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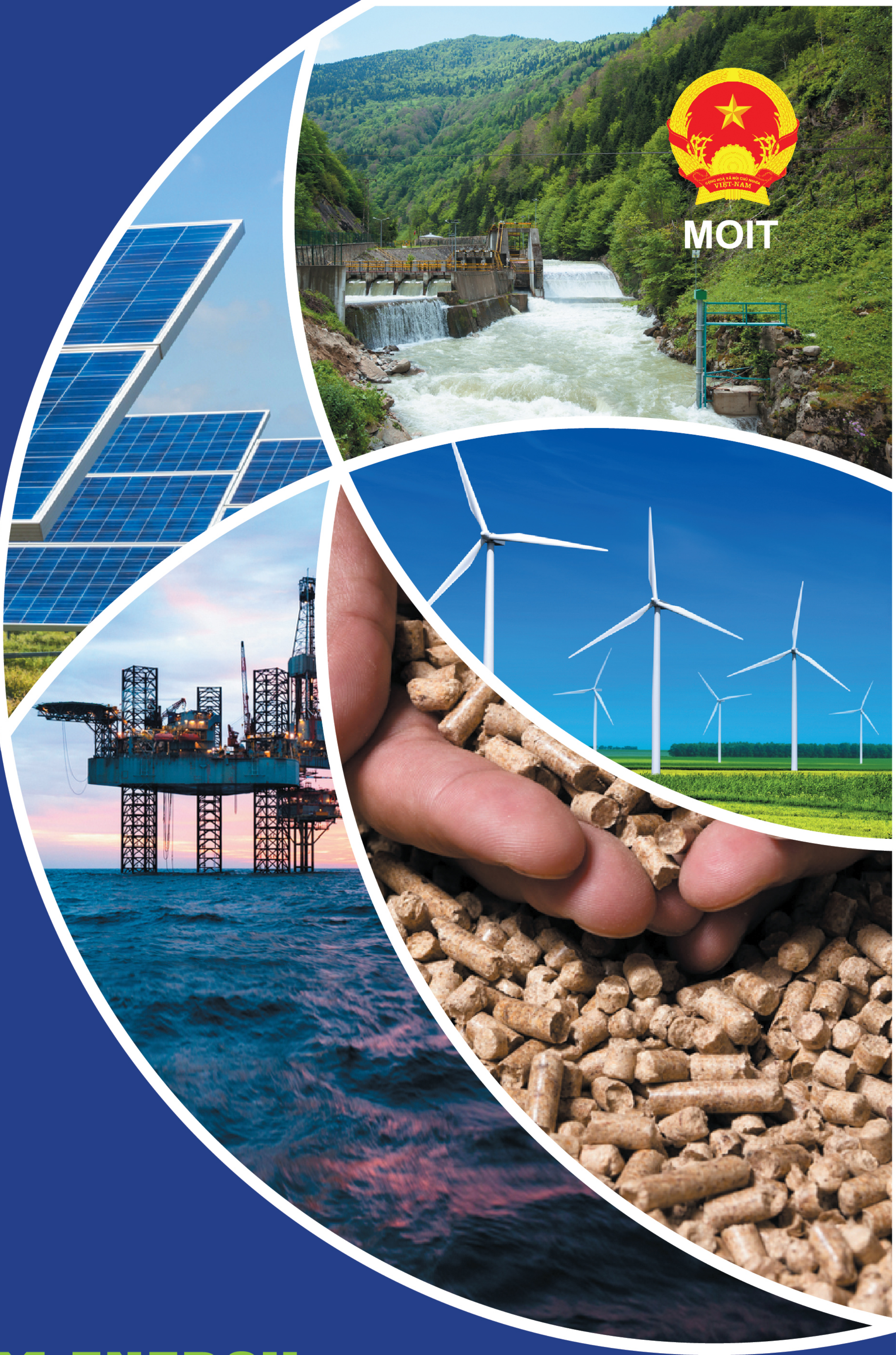

VIETNAM ENERGY OUTLOOK REPORT 2017

Danish Energy Agency

EXECUTIVE SUMMARY

Overview of the energy sector

For decades Vietnam has been one of the active and fastest growing economies in the region and in the world. Economic growth has been the key to improvement of the quality of life, and has resulted in a dramatic drop in poverty rate. Economic growth is still high priority by the government, however governmental strategies emphasize that fast development has to go side by side with sustainable development.

The energy sector plays a significant role in promoting the economy development. Economic growth requires secure and affordable supply of energy to all of the society participants and economic sectors. At the same time, in order to be sustainable, the energy sector must be able to attract the capital required to expand infrastructure, securing the needed supply of energy sources in the long term, and reducing negative environmental impacts as well as controlling green-house gas emissions.

Vietnam has laid out a number of policies and strategies, including masterplans for exploitation of domestic fossil fuel resources and a strategy for increase of the use of renewable energy. In the past the government has played an important role of securing investments in the energy sector through mobilization of state finance from state-owned enterprises and partly investment capital from private and foreign investors via energy sector development policies. Vietnam needs to continue developing an appropriate legal and regulatory framework to secure a competitive and attractive investment environment, favoring new and advanced technologies complying with the national policies of environmental protection and energy security.

The purpose of this report is to provide an analysis of available data for formulating the energy sector planning to propose overall development directions for the energy sector in general and the power sector in particular on the basis of identification of potential energy sources and cost optimization in exploitation and usage of primary energy and final energy sources for medium and long term socio-economic development targets of Vietnam. The report especially focuses on the integration of renewable energy (RE) into the national power grid in the future with analyses on opportunities and challenges of the sector development outlook and proposal of scenarios and solutions to overcome them.

The energy outlook report will provide an overview of the opportunities and challenges for Vietnam to secure a cost-effective and sustainable energy sector with a high level of supply security. The report combines findings from other studies with new analysis of the energy sector development opportunities.

Key findings

Surging energy demand

According to the draft report of National Energy Development Plan for the period 2016-2025 with the vision to 2035, which is currently in preparation by the Institute of Energy under the Ministry of Industry and Trade, the forecast on energy demand in the Business-as-usual (BAU) scenario indicates that by 2035 the total final energy demand will be nearly 2.5 times higher than in 2015. In 2035 the energy consumption in the transportation sector (covering 27.5%) is projected to achieve the highest growth (5.7%/year), while the industrial sector (covering 45.3%) has the growth of 5.0%/year in the period 2016-2030.

The share of coal and renewables in primary energy supply

In 2000, RE including biomass and hydro together contributed 53% of the total primary energy supply. However, this share dropped to 24% in 2015. In the same period, coal share grew from 15% to 35% of total supply. This trend is expected to continue far into the future as the domestic supply of hydro and biomass seems to be unable to meet the increasing demand. Power plants play a key role in domestic coal consumption, followed by cement, fertilizer and chemical sectors. The total domestic coal consumption in 2015 was about 43.8 million tons, of which the power plants consumed 23.5 million tons and the final coal consumption was 20.3 million tons (the industrial sector accounted for 87% of final coal consumption).

