in the processes that lead to energy savings. The outcome of an energy audit is recommendations on energy efficiency measures to be implemented and an evaluation of their costs and benefits. Energy audits are typically done by external consultants with expertise in energy auditing methods and the facility.

ST is implementing an energy audit and management programme that offers free energy audits to large and medium-size industries. In return, the owners are required to invest in energy-savings measures with an amount equal to the cost of the audit. The energy savings that can be expected from energy audits are at least 5% per year for 3 years of the total energy consumption of the installations concerned. Most of these savings are derived from eliminating energy wastage and accelerated change of inefficient equipment which are beyond their economic and technical lifetime. Larger energy efficiency projects are not considered in the savings calculations but will most likely also take place in many of the facilities which will significantly increase the savings.

Energy management is the day-to-day monitoring and management of the energy consumption in a facility. Programmes are initiated to mandate facilities to implement energy management by appointing an energy manager and preparing energy management reports. The Efficient Management of Electrical Energy Regulations 2008 already prescribes that large facilities need to implement energy management and this will be expanded to cover medium-size facilities. Furthermore, the energy management system requirements will be improved to ensure that energy efficiency measures and practices are being continuously implemented and tracked.

The campaign will run in the period 2016–2025 and target large and medium-size industrial facilities. The former consume a monthly electricity exceeding 500,000 kWh. It is estimated that there are approximately 1,500 and 3,000 large and medium-size industries, respectively.

Promotion of cogeneration in industries

Cogeneration increases thermal conversion efficiencies by generating both electricity and thermal power. However, its implementation, especially in the industries, is hindered by high top-up and standby rates and the inadequacies in the natural gas supply for co-generation.

These barriers will be addressed in ST's effort in promoting cogeneration in industries with high demand of heating or cooling. Several key strategic measures will be implemented including:

- Design of standby, top-up and load-connected charges that are cogeneration friendly by lowering the amount of charges and offering non-firm standby charges (daily or monthly as used charges).
- Open bidding for special package of cogeneration plants with special gas tariff pricing.
- Promoting the existing incentives such as low-cost financing by the Malaysia Green Technology Corporation and others.
- Capacity building for local manufacturers.
- Regulatory framework for grid-connected cogeneration and sales of excess power.
- Awareness enhancement on the benefits of cogeneration.

The market is facilities with high demand for heating or cooling. The preliminary market is only considered to be the supported projects in this programme. By the end of the plan period, it is targeted to have 100 operating cogeneration plants.

Use of high-efficient motors in industries

Motors are widely used in industrial processes and machinery and can either be purchased as stand-alone motors or integrated in equipment. Malaysia's Energy Commission or Suruhanjaya Tenaga (ST) has adopted the international standard by the European Committee of Manufacturers of Electrical Machines and Power Electronics and the International Electronical Commission for energy rating of motors, which classifies motors per the level of energy efficiency. ST is implementing a mandatory minimum energy performance standard for motors, planned to be effective in 2020, that defines the minimum performance for motors. In the period until 2019, awareness and promotion campaigns will be carried out to inform the industries about the benefits of energy-efficient motors and phasing out of low-efficient types. The campaign will also target importers and manufacturers of motors and equipment with integrated motors.

Oil and gas sector

Flaring and venting reduction in oil and gas operations in Malaysia

Fugitive emissions occur in oil and gas systems that comprise all infrastructure required to produce, collect, process or refine, and deliver natural gas and petroleum products to the market. The system begins at the wellhead or oil and gas source and ends at the final sales point to the consumer. The sources of fugitive emissions on oil and gas systems include, but are not limited to, equipment leaks, evaporation and flashing losses, venting, flaring, incineration, and accidental releases (e.g. pipeline dig-ins, well blow-outs, and spills).

Petronas, an oil and gas company owned by the government of Malaysia, recognizes its corporate responsibility to balance climate change risks while sustainably producing affordable and reliable energy. Within its Climate Change Framework, Petronas' carbon commitments drive the efforts to reduce carbon footprint and improve operational efficiency, including reducing flaring and venting in upstream.

In 2015, the oil and gas company's reduction in flaring and venting at several oil fields in domestic operations led to a 17-% decline of its overall annual emissions compared to 2014. The reduction was mainly attributable to the elimination of continuous flaring and venting for new projects, vent-to-flare conversion projects in existing undertakings and assets, better good management, and improved export compressor reliability.

Petronas has been gathering information of relevant activities since 2005 that result in emissions reductions from flaring and venting operations. This information is subject to third-party verification. Subsequently, upon internal approval, it may be disclosed in sustainability report and/or provided to relevant government ministries. The verified information is expected to be available in the first half of 2017. The estimated emissions reduction of 5–8 $MtCO_2e$ is the amount of reductions targeted to be achieved annually by 2030.

Commercial and residential sector

Energy efficiency measures in large and medium-size commercial buildings

ST is implementing an energy audit and management programme that offers free energy audits to large and medium-size commercial buildings. In return, the owners are required to invest in energy-saving measures an amount equal to the cost of the audit. The energy savings that can be expected from energy audits are at least 5% per year for 3 years of the total energy consumption of the installations concerned. Most of these savings are derived from eliminating energy wastage and accelerated change of inefficient equipment which are beyond their economic and technical lifetime. Larger energy-efficiency projects are not considered in the savings calculations but will most likely also take place in many of the facilities which will significantly increase the savings.