Environmental protection challenges significantly affecting the environment

The challenges of environmental impacts of energy supply are going to increase very significantly due to the combination of a fast growth in domestic energy demand and a fast growing share of fossil fuel, particularly coal, in the energy supply mix.

Security of energy supply

Vietnam has moved from a position of energy exporter to a net importer. This change is going to impact the security of energy supply. It is expected that the import share of total primary energy supply is due to increase to 37.5% in 2025 and 58.5% in 2035. The consequent impacts on the security of supply could be significant, and Vietnam would have to rely on imported fuel, particularly coal. However, this dependency can be reduced through increased energy efficiency and by exploiting the domestic RE sources.

The electricity sector

In the period 2011-2015, the national electricity consumption grew at the average rate of 10.6%/year, which was lower than the average growth of the period 2006-2010 at 13.4%/year.

Electricity is taking up an increasing share in the final energy consumption mix, and electricity demand is expected to grow by 8% annually on average until 2035, corresponding to a need for additional 93 GW of power generation capacity during the period. Almost half of the new capacity is supposed to be coal fired, while almost 25% will be renewable energy.

Renewable energy strategy and capability of renewable energy development

The revised National Power Development Plan in the period 2011-2020 with the vision to 2030 (revised PDP 7) and the Renewable Energy Development Strategy together set relatively concrete directions for the development of the power sector in the coming years.

Studies also show that even considerably more ambitious targets on reduction of CO_2 emissions as well as energy import dependence could be obtained from imposing a price on CO_2 emissions. Such measure would create the incentive for investment on additional natural gas and RE power capacity, through which the RE Strategy goals can be achieved with low additional costs compared to the BAU scenario, within the capability of the economy. Very significant levels of RE can be efficiently integrated in the Vietnamese electricity system so that the national RE policies will be satisfied.

Energy efficiency as a "first fuel"

Vietnam is currently an energy intensive economy in the region and the world. Several studies in the industrial sector as well as the building sector have revealed a considerable financially viable potential for reduction of the energy intensity by upgrading the technologies and by adopting measures for more efficient management of the resources. Untapped energy efficiency potentials have been found to be about 8.1% by 2030. The costs of green-house gas (GHG) emission reduction from the energy savings have been found to be considerably less than the benefits of energy savings. Hence, the energy efficiency options as well as the fuel substitution opportunities can offer an economic gain while reducing GHG emissions and improving the national energy security.

A considerable potential for energy efficiency improvement has been documented in several studies, but the studies cover only part of the sectors. A 17% potential for electricity saving has been identified by 2030. In order to tap this potential, the energy efficiency policy framework of Vietnam needs to be strengthened.

Activating the large biomass energy potential

Biomass energy is a largely overlooked source of energy. In addition to nearly 4,000 MW of electricity generation capacity, biomass could substitute coal and oil in the industrial sector to a large extent.

Overall evaluation

It is found that the nationally determined contributions of Vietnam following the UNFCCC with a conditional 25 % reduction target in greenhouse gasses could be achieved through strengthening energy efficiency and exploiting RE sources with international support. These measures could help reduce environmental impacts from energy supply activities as well as dependence on energy import.

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ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
BAU	Business-as-usual
CCS	Carbon capture and storage
CNG	Compressed natural gas
CO_2	Carbon dioxide
DANIDA	Danish International Development Agency
DEA	Danish Energy Agency
EE	Energy efficiency
EE&C	Energy efficiency and conservation
EVN	Electricity of Vietnam
FIT	Feed-in-tariff
GDP	Gross Domestic Product
GEF	Global Environment Fund
GHG	Green-house gas
GIS	Geographic information system
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GOV	Government of Vietnam
GW	Gigawatt
IEA	International Energy Agency
IMF	International Monetary Fund
IPP	Independent Power Producer
JICA	Japan International Cooperation Agency
kgOE	Kilogram oil equivalent
KTOE	Kilotonne of oil equivalent
LNG	Liquefied Natural Gas
LPG	Liquefied petroleum gas
MEPS	Mimimum Energy Perfomance Standard
MOIT	Ministry of Industry and Trade

MTOE	Million tonnes of oil equivalent
MWS	Municipal waste
RE	Renewable energy
ODA	Official Development Aid
PDP 7	Power Development Planning 7
PJ	Petajoule
SIDA	Swedish International Development Cooperation Agency
TOE	Tonne of oil equivalent
TSO	Transmission System Operator
TWh	Terawatt hour
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization
Usc/kWh	US cent/kWh
USD	US dollar
VND	Vietnam dong
VNEEP	Vietnam National Target Program on Energy Efficiency and Conservation
WB	World Bank

INTRODUCTION

The Vietnam Energy Outlook Report 2017 is the first report developed by the Ministry of Industry and Trade and is expected to be published once every two years in the future. The purpose of the report is to provide an overview of the directions taken by the energy sector with a focus on the power development scenarios, based on the potential and cost of primary energy sources, and concurrently to identify main challenges of the sector in the medium and long term. The long-term objective of the continuous update of the energy outlook for Vietnam is to achieve a wider consensus of all parties about opportunities and challenges of the sector, as well as measures to overcome them.

The report focuses particularly on the power sector by defining power development scenarios and considering the possibility of developing renewable energy sources in the future. The Ministry of Industry and Trade (MOIT) in collaboration with the Danish Energy Agency (DEA) conducted a study and developed a report on power development planning scenarios to identify solutions and set a roadmap to achieve the current policy objective at the least cost while ensuring energy supply security and environmental protection. This study particularly focuses on the future integration of renewable energy into the power system.

In addition, the report also provides some initial findings on the potential use of renewable energy including wind, solar and biomass, etc. on the basis of data from previous studies.

Contents and overall analysis of the energy sector are based on the previous reports. MOIT later can further analyze other issues in the following energy outlook reports when doing more intensive studies on the data assumptions used.

By nature, the report looking into the future with a vision to 2050 provides the conclusions based on a number of assumptions that can only be proven in terms of reliability in the future.

This report is intended for policy-makers in the sector as well as national and foreign organizations and citizens who are interested in the development of Vietnam energy sector.

The report, as well as analysis of power development scenarios and possibility of renewable energy development for power generation, has been funded by the Danish government. During the research process, data on the potential of renewable energy sources was consulted from a study funded by the GIZ and accomplished with wind speed series data provided by Vestas Company and the Technical University of Denmark.

The recommendations and evaluations in this report will be further studied and updated during the next three years of implementing the Energy Partnership Program between Viet Nam and Denmark.

1 OVERVIEW OF VIETNAM ENERGY SECTOR

1.1 Current Status of Energy Development

1.1.1 Current status of the energy sector

In the past two decades, Vietnam has experienced one of the worlds´ most rapid economic growth rates. Economic growth has been key to the improvement of the quality of the peoples lives, expressed most clearly in the dramatic drop in the poverty rate.