Energy management is the day-to-day monitoring and management of energy consumption in a facility. Programmes will be initiated to mandate facilities to implement energy management by appointing an energy manager and preparing energy management reports. The Efficient Management of Electrical Energy Regulations 2008 already prescribes that large facilities need to implement energy management and this will be expanded to cover medium-size facilities. Furthermore, the energy management system requirements will be improved to ensure that energy-efficiency measures and practices are being continuously implemented and tracked.

The campaign will run in 2016–2025. Energy management in large commercial facilities will be conducted during the whole plan period. Training courses and materials will be prepared to create awareness about energy-saving options and reporting will be required from the facilities. It will be marketed as an additional brand value for the facility.

The programme targets large and medium-size commercial buildings. The former consume a monthly electricity exceeding 500,000 kWh. It is estimated that there are approximately 600 and 1,400 large and medium-size commercial buildings, respectively.

Energy-efficiency measures in large government facilities

ST is implementing an energy audit and management programme that offers free energy audits to large government buildings. In return, the owners are required to invest in energy-saving measures an amount equal to the cost of the audit. The energy savings that can be expected from energy audits are at least 5% per year for 3 years of the total energy consumption of the buildings concerned. Most of these savings are derived from eliminating energy wastages and accelerated change of inefficient equipment that are beyond their economic and technical lifetime. Larger energy-efficiency projects are not considered in the savings calculations but will most likely also take place in many of the facilities which will significantly increase the savings.

Energy management is the day-to-day monitoring and management of energy consumption in a building. Programmes will be initiated to mandate facilities to implement energy management by appointing an energy manager and preparing energy management reports. The Efficient Management of Electrical Energy Regulations 2008 already prescribes that large building need to implement energy management. Furthermore, the energy management system requirements will be improved to ensure that energy-efficiency measures and practices are being continuously implemented and tracked.

The campaign will run in 2016–2025. For large government facilities, energy management will be compulsory by circular. This will allow the government to show leadership in energy efficiency as well as in implementing cost-reduction measures. A part of the energy management will be procurement procedures, ensuring that the government facilities are purchasing 5-star rated equipment.

The programme targets large government buildings that consume a monthly electricity exceeding 500,000 kWh. It is estimated that there are approximately 108 large government buildings.

Building energy efficiency through Green Building Index

The Green Building Index is a private-sector regulated green building rating tool initiated in 2013. In line with the demand for good corporate social responsibility, it aims to promote sustainability in the built environment through the application of green rating tools for buildings and townships by stakeholders in the building sector. The tool also encourages property developers and owners to plan, design, construct, and sustainably manage buildings and sites to optimize energy and water efficiency, enhance indoor environment quality, and to use materials and resources sustainably. During its implementation, the index compiles electricity consumption of all completed, assessed, and verified buildings based on the findings of completion and verification assessments conducted for computing energy savings in the certified buildings.

Promotion of 5-star rated refrigerators

The Programme for Promoting 5-Star Rated Refrigerators aims to transform the market of new refrigerators into more efficient models. It builds on the existing 5-star rating and labelling for refrigerators, which was introduced on a voluntary basis in 2005. Over the years, the rating and labelling initiative stimulated the 5-star rated refrigerators in the market, but its share is still low compared to conventional refrigerators that are 3-star rated. The 5-star rated refrigerators are more than 25% energy-efficient than the average 3-star refrigerators. As nearly all households in Malaysia own a refrigerator, which is often one of the most electricity-consuming appliances, increasing the market share of more energy-efficient refrigerators will result in high potential for energy savings. Total market is determined based on all residential consumers having one refrigerator each and this will increase annually with the increase in the number of registered consumers.

The programme will be implemented through several measures, including enforcement of minimum energy performance standards (MEPS) and labelling, review of the current MEPS value, awareness raising for promoting purchase of 5-star refrigerators, and the benefits of smart meter.

Promotion of 5-star rated air-conditioners

The programme aims to promote 5-star rated air-conditioners to residential and commercial users for saving energy use. The sale of air-conditioners is expected to increase with the growth of economy and population. For modern homes, it is not unusual that three to four air-conditioners are installed. Therefore, it is important to ensure that the consumers are choosing energy-efficient models.

The Energy Commission is implementing a mandatory star-rating scheme and energy labelling for air-conditioners. Air-conditioners with 5-star rating are at least 25% more efficient than conventional models. The programme will be implemented through several measures, including enforcement of mandatory MEPS and labelling of all air-conditioners in the market, improving the standards (wider range of capacity) and MEPS value, and raising awareness for promoting purchase of 5-star air-conditioners and the benefits of smart meter.

Promotion of energy-efficient lighting

Lighting is a basic electrical energy-consuming appliance to residential and commercial users. For the latter, lighting accounts for about 15%–20% of total electricity consumption. As such, improving lighting energy efficiency can result in substantial energy savings. The Programme for Promoting Energy-Efficient Lighting aims to achieve such objective. Measures to be implemented by ST include enforcement of MEPS and labelling as well as awareness-enhancement programmes including the benefit of using smart meters.

Conclusions

The progress of INDC implementation needs to be monitored to determine if the intensity-reduction targets are achieved. Such tracking will provide early alert if additional mitigation efforts are required when necessary.