The Government of Vietnam (GOV) considers economic growth a high priority; however the GOV strategies have emphasized that fast development has to go side by side with sustainable development together with equality and social inclusion.

According to the draft report of National Energy Development Planning for the period 2016-2025 with a vision towards 2035 developed by MOIT (in cooperation with the Institute of Energy), between 2006-2015, the growth rate of annual final energy demand increased by 4.1% on average, reaching 54,080 KTOE in 2015. Such a relatively low growth rate is due to dramatic fall in non-commercial energy consumption, which used to account for a predominant share of energy consumption. The final commercial energy intensity in this period also changed through each development stage of the economy. In the period between 2006 and 2010, this indicator went up from 249.4 kgOE/1000 USD to 289.6 kgOE/1000 USD, and then dropped to 270 kgOE/1000 USD in 2015. However, the final commercial energy consumption per capita is constantly increasing. In the period between 2006 and 2015, this indicator increased from 273.3 kgOE/person to 454.8 kgOE/person.

The energy economy of Vietnam has changed rapidly in the past few decades with the transformation from an agricultural economy based on traditional biomass fuels, to a modern mixed economy. The gross domestic product (GDP) per capita has increased nearly 20 times, from USD 114 in 1990 to USD 2,109 in 2015; this is an important milestone for Vietnam to become a middle-income country.

Vietnam has a large range of domestic primary energy sources such as crude oil, coal, natural gas and hydro power which have played an important role in ensuring energy security for economic development in the past two decades. With the increasing energy demand and recent fluctuations in energy import and export, Vietnam has become a net energy importer since 2015.

In 2015, the total primary energy supply of Vietnam was 70,588 KTOE, of which commercial energy accounted for 75.5% and non-commercial energy accounted for 24.5%. The share of noncommercial biomass energy[1] in total primary energy supply, decreased significantly from 44.2% in 2000 to 16.9% in 2015. In the whole period between 2001 and 2015, commercial primary energy supply grew by 9.5%/year. This growth rate was higher than the GDP growth rate during the same period, leading to the elasticity coefficient of commercial energy to GDP, greater than 1. Among commercial energies, natural gas had the highest growth rate with 13.4%/year. The growth rate of coal, oil products, and hydro power in the same period was of 12.2%, 6.2% and 27.6% per year, respectively. Vietnam's main drives for energy consumption growth include: industrial growth, residential energy use and level of transportation mechanization.

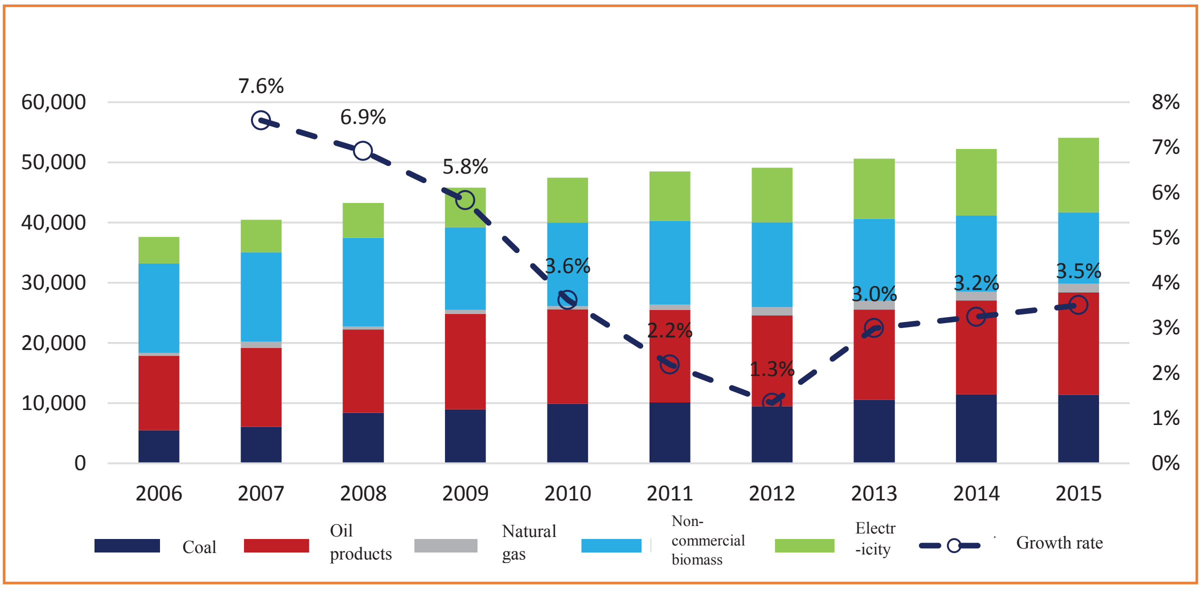
[1] Non-commercial biomass energy: fuels that not traded commercially or do not have official market, often used as fuels for burning in residential use, herewith mainly including wood, agricultural by-products, animal waste, etc.

Table 1-1: Progress of primary energy supply between 2000-2015 (KTOE)

	2000	2005	2010	2011	2012	2013	2014	2015
Coal	4,372	8,376	14,730	15,605	15,617	17,239	19,957	24,608
Oil	7,917	12,270	17,321	16,052	15,202	14,698	17,700	19,540
Gas	1,441	4,908	8,316	7,560	8,253	8,522	9,124	9,551
Hydro power	1,250	1,413	2,369	3,519	4,540	4,468	5,146	4,827
Non-commercial energy	14,191	14,794	13,890	14,005	14,121	13,673	12,745	11,925
Electricity import		33	399	333	125	200	124	136
Total	**29,171**	**41,794**	**57,025**	**57,075**	**57,857**	**58,801**	**64,797**	**70,588**

Source: [1]

Figure 1-1: Progress of primary energy supply between 2000-2015



As estimated, the non-commercial biomass energy has gradually been replaced by other commercial energy sources. The shift to fossil energy has been a key reason for the increase in greenhouse gas (GHG) emissions. In the past decade, Vietnam has had the highest GHG emissions in the ASEAN region. The total GHG emissions and GHG emissions per capita have increased nearly 3 times in a 10 year period, while the carbon intensity per GDP increased by 48%. Crude oil, coal, gas, hydro power and non-commercial energy are the energy sources exploited within the country.The total exploited energy in recent years intends to remain stable, mainly due to no large fluctuation in the exploitation volume of commercial energy products.

In 2015, the domestic exploitation volume reached 68,655 KTOE, where coal and crude oil were the two largest contributors, with a respective share of 34% and 28%. In both periods of 2006-2010 and 2011-2015, the domestic exploitation volume increased by approximately 1.3%/year. For the energy mix structure, non-commercial energy contributed with 24% in 2005 and later decreased to 17% in 2015. Hydro power also experienced a significant change in its share, from 2.3% in 2005 increasing to 7% in 2015 as the generation capacity from hydro power increased nearly 3.5 times in the period between 2006-2015. In the total primary energy supply, the growth rate of total supply of commercial energy has been declining. This rate reached about 12.5%/year and 9.8%/year respectively in the period between 2001-2005 and between 2006-2010; later falling to 6.3%/year in the period between 2011-2015. The table below shows the exploited capacity of each energy source in the primary energy supply of Vietnam between 2005-2015:

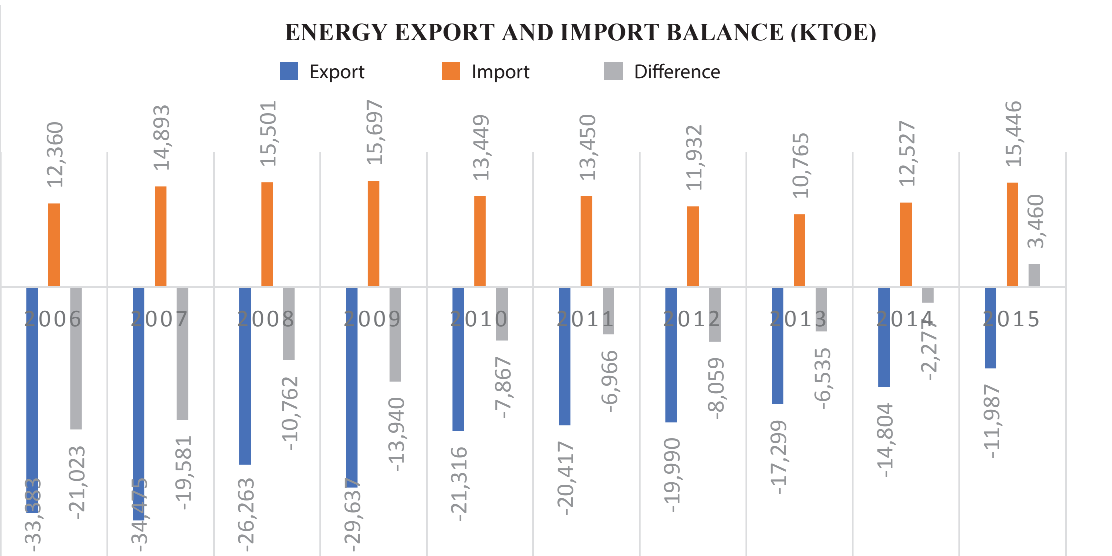
Table 1-2: Domestic energy exploitation between 2005-2015 (KTOE)

Items	2005	2009	2010	2011	2013	2014	2015
Coal	19,076	24,684	24,646	26,102	22,985	22,998	23,231
Crude oil	18,901	16,687	15,266	15,489	17,039	17,740	19,121
Gas	6,204	7,290	8,316	7,560	8,522	9,124	9,551
Hydro power	1,413	2,578	2,369	3,519	4,897	5,146	4,827
Non-commercial biomass energy	14,860	13,778	13,890	14,005	13,669	12,745	11,925
Total locally exploited energy	**60,453**	**65,017**	**64,488**	**66,675**	**67,112**	**67,753**	**68,655**

Source: [1]

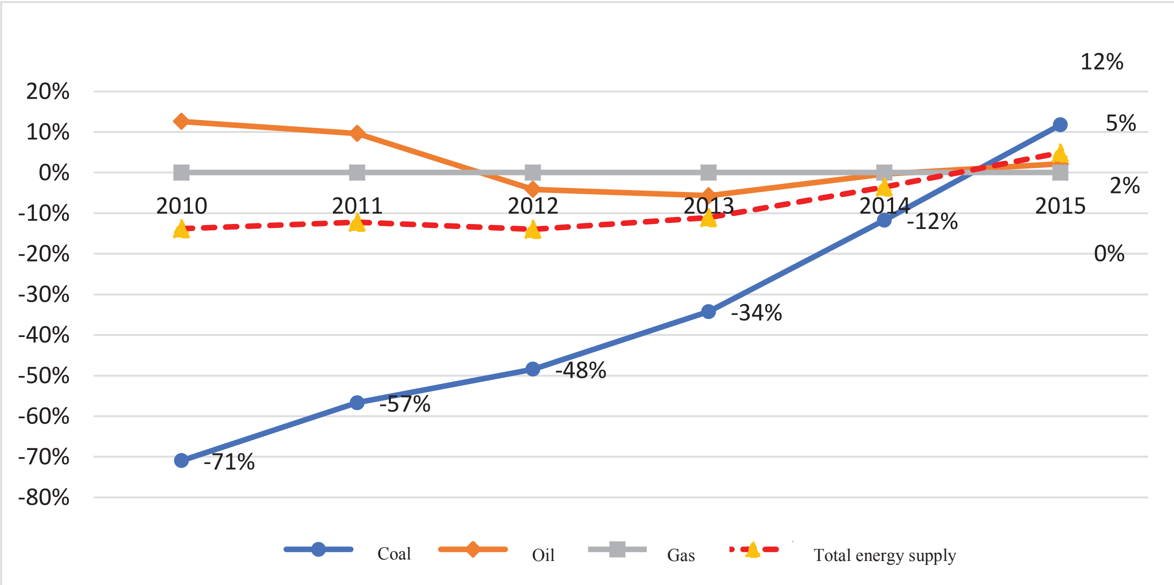
Energy export aims at generating foreign currency revenue and optimizing resource use while energy import is implemented to meet the supply shortage, due to the lack of energy sources for domestic production or conversion. The figure below shows the correlation between energy export and import in the period 2006 – 2015.

Figure 1-2: Progress of energy export and import in the period 2006-2015 (KTOE)



Energy export tends to decline in recent years, with an export volume of nearly 12 thousand KTOE in 2015, i.e only 40% compared to that in 2009. Meanwhile, energy import, after several years of decline, has increased again in 2015. Looking at the difference between the energy export and import in the data series above, it can be noticed that Vietnam has become a net energy importer since 2015.