References

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3I.Review of Nationally Determined Contributions of Myanmar

National Circumstances

Myanmar's Intended Nationally Determined Contributions (INDC) is an opportunity to confirm its commitment to climate change mitigation by pursuing the correct balance between socio-economic development and environmental sustainability. To this end, Myanmar has identified mitigation actions and policies in the primary areas of forestry and energy, complemented by supporting policies in other sectors.

However, as one of the world's least developed countries, Myanmar's existing technological, financial, and capacity gaps limit its ability to achieve its vision for sustainable development while balancing socio-economic development with environmental sustainability. For this reason, Myanmar requires significant support from the international community for capacity building, technology development and transfer, and financial resources to implement the actions proposed in its INDC.

Mitigation Contribution

Myanmar would undertake mitigation actions in line with its sustainable development needs, conditional on availability of international support, as its contribution to global action to reduce future emissions of greenhouse gases (GHG).

Mitigation actions

The actions presented below will result in significant reductions in GHG emissions. The implementation of these actions will be contingent to several factors, including support for capacity-building, technology development and transfer, and financial resources from the international community, as well as the active participation of the national and international private sector.

- By 2030, Myanmar's permanent forest estate target is to increase national land area as forest land.
- Actions are taken on both the supply side and the demand side of energy.
- The government of Myanmar is currently developing policies with the Long-Term Energy Master Plan and the National Electrification Master Plan, developed alongside the Energy Master Plan to increase the share of hydroelectric generation within limits of technical hydroelectric potential.
- To increase access to clean sources of electricity amongst communities and households currently without access to an electric power grid system.
- For energy efficiency in industrial processes:

(a) To mitigate GHG emissions in the rapidly developing industrial production sector by improving energy efficiency within the Myanmar industry.

(b) To focus on the implementation of energy management systems compatible with the international standard ISO50001.

(c) To realise a 20% electricity saving potential by 2030 of the total forecast electricity consumption.

- To increase the number of energy-efficient cooking stoves disseminated to reduce the amount of fuel wood used for cooking under the National Forestry Master Plan and National Energy Policy.

Institutional arrangements and planning for implementation

Climate change and environment

- The National Climate Change Policy, Strategy and Action Plan is being developed by the Myanmar Climate Change Alliance Programme and the Ministry of Environment, Conservation and Forestry and is designed to increase awareness of climate change in Myanmar, strengthen institutional capacity to develop policies to address it, and develop ecosystem-based adaptation practices.
- The Green Economy Strategic Framework is under development and will be ready in 2016.
- The National Environmental Policy, Framework and Master Plan (2030) is also currently being developed with the United Nations Development Programme and will update the National Environmental Policy (1994).
- The Environmental Conservation Law (2012) is being implemented and includes provisions to address climate change and make provisions for environmental impact assessments for development projects.
- The State of Environment Report 2015 was published.

Forest management

- The National Forestry Master Plan was first implemented in 2001 and will expire in 2030, upon which the next strategy will be designed and implemented.
- In 2011, the National Biodiversity Strategy and Action-Plan was published as a complementary strategy to the Master Plan.
- The National Strategy Action plan (2015) was published.
- Myanmar joined the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries

in November 2011, submitted its REDD+ Readiness Roadmap document in 2013, and developing country programme and taking actions in line with the REDD+ roadmap.

Energy management

- The National Energy Policy (2014) is the overarching national policy that provides the framework for energy development and planning in Myanmar.
- The Long-Term Energy Master Plan was published.
- The National Energy Efficiency and Conservation Policy, Strategy and Roadmap for Myanmar draft was finalized.
- The National Electricity Master Plan draft has been finalized. It aims to harmonize the medium- and long-term decisions on primary energy source selection and transmission system planning.

Other key sector

- The National Transport Master Plan and the National Implementation Plan on Environmental Improvement in the Transport Sector are being developed.
- To promote sustainable urbanisation, the government of Myanmar is drafting the National Urban and Regional Development Planning Law, a national housing policy, and a national urban policy.
- The National Waste Management Strategy and Action Plans was completed in 2017.
- The Ministry of Agriculture and Irrigation is involved in the following research works: alternative wet and dry paddy production techniques, implementing effective mitigation actions such as energy from crop residues, promoting the use of organic fertilisers, and methods to shorten the time of composting agricultural by-products. The bio-char programme is also being planned and will reduce GHG emissions as a result of less anaerobic decomposition in the production process. At the same time, this will increase crop production.

Adaptation

A National Adaptation Plan will be developed to plan, fund, and guide actions to meet adaptation objectives and priorities. Its implementation will be continued as planned in the document submitted to the INDC.

Implementation of INDC

There are five main aspects for successful implementation of INDC:

- Development of a clear strategy and coordination plan;
- Separate needs assessments for mitigation and adaptation activities;
- Identification of capacity-building requirements for mitigation and adaptation activities;
- Mobilising resources for policy development, identification, and purchase of suitable technologies for planned actions; and
- A monitoring system

Means of Implementation

To implement its INDC, Myanmar, as a least developed country, requires further capacity building along with access to technological and financial support from the international community.

Technology development and transfer

Understanding technology development and transfer needs in Myanmar is still developing and an additional technology need assessment should be completed with international support to better understand these requirements. Clearly needed is the transfer of environmentally sound technologies such as renewable energy and energy efficiency technologies for mitigation and flood control technology and early warning technologies for adaptation.

Capacity building

Mitigating climate change and adapting to its impacts will require significant capacity building in all aspects of Myanmar's plans to implement actions identified in its INDC. Human resources, scientific research, and technical and institutional capacities all require development, and international assistance is an important requirement to achieve these. For the various stages of the monitoring, reporting, and verification process, Myanmar will require international support at each step.

Financial support

The financial support required for the technology needs assessment for mitigation and adaptation activities, financial need assessment for estimation of implementation and operational and maintenance cost, identification of need assessment for capacity building for implementation, and monitoring of mitigation and adaptation activities. It is envisaged that financial support will be utilised by Myanmar in a variety of ways including but not limited to implementing identified actions in the forestry sector and energy sector; addressing financial needs of the other key sectors; development and implementation of other sectoral and eventually national monitoring, reporting, verification systems; producing GHG emissions inventories; quantifying development benefits; accounting for funds received; and reduction in vulnerability.

Mitigation Actions and Policies in the Energy Sector

1. Energy: 30% renewable in rural electrification (mini hydropower; biomass; solar, wind, and solar minigrid technologies)
2. Clean cooking and heating: Distribute approximately 260,000 energy-efficient cooking stoves between 2016 and 2031.
3. Renewable energy (hydropower): 9.4 GW hydro-electric generation by 2030.
4. Energy efficiency: 20% electricity-saving potential by 2030 of the total forecast electricity consumption.

Way Forwards

1. To finalize and submit NDC.
2. To revise INDC.
3. To update and add to NDC ahead of finalization, including corrections and clarifications.
4. Means of implementation, including progress on climate finance framework.
5. Implementation plans, including any outputs from the stakeholders' workshop.
6. To draw the NDC implementation roadmap.
7. To define the specific targets for each sector.

Reference

Myanmar's Intended Nationally Determined Contribution (2015), Ministry of Environment Conservation and Forestry.

3J.Review of Nationally Determined Contributions of New Zealand

An important feature of the Paris Agreement is the emissions target each country pledges under the framework of Intended Nationally Determined Contributions (INDC), which further progressed into Nationally Determined Contributions (NDC) once countries ratified the agreement. New Zealand's first NDC sets a clear commitment to reduce emissions by 30% below 2005 levels by 2030 that equals to 11% of emissions reduction against the 1990 levels. This demonstrates a progression beyond the current target, particularly with regards to cost and emissions impact. Compared to the Business as Usual (BAU) emissions, New Zealand's NDC target represents a significant reduction that also reflects continuous improvement in emissions efficiency across the economic activities in the country. New Zealand's INDC target is economy-wide absolute emissions reduction covering five sectors of the economy (UNFCCC, 2016). The scope and coverage of New Zealand's NDC is presented in Table 3J.1.

Table 3J.1. Scope and Coverage of New Zealand's NDC

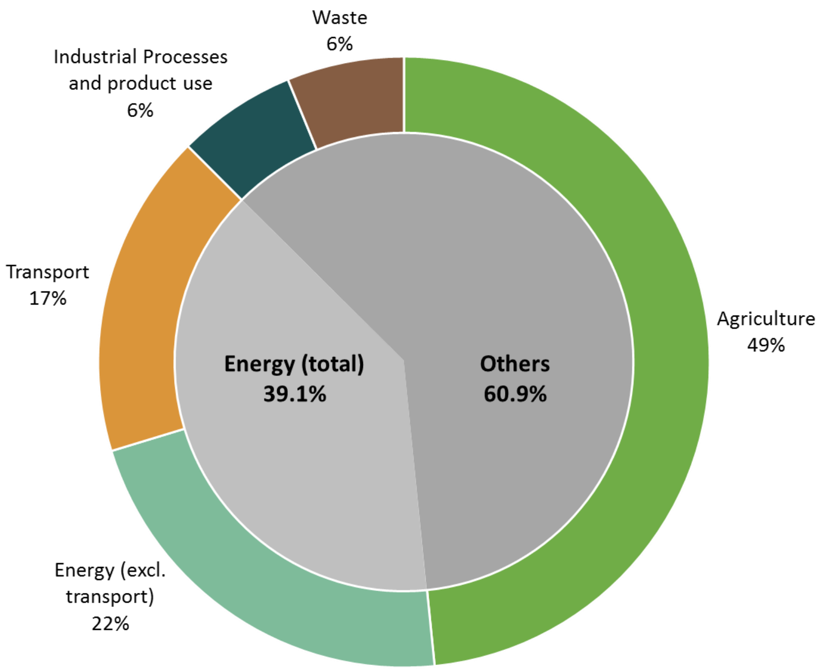
Target	Emissions reduction to 30% below 2005 levels by 2030
Target type	Absolute reduction target, managed using a carbon budget
Gases covered	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6), nitrogen trifluoride (NF_3)
Sectors covered	Energy, industrial processes and product use, agriculture, forestry and other land use, and waste.
Baseline scenario	2005

NDC = Nationally Determined Contributions.
Source: UNFCCC (2016).