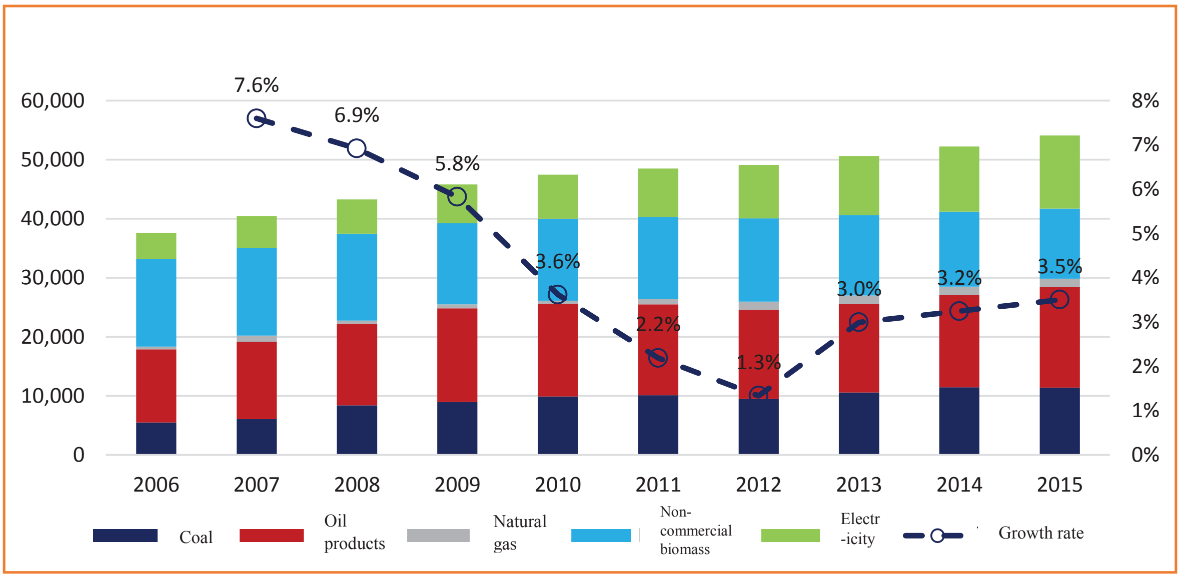
Figure 1-3: Progress of dependence on net energy import



The diagram above shows a significant changes between coal import and export with decline of coal export and increase of coal import; displaying a net coal import of 12%. The coal import in 2016 was more than 10 million tons and imports are expected to continue to increase in the coming years. The trends in coal import and export, together with the net oil import proportion (crude oil and oil products) is now making Vietnam a country depending on imports with a net import of 5% in 2015. This level of import is not high compared to other countries in the region and the rest of the world; however, this is a development that requires the attention of policy makers due to Vietnam's long experience as a net energy exporter.

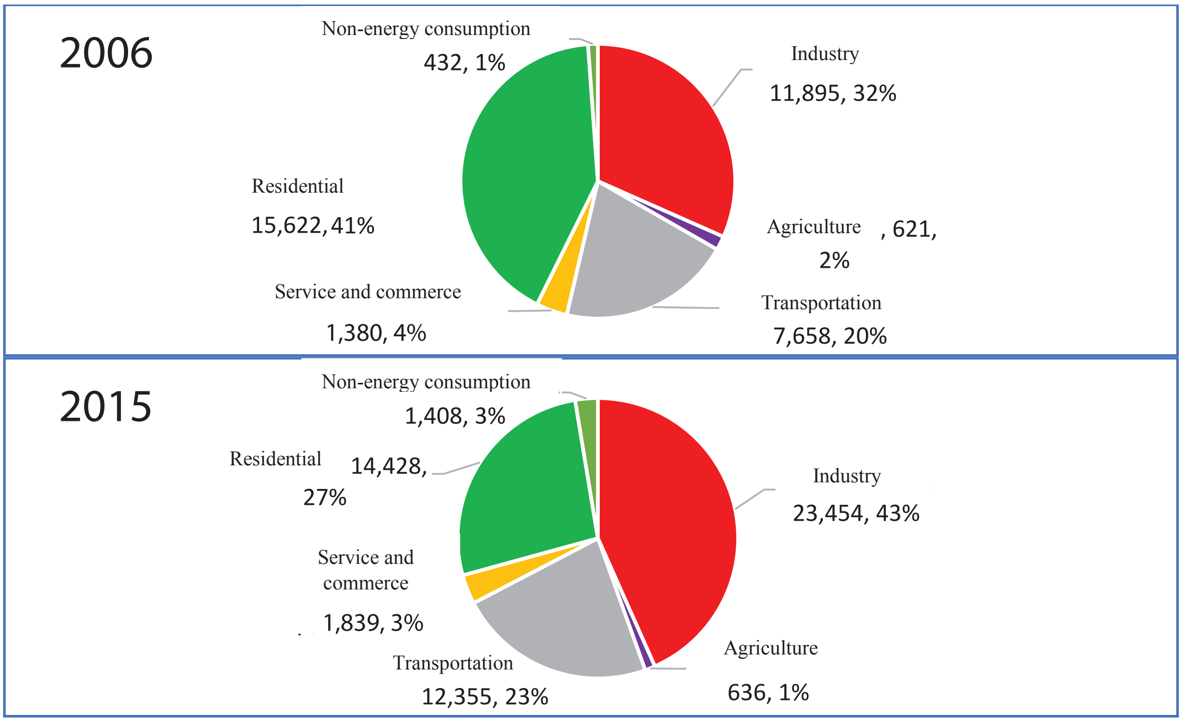
Commercial energy consumption in 2015 reached 41,715 KTOE and grew by 7.1%/year in the period between 2006 and 2015. This growth is higher than the GDP growth in the same period, which was 6.0%/year. The following graph shows the final energy consumption changes by type of fuel in the period 2006-2015:

Figure 1-4: Final energy consumption by type of fuel in the period 2006-2015 (KTOE)



The most noticeable change in the mix of the final energy consumption is the continuous increase of the ratio of electricity consumption compared to total energy consumption, which reflects the transition from primary fuel types into electricity. In 2010, this ratio reached 22.2% while in 2015 it increased to 29.6%. Regarding the commercial energy consumption, oil had the highest proportion with 40.7%, followed by electricity and coal with 29.6% and 27.3% respectively. Natural gas was used mainly in the industrial sector, accounting for only 2.4%. In terms of sectoral structure in final energy consumption in 2015, the industrial sector is still the largest consumer with 43.0%, followed by the residential sector with 29.6% and the transportation sector with 22,7%. There was a significant change in the structure of final energy consumption by sector in the period between 2006-2015. While in 2006, the residential sector accounted for the largest share of energy demand i.e. 41%, in 2015 the industrial sector had the highest share with 43%. The growth rate of final energy demand of the transportation sector was also fairly high.

Figure 1-5: Structure of final energy consumption in 2006 and 2015 per economic sector (million TOE,%)



Source: [1]

Challenges for the energy sector:

- Growth in energy demand, and especially rapid growth of electricity demand as summarized above, has resulted in big challenges;
- Since 2015 Vietnam has become a net energy importer, with a net import rate of about 5% of total energy supply. This rate is forecasted to continue increasing;
- Energy resources are being depleted: most of the hydro resource potential for large and medium hydro power plants will be fully exploited and their current capacity will increase from nearly 18 GW to about 21.6 GW in 2020; domestic coal is currently insufficient to supply the power plants. With the coal exploitation planning, approved by the Prime Minister, coal can be exploited within 70 years; however it will still not meet the demand; oil and gas resources will be reduced and depleted in the next 60 years;
- Requirements for minimizing environmental pollution from the energy sector are stricter in order to ensure sustainable development.