New Zealand is endowed with abundant and diverse energy sources, including renewable sources. Among OECD countries, New Zealand already has the highest share of renewable sources in electricity generation. Around 80% of its electricity has come from renewable sources in recent years and New Zealand aspires to progress towards achieving 90% of electricity generation from renewable sources by 2025 (UNFCCC, 2015).

Since 1990, emissions intensity in the New Zealand economy has decreased by 33%. On a gross emissions basis, New Zealand generated around 400 tonnes of carbon dioxide (CO_2) per unit of GDP in 2013. Chart 3J.1 presents GHG emissions per sector in New Zealand (2013) as reported in its national inventory report in 2015 (UNFCCC, 2015).

Chart 3J.1. New Zealand Greenhouse Gas Emissions by Sector in 2013



Source: Prepared by author with data sourced from UNFCCC (2015).

New Zealand emissions are relatively small compared to the total global emissions. In 2012, New Zealand only contributed 0.15% of global emissions. Despite having small share of emissions globally, New Zealand is committed to play its part in the global efforts to combat climate change. The country's first INDC communication mentions that the cost to attaining the 2030 target would be greater than that borne by other countries in meeting their climate target (in terms of GDP). The reasons for high abatement cost are the inclusion of already high level of renewable electricity generation and nearly half of the country's emissions generated from the agriculture sector (UNFCCC, 2015).

While New Zealand is committed to decarbonising its economy, significant challenges lie ahead. The country acknowledges that capturing the atmospheric stocks of CO_2 is perceived as the most pressing challenge. Given the limited potential for domestic abatement, New Zealand will employ market mechanism to meet the pledged target. An example is through carbon markets that allows the trading and the use of wide variety of mitigation outcomes that meet the standard and guidelines. The New Zealand government wants to ensure the environmental integrity of emissions reductions generated or purchased, avoid double counting, and ensure transparency in accounting and governance (UNFCCC, 2016).

Another challenge to decarbonization is the significant share of emissions from the agricultural sector, particularly biological methane that brings manifold challenges to the transformation into low-emissions economy (UNFCCC, 2015). Significant proportion of emissions coming from the agriculture sector seems to be unusual for a developed country. Reducing emissions from the agriculture sector would be burdensome for New Zealand considering that it needs more food to accommodate the growing population. At the same time, the agriculture industry historically provides critical contribution to the country's economic growth. In addition to that, historical forest planting and harvest cycle are significantly contributing to New Zealand emissions and are projected to continue in the future. In 2013, removals by forest land reached 33% of gross emissions. Nevertheless, New Zealand operates a highly efficient food production system and thus reducing total emissions from agriculture will be determined by technological innovation and adoption on the farm (MET, 2015). Moreover, New Zealand is gazette a target to reduce emissions to 50% (against 1990 levels) by 2050 (UNFCCC, 2015).

New Zealand's electricity generation is rather different from most countries. It has 80% of electricity generated from renewable sources, which means that New Zealand does not have much room to reduce emissions from power generation. The challenge for New Zealand is reducing the amount of carbon generated from the transport sector. Although emissions from this sector has been slowed recently, the amount accounts for the largest share of total energy emissions. Nonetheless, New Zealand is well placed to take advantage of its high share of renewable sources in electricity generation. The target to increase renewable uptake to 90% will further support the decarbonization in the transport sector (UNFCCC, 2015).

Decarbonizing the transport and agriculture sectors will take longer than the INDC commitment period (2021–2030). However, the government has anticipated the accelerated emissions reduction post-2030 if the agricultural mitigation technology and low-emission transport technology achieved their widespread deployment and uptake. Despite the manifold challenges of emissions reduction from the agriculture and transport sectors, the government is taking serious actions on each sector. For example, New Zealand has committed NZ$45 million to the Global Research Alliance on Agricultural Greenhouse Gases. The government further allocated NZ$48.5 million through New Zealand Agricultural Greenhouse Gas Research Centre for research on agricultural mitigation technology. Support for research will become priority for the New Zealand government (UNFCCC, 2015).

In response to the climate change challenges, New Zealand has formulated policies and actions that incorporate the national circumstances, level of the climate target, and recognition that climate change is a global issue that relies largely on domestic actions. New Zealand has formulated the Climate Change Response Act 2002 (the Act) that contains legal framework to enable the country to achieve its international climate pledge. Some amendments were made in 2008, including the introduction of the New Zealand Emissions Trading Scheme, the primary mechanism for reducing national emissions and achieving the international climate commitments (UNFCCC, 2015).

Apart from that, New Zealand is expanding its efforts to reduce emissions well beyond its own footprint by, for example, providing leadership in research, technological advancement, and innovation to reduce emissions from the agriculture sector. The government has also established the New Zealand Agricultural Greenhouse Gas Research Centre that aims to deliver knowledge, technologies, and practices to allow the country to enhance its agricultural productivity with low emissions. New Zealand is one of the members of the Global Research

Alliance on Agricultural Greenhouse Gases whose objective is to increase international cooperation and investment in agricultural research to explore solutions for increasing food production in a sustainable way (UNFCCC, 2015).