On the other hand, the energy sector of Vietnam is also facing great opportunities:

- The Government is focusing on economic development along with energy security, and environmental protection;

- Great potential for continued implementation of energy efficiency;
- The potential for renewable energy, especially solar and wind energy is quite large, and can play an important role in energy supply in the medium and long term;
- Cooperation in the energy sector is growing with increasing participation of international organizations and the private sector.

In the recent years, the Government has promulgated many important policies and solutions to attract investment from the economic sector into the energy sector, through the mobilization of the state budget, and encouraging private and foreign investors to participate directly in the construction, ownership and operation of energy infrastructure. The future projects in the energy sector will continue to attract investment from the private sector with an increasing proportion. Therefore, the Government should continue to build an appropriate legal and regulatory framework to ensure the investment market competitive, attractive, encouraging application of advanced technologies to meet national standards on environmental protection and energy security.

1.1.2 Current status of energy efficiency and conservation

In the early 2000s Vietnam was facing the risk of energy shortage due to globally rising oil prices, the decline of hydro power resources due to unfavorable weather as well as the inefficient exploitation and use of primary energy sources of the country. The Law on Energy Efficiency and Conservation 2010[2], approved by the National Assembly in 2010, creates a solid legal basis for implementation of activities of energy efficiency and conservation (EE&C). Many programs were approved to promote efficient use of limited domestic energy resources to achieve sustainable economic development. These programs were carried out throughout the country, integrated with other EE projects sponsored by international organizations to ensure effective use of ODA as well as international experience in implementation of EE&C activities in Vietnam.

The National Target Program on energy efficiency and conservation in the period 2012-2015 (VNEEP 2) was approved by the Government uner the Decision No.1427/QD-TTg dated 2 October 2012. The program **aims at the saving target from 5-8% of total energy consumption of the country in the period 2012-2015 compared to the forecasted energy demand in the national power development planning in the period 2011-2020 with the vision to 2030 approved by the Prime Minister**, equivalent to 11-17 million TOE in the 2012-2015 period. Besides, the program also sets some specific targets for energy savings for some industries that consume a lot of energy as follows:

- Reduce the average energy consumption to produce one ton of cement from 97 kgOE in 2011 to 87 kgOE in 2015;
- Reduce the average energy consumption to produce one ton of steel finished products, from 179 kgOE in 2011 to 160 kgOE in 2015;
- Reduce the average energy consumption to produce one ton of fiber from 773 kgOE in 2011 to 695 kgOE in 2015.

[2] *Law No. 50/2010/QH12*

For VNEEP 2, evaluation results show that the achieved actual saving is 5.65%, equivalent to 10,610 KTOE [2]. Although some accomplishments have been achieved, a number of problems still exist during implementation of VNEEP 2 activities. In particular:

- The allocated fund from the state budget for annual implementation of the program is still relatively low, for example: in 2011 it was VND 70 billion; in 2012 it was VND 82.5 billion (including VND 55 billion from the state budget and VND 27.5 billion granted by the Government of Denmark); in 2013 it was VND 96.1 billion; in 2014 it was VND 58.7 billion; in 2015 it was VND 42 billion. The total allocated fund from the state budget for the program by the end of 2015 was VND 349 billion (excluding local budget and investment capital of enterprises) while the participants of the program are very broad and varied from the central to local level;
- The implementation of the roadmap for energy labeling encountered some difficulties such as: infrastructure still in testing; limited human resources and funds for implementation; insufficient and asynchronous standards and equipment for energy performance testing;
- The community and enterprises have limited awareness and are not proactively seeking information on EE&C technologies and solutions;
- Enterprises neither have capital nor access to preferential credit loans for energy efficiency projects, and due to financial difficulties, enterprises have not yet implemented the energy efficiency projects, especially in steel and cement industries;
- Supporting mechanisms for enterprises to replace outdated technology in production lines with those having high performance and energy efficiency. The VNEEP program provides financial support of up to 30% of the total investment in high performance technologies and equipment for enterprises, which is limited to no more than VND 7 billion for one enterprise. Such support is no longer attractive to large enterprises to invest in changing technologies since it is significantly smaller than the enterprise's total investment;
- Many enterprises have not actually implemented all requirements prescribed by law, decrees, circulars and decisions issued, yet they have built energy management models as well as developed annual and five-year plans on energy consumption in their enterprises, but have not reported to the local authorities (Department of Industry and Trade) on the full situation of their energy consumption;
- Projects of enterprises faced many difficulties due to poor economic conditions and hence could not be carried out as planned, so the investment projects have either been slow or not implemented;
- Energy prices have risen more than 10%. However, compared to other countries in the region, the domestic energy prices are still low, thus also affecting the implementation of energy saving measures;
- Although there are some changes in the resources for implementation and supervision of the implementation of the Law on Energy Efficiency and Conservation and relevant legal documents and regulations from the central to local levels, it is still necessary to further supplementation and training for capacity building;

- Many agenciesare not very proactive in implementing their tasks assigned under the program. Financial sources as well as the force of technical experts, particularly in the fields of civil construction, transport and resources at the local level, are limited; thus, the opportunity for implementation of energy audits for enterprises in these fields to identify energy saving solutions, consultancy for project formation, seeking funds for energy efficiency projects remain limited.

Besides the VNEEP, since 1997 there have been a number of programs related to the similar field in Vietnam, such as loan programs, programs on capacity enhancement, financial and technical support by international organizations such as the World Bank (WB), ADB, UNIDO, GEF, UNDP, SIDA, JICA and DANIDA.

1.1.3 Current status of renewable energy (RE) development

Although it is assessed that Vietnam has a significant renewable energy potential, the current development of RE in Vietnam is still low compared with the actual potential. A particular example is the development of RE sources with great potential in Vietnam for power generation such as small hydro, wind, solar, biomass.

Apart from the small hydro capacity (installed capacity below 30 MW) which is relatively high (total installed capacity of around 2300 MW by the end of 2015), the capacity of other types of power supplies is very limited. Currently there are 4 large wind power projects with the total capacity of 159 MW, only covering about 2.7% of the wind power development target until 2030. Regarding biomass, according to a GIZ study [3], in 2010, the use of biomass for combined electricity and heat production in Vietnam was only 552 KTOE (in total biomass use was 12,808 KTOE). This figure is tiny compared to 8,915 KTOE used as fuel for residential activities, 1,168 KTOE for furnaces and 2,173 KTOE for incinerators. Besides, solar power capacity (or even including solar water heaters) is very small compared to the huge potential of the country. The RE development in Vietnam is facing major hurdles as follows:

- Technical barriers:
  - Lack of project development capacity;
  - Poor infrastructure;
  - Technology dependence.
- Institutional barriers:
  - No national planning for renewable energy;
  - Policies and mechanisms for supporting renewable energy are not attractive enough for investors;
  - Low electricity prices.
- Economic barriers:
  - Relatively large initial investments are required;
  - Difficulties in accessing loans.