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3K. Review of Nationally Determined Contributions of the Philippines

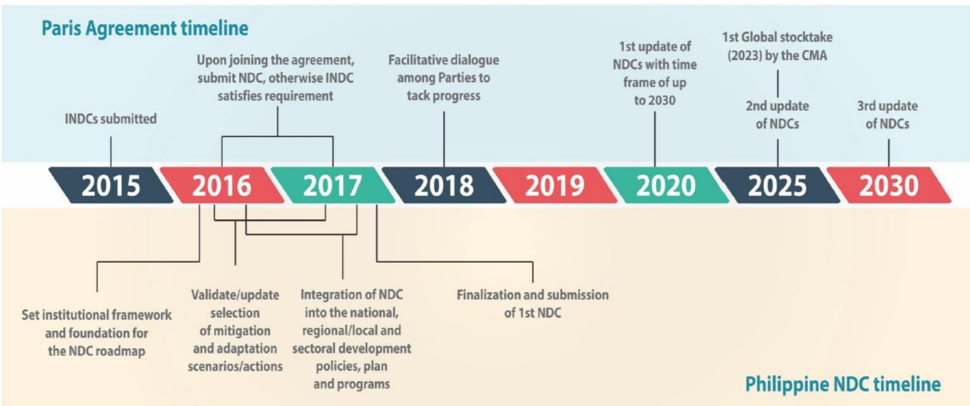
Introduction

The Republic of the Philippines officially submitted its Intended Nationally Determined Contributions (INDC) to the United Nations Framework Convention on Climate Change on 1 October 2015. It was premised on pursuing climate change mitigation as a function of adaptation since the country is highly vulnerable to climate and disaster risks. The Philippines recognizes its responsibility to contribute its fair share in global climate action, particularly in the effort to realize the ultimate aim of the convention to avoid dangerous anthropogenic interference with the climate system. Its adaptation actions that require additional support from international sources will enhance the country's capacity towards climate resiliency and its capacity to implement the mitigation options.

However, the Nationally Determined Contributions (NDC) efforts of the Philippines encompass a transition period from the previous government administration to the current one where, even if the level of commitment to the Paris Agreement i maintained, some differences in terms of perspectives on assumptions, methodologies, and other considerations on the NDC planning process are anticipated.

Content of INDC and NDC Roadmap Under the Previous Administration (2015)

Figure 3K.1. NDC Roadmap (Under the Previous Administration)



CMA = Conference of the Parties serving as the meeting of the Parties to the Paris Agreement, INDC = Intended Nationally Determined Contributions, NDC = Nationally Determined Contributions.
Source: Climate Change Commission, Office of the President of the Philippines.

The country's commitment to the Paris Agreement is described in Figure 3K.1. In 2015, INDC was officially submitted, while from 2016 to 2017, the first NDC (which was supposed to be based on INDC) was finalized and submitted. The NDC is expected to be updated from 2020 until a third one in 2030.

Regarding its INDC commitment on mitigation options, the Philippines will target greenhouse gas (GHG) emissions reduction of 70% by 2030 relative to its Business as Usual (BAU) scenario of 2000–2030. The mitigation contribution is conditioned on the extent of financial resources – including technology development and transfer – and capacity building that will be made available to the Philippines. In the identification and selection of mitigation options, the country's climate vulnerabilities and capacity to implement are among the critical determinants.

For adaptation, the Philippines will strive to ensure that climate change adaptation and disaster-risk reduction are mainstreamed and integrated into the country's plans and programmes at all levels. The path towards a low-emission development will require climate resilience and improved adaptive capacity. Financial resources, technology transfer, and capacity-building support for adaptation will ensure that the country's committed mitigation INDC will be attained.

Current Position of the Philippines on NDC Effort

The Climate Change Commission of the Philippines announced on 24 March 2017, through its website, that the Instrument of Accession to the Paris Agreement of the Republic of the Philippines had been submitted to the United Nations. With this, the Philippines became a full-fledged party to the Paris Agreement on 22 April 2017.

With this development, the government makes the following declaration in relation to the Paris Agreement (Office of the President, 2017):

- That it is the understanding of the Government of the Philippines that its accession to and the implementation of the Paris Agreement shall in no way constitute a renunciation of rights under any local and international laws or treaties, including those concerning State responsibility for loss and damage associated with the adverse effects of climate change.
- That the accession to and implementation of the Paris Agreement by the government is for supporting the country's national development objectives and priorities such as sustainable industrial development, the eradication of poverty and provision of basic needs, and securing social and climate justice and energy security for all its citizens.
- Finally, the Government of the RP will submit its first Nationally Determined Contribution before 2020.

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Office of the President (2017), Text of Declaration to Accompany Instrument of Accession, Declaration of the Government of the Republic of the Philippines, 6 March 2017.

Climate Change Commission, Office of the President of the Philippines, Website Press release, 24 March 2017

3L.Review of Nationally Determined Contributions of Singapore

Singapore's National Circumstances

Singapore's national circumstances are recognized by the United Nations Framework Convention on Climate Change, where Articles 4.8 and 4.10 stand out as particularly relevant to the country's situation. Under Article 4.8, Singapore is classified as a small island country, with low-lying coastal areas and is very dependent on income coming from the processing and trade of fossil fuels and associated energy-intensive commodities. Difficulties in switching to alternative forms of cleaner energy could be attributed mainly to the land constraints Singapore faces, with only 719 km^2 of land area by which to accommodate around 5.6 million people (SINGSTAT, 2017). Hence, virtually no natural fuel resource could be found in Singapore and that it is challenging to accommodate infrastructure that could harness the potential of renewable energy sources such as wind and geothermal power.