- Market barriers:
    - Lack of information or no access to information on potential and technologies of various RE types.

To overcome these barriers, the incentive mechanisms for RE need to be articulate, transparent and determined enough to attract investments. The RE development strategy[3] approved in 2015, has set specific targets for RE in general and for each type of RE in particular. The electricity purchasing price from RE projects (avoided-cost tariff, feed-in tariff or FIT) has been identified as a significant supporting mechanism for RE development in Vietnam. The summary of current mechanisms for supporting RE development is presented as follows:

Table 1-3: Summary of existing supporting mechanisms for renewable energies

Generation sources	Technology	Tariff	Electricity sale price
Small hydro power	Electricity production	Avoided cost tariff published annually	598-663 VND/kWh (by time, region, season) 302-320 VND/kWh (surplus energy vs contracted) 2,158 VND/kWh (capacity price)
Wind power	Electricity production	FIT for 20 years	7.8 USc/kWh (on land)
Biomass	Co-generation	FIT for 20 years	5.8 USc/kWh
	Electricity production	FIT for 20 years	7.5551 USc/kWh (North) 7.3458 USc/kWh (Central) 7.4846 USc/kWh (South)
Waste	Direct burning	FIT for 20 years	10.5 USc/kWh
	Landfill for gas production	FIT for 20 years	7.28 USc/kWh
Solar power	Grid-connected generation	FIT for 20 years	9.35 USc/kWh

Source: Summarized from many legal documents on RE supporting mechanisms; Avoided-cost tariff referred in 2017

The subsidy for RE development is necessary to attract investments. However, since the subsidy price for electricity (excluding small hydro) is higher than the average price offered by the EVN on the electricity market, it is necessary to considerthe option for setting up a fund to support RE development (or clean energy projects in general, including EE&C activities).

[3] *Decision No.2068 QD-TTg dated 25/11/2015 approving the RE Development Strategy in Vietnam to 2030, with vision to 2050*

1.1.4 Major energy policies

1.1.4.1 The Petroleum Law 1993, 2000, 2008 and Decree

This Law regulates the petroleum exploration and exploitation activities in the territory, exclusive economic zones and continental shelf of the Socialist Republic of Vietnam.

1.1.4.2 The Electricity Law 2004[4] and the Law amending and supplementing some articles of the Electricity Law[5]

This Law regulates the power planning and development investment; electricity saving; electricity market; rights and obligations of organizations and individuals operating in the electricity industry and using electricity; protection of electric equipment, electricity works and electricity safety.

1.1.4.3 The Law on Energy Efficiency and Conservation 2010[6]

This Law stipulates the energy efficiency and conservation; policies and measures to promote EE&C; rights, obligations and responsibilities of organizations, households and individuals in EE&C. This Law creates a legal framework to promote EE&C activities in all sectors of the economy through regulations, standards, incentives and encouragement. The main contents of the Law are as follows:

- Obligations for major energy users: development of annual and 5-year energy plans; appointment of energy managers, building energy management models; mandatory energy audits every 3 years;
- Development of standards and equipment labeling;
- Incentives: tax exemption, preferential land use, concessional loans from the Development Bank of Vietnam, Fund for Science and Technology Fund; Fund for National Technology Innovation, Fund for Environmental Protection, and the National Target Program on energy efficiency and conservation (VNEEP);
- MOIT in charge of state management in the field of EE&C.

1.14.4 National energy development strategy until 2020 with the vision to 2050[7]

The National energy development strategy of Vietnam was approved in 2007 with specific objectives as follows:

- Striving to ensure adequate energy supply to meet the demand for socio-economic development, in which the primary energy in 2010 was about 47.5 - 49.5 million TOE, reaching about 100-110 million TOE in 2020, approximately 110-120 million TOE by 2025 and about 310-320 million TOE by 2050;
- Developing generation sources and power grid, ensuring to meet the electricity demand for socio-economic development: in 2010, the reliability of the power supply was 99.7% and the grid met the standard n-1;

[4] *Law No. 28/2004/QH11*
[5] *Law No. 24/2012/QH13*
[6] *Law No. 50/2010/QH12*
[7] *Decision No. 1855/2007/QD-TTg*

- Developing oil refinery plants, to bring the total capacity of oil refinery to about 25-30 million tons of crude oil in 2020;
- Ensuring the national strategic reserve of oil at 45 days of average consumption in 2010, 60 days in 2020 and 90 days in 2025;
- Completing the rural and mountainous electrification program: by 2020 almost all rural households will have access to electricity;
- Developing long-term environmental objectives and standards in consistence with regional and global environmental standards and in line with the country's economic conditions;
- Robust transformation of operation of electricity, coal, oil and gas industries into competitive market mechanism with the regulation of the goevernment, forming a competitive retail power market for the period after 2022, and a coal and petroleum business market from now until 2015;
- Strengthening international cooperation in the energy sector.

1.1.4.5 National Target Program on energy efficiency and conservation[8]

The program sets the goal regarding savings to 5-8% of the total energy consumption of the country in the period 2012-2015 compared to the energy demand forecast in the national power development planning in the period 2011 - 2020 with the vision to 2030 approved by the Prime Minister, equivalent to 11 million TOE to 17 million TOE in the period 2012 – 2015.

1.1.4.6 Renewable energy development strategy[9]

The strategy aims to encourage mobilization of all resources from the society and citizens for RE development, gradually increasing the proportion of RE sources in the national energy production- and consumption in order to reduce dependence on fossil based energy sources, contributing to ensure energy security, climate change mitigation, environmental protection and sustainable socio-economic development:

- Mitigation of greenhouse gas emissions in energy activities compared with the business-as-usual scenario: approximately 5% in 2020; about 25% in 2030 and 45% in 2050;
- Contributing to reduce fuel imports for energy purposes: Reducing about 40 million tons of coal and 3.7 million tons of oil products by 2030; reducing about 150 million tons of coal and 10.5 million tons of oil products by 2050;
- Increase in the total RE generation and use from about 25 million TOE in 2015 to 37 million TOE in 2020; about 62 million TOE in 2030 and 138 million TOE in 2050. The RE proportion in total primary energy consumption in 2015 was about 31.8%; approximately 31.0% in 2020; approximately 32.3% in 2030 and increasing to around 44.0% in 2050;

[8] Decision No. 1427/QD-TTg approving the National Target Program on energy efficiency and conservation in the period 2012 - 2015
[9] Decision No. 2068/QD-TTg dated 25/11/2015 approving the RE development Strategy of Vietnam until 2030 with the vision to 2050

- Increased power production from RE: increasing from approximately 58 billion kWh in 2015 to about 101 billion kWh in 2020, about 186 billion kWh in 2030 and about 452 billion kWh in 2050. The proportion of RE power production in the total national power production increased from 35% in 2015 to about 38% in 2020; approximately 32% in 2030 and around 43% in 2050.