However, Singapore is not deterred by this constraint and has intensified its carbon-reduction efforts to realise its climate change commitments which were endorsed during the Paris Agreements at the 21st session of the Conference of Parties to the United Nations Framework Convention on Climate Change on 12 December 2015, and further ratified in September 2016. Led by the Inter-Ministerial Committee on Climate Change and coordinated by the National Climate Change Secretariat, Singapore has put in place several mechanisms – mainly led by the public sector – by which to facilitate progress in reducing carbon and other associated greenhouse gas (GHG) emissions.

Singapore's Climate Commitments

Singapore pledged in 2009 to unconditionally reduce carbon emissions to 7% to 11% lower than its Business as Usual level by 2020 (UNFCCC, 2017). A further 16% reduction by 2020 is also committed after COP-21 in Paris on 12 December 2015 (Ho et al, 2016), where participating countries adopted a universal and legally-binding agreement on post-2020 climate action. In conjunction with this target, Singapore plans to further reduce emissions intensity by 36% in 2030 as compared to 2005 and stabilize its emissions at a peak by 2030. This means that at 2010 prices, Singapore's GHG emissions/S$ GDP should reduce from 0.176 kilogramme of carbon dioxide (CO_2) equivalent per Singapore dollar ($kgCO_2e$/S$) in 2005 to about 0.113 $kgCO_2e$/S$ in 2030.

Outline of Carbon Mitigation Efforts

Singapore's efforts mainly focus on policy measures that facilitate the investment of efficient technologies, fuel switching in power generation (from fuel oil to natural gas and solar power), as well as the measurement/reporting of energy use and associated emissions from both power-generation companies and firms listed in the Singapore Exchange Limited. There is emphasis on the integration of solar photovoltaic systems into the electricity grid, where harnessing power from the sun is currently the most viable renewable option for tropical Singapore. As such, 8% of Singapore's peak electricity demand could come from renewables in 2030. In addition, introducing carbon tax in 2019 is intended to ensure GHG emissions are further controlled (National Climate Change Secretariat, 2017). Singapore's mitigation efforts are supported by collaborative programmes with various organizations and research institutes worldwide (NEA, 2016), where it learns and shares experiences on carbon-mitigation strategies to further enhance its capabilities on climate actions.

Efforts so far have helped curb emissions in such a way that Singapore's share of global emissions (0.11%) is significantly smaller than its share of global trade (2.2%) (see Figure 3L.1).

Figure 3L.1. Efforts of Singapore to Curb Emission

As outlined in Singapore's Second Biennial Update Report 2016, it has achieved an estimated carbon abatement of more than 6 metric tonnes in 2014, which is already more than two-thirds of its quantitative goal in 2020. As such, it is well on track to realize its climate change commitments.

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3M.Review of Nationally Determined Contributions of Thailand

On 29 September 2015, Prime Minister H.E General Prayut Chan-o-cha (ret.) of the Kingdom of Thailand announced at the general debate of the 70th Session of the United Nations General Assembly that 'Thailand intends to reduce greenhouse gas emissions by 20% from the BAU [Business as Usual] level by 2030.' Thailand's level of contribution, the prime minister further said, could increase up to 25% subject to adequate and enhanced access to technology development and transfer, financial resources, and capacity-building support through a balanced and ambitious global agreement under the United Nations Framework Convention on Climate Change.

On 1 October 2015, Thailand's Office of Natural Resources and Environment Policy and Planning officially submitted the country's Intended Nationally Determined Contribution (INDC) in greenhouse gas to the United Nations Framework Convention on Climate Change (see Table 3M.1).

Table 3M.1. Accompanying Information to Annex Thailand INDC to UNFCCC

Baseline	Business as Usual projection from reference year 2005 in the absence of major climate change policies (BAU2030: approx. 555 $MtCO_2e$)
Time frame	2021–2030
Coverage	Economy-wide (inclusion of land use, land-use change, and forestry will be decided later)
Gases	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6)
Assumptions and methodological approaches	– Global warming potential on a 100-year timescale in accordance with the Intergovernmental Panel on Climate Change Fourth Assessment Report – National statistics, including sector activity and socioeconomic forecasts
Planning processes	Thailand's INDC was developed through participatory process. Stakeholder consultations were conducted through the establishment of an inter-ministerial working group and steering committee comprising representatives from relevant sectoral agencies, the academe, and the private sector. In addition, three national consultations were held during the technical analysis phase. Thailand's INDC was formulated based on the following plans already approved or in the pipeline for approval by the Cabinet: – National Economic and Social Development Plans – Climate Change Master Plan B.E. 2558–2593 (2015–2050) – Power Development Plan B.E. 2558–2579 (2015–2036) – Thailand Smart Grid Development Master Plan B.E. 2558-2579 (2015–2036)

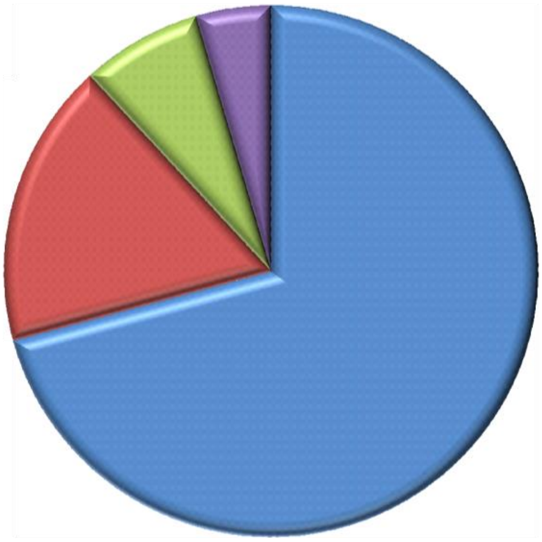
	– Energy Efficiency Plan B.E. 2558–2579 (2015–2036) - Alternative Energy Development Plan B.E. 2558–2579 (2015–2036) – Environmentally Sustainable Transport System Plan B.E. 2556–2573 (2013–2030) – National Industrial Development Master Plan B.E. 2555–2574 (2012–2031) – Waste Management Roadmap
International market mechanism	Thailand recognizes the important role of market-based mechanisms to enhance the cost effectiveness of mitigation actions, and, therefore, will continue to explore the potentials of bilateral, regional, and international market mechanisms as well as various approaches that can facilitate, expedite, and enhance technology development and transfer, capacity building, and access to financial resources that support Thailand's efforts towards achieving sustainable, low-carbon, and climate-resilient growth, as appropriate.
Review and adjustments	Thailand reserves the right to review and adjust its INDC as necessary upon finalizing the new global agreement under the UNFCCC.

INDC = intended nationally determined contributions, $MtCO_2e$ = million tonne of carbon dioxide equivalent, UNFCCC = United Nations Framework Convention on Climate Change.
Source: Office of Natural Resources and Environment Policy and Planning.

Greenhouse Gas Situation

According to the report of Thailand's contribution to COP21 in the UNFCCC, GHG emissions increased from 229.08 million tonnes of carbon dioxide equivalent ($MtCO_2e$) in 2000 to 305.52 $MtCO_2e$ in 2011, or an increase of 2.65% a year on the average. For GHG emissions by sector, on the average, the energy sector was highest emitter with a share of 70.79% and followed by agriculture, industrial process, and waste with 17.35%, 7.33% and 4.53%, respectively (see Figure 3M.1).

Figure 3M.1. Thailand's Emission of Gas by Source in 2011



Source: Office of Natural Resources and Environment Policy and Planning, 2015

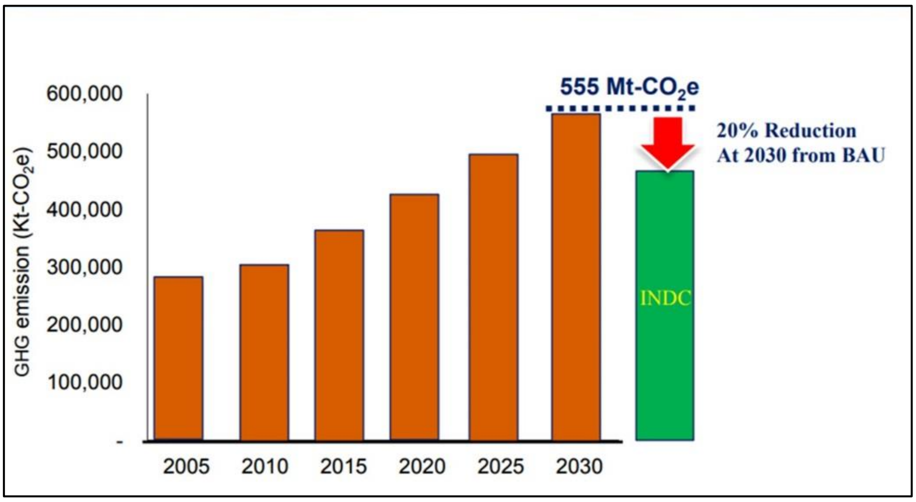
Greenhouse Gas Projection, BAU

According to the Office of Natural Resources and Environment Policy and Planning, GHG emissions in BAU case is expected to grow continuously from 279 $MtCO_2e$ in 2005 to 555 $MtCO_2e$ in 2030 or a 2.79 growth rate per year because of economic development, economic activities, rapid expansion of urban areas, and high consumption. The energy sector will continue to contribute the highest amount of GHG emissions among the big four sectors: the rest of them, agriculture, industrial process, and waste. GHG emissions from energy will increase from 195 $MtCO_2e$ in 2005 to 426 $MtCO_2e$ in 2030 or 76.76% of the total GHG emissions of all sectors. The rest of the three sectors taken together will take only 23.24% of the total GHG emissions. The second largest will be agriculture and is expected to emit much less than the energy sector, at around 77 $MtCO_2e$ in 2030, compared to 426 $MtCO_2e$ of the latter.

INDC and NDC of Greenhouse Gases in 2030

From BAU of GHG emissions in 2030, Thailand expects its GHG emissions to reach 555 $MtCO_2e$ by then, with 76.8% mainly from the energy and transport sectors alone. According to Thailand's INDC, the country will intend to reduce GHG emissions by 20% of the BAU emissions in 2030. It means that the amount of GHG emissions reduction of Thailand's intention should be 111 $MtCO_2e$.

Figure 3M.2. Thailand's INDC/NDC by 2030



Source: Office of Natural Resources and Environment Policy and Planning, 2017