Table 1-4: Targets for renewable energy development

	2015	2020	2030	2050
RE use in production (MTOE)	25	37	62	138
Share in total primary energy (%)	31 8	31.0	32.3	44
Electricity produced from RE (TWh)	58 (35%)	101 (38%)	186 (32%)	452 (43%)
Hydro power (TWh)	56	90	96	
Pump storage (MW)			2400	8000
Biomass for power production (TOE)	0.3 (1%)	1.8 (3%)	9.0 (6.3%)	20.0 (8.1)
Biomass for heat production (TOE)	13.7	13.6	16.8	23.0
Biomass for bio energy (TOE)	0.2	0.8	6.4	19.5
Wind power (TWh)		2.5 (1%)	16 (2.7%)	53 (5%)
Solar power (TWh)		1.4 (0.5%)	35.4 (6%)	210 (20%)

1.2 Energy demand forecast

1.2.1 Socio-economic development forecast

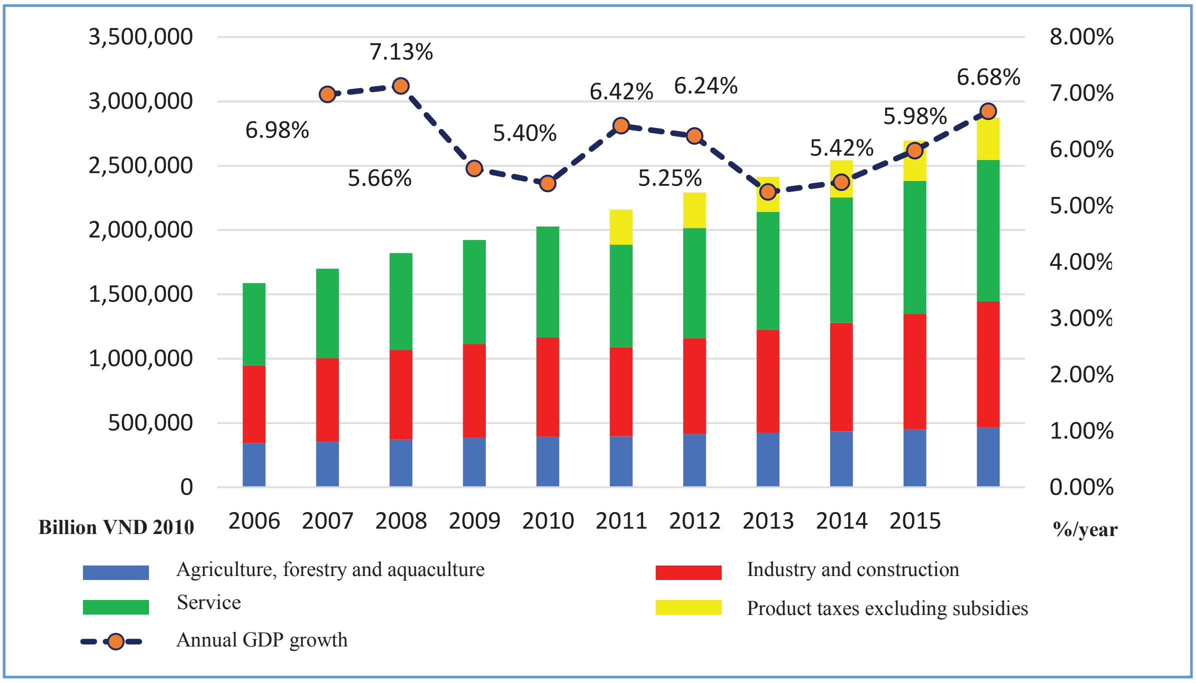
Vietnam's GDP growth rate in the period 2011-2015 reached 5.91%/year; lower than for the period 2006-2010 (6.32%/year). In the period 2011- 2015, the sector of agriculture, forestry and aquaculture grew by 3.12%, approximately equivalent to the growth of the previous period; the sector of industry and construction grew by 7.22%, higher than the growth of 6.38% in the previous period; the service sector grew by 6.68%, lower than the growth of 7.64% in the period 2006-2010. Progress of some major socio-economic indicators in the period 2006-2015 is presented in the below table:

Table 1-5: Progress of socio-economic indicators in the period 2006-2015

Item	Unit	2006	2010	2011	2012	2013	2014	2015
GDP	Billion VND, 2010	1,699,501	2,157,828	2,292,483	2,412,778	2,543,596	2,695,796	2,875,856
GDP growth	%/year	6.98%	6.42%	6.24%	5.25%	5.42%	5.98%	6.68%
GDP	Million USD, 2010	91,308	115,932	123,166	129,629	136,658	144,835	154,509
Population	1,000 people	83,311	86,947	87,860	88,809	89,760	90,729	91,713
Urban population	1,000 people	23,046	26,516	27,719	28,269	28,875	30,035	31,132
GDP per capita	USD/person, 2010	1096	1334	1402	1460	1522	1596	1685

Source: [4]

Figure 1-6: Structure and growth rate of GDP of Vietnam in the period 2006-2015



Source: [4]

Growth scenarios that can occur are:

- Low Scenario (the local economy experiences many difficulties): The average growth of the period 2016 – 2020 reaches 6.2%/year. The average income per capita in 2020 is USD 2,794;
- Business-as-usual (BAU) Scenario (the world economy is recovered in accordance with the IMF forecast): the average growth in the period 2016 – 2020 reaches 6.7%/year. The average income per capita in 2020 is USD 3,180.
- High Scenario (the restructure and conversion of the growth model results in very concrete changes in relation to the economy): the average growth in the period 2016 – 2020 reaches 7.5%/year. The average income per capita in 2020 is USD 3,473.

According to assumptions of the BAU scenario, the scale of the economy will increase from VND 2,879 billion (2010 fixed price) to VND 5,910 billion in 2025 and VND 11,154 billion in 2035.

Table 1-6: GDP value across development scenarios (billion VND, 2010 price)

Year	BAU scenario (baseline)	Low scenario	High scenario
2015	2879	2879	2879
2020	3985	3897	4121
2025	5910	5215	6341
2030	8375	6835	9605
2035	11154	8765	13585

Source: Updated projection results by the Development Strategy Institute, Ministry of Planning and Investment

The GDP growth rate in the BAU scenario is as shown below: period 2016-2020: 6.7%; period 2021-2025: 8.2%; period 2026-2030: 7.2%; period 2031-2035: 5.9%. Under the High scenario, it is expected that the GDP could achieve a high growth rate in the whole period 2016-2035, at 8.1%/year. Under the Low scenario, the GDP growth rate is lower in the whole period 2016-2035, reaching 5.7%/year. The GDP growth rate for socio-economic development scenarios across periods is projected as below:

Table 1-7: Forecast of GDP growth rate across 3 scenarios in the period 2016 – 2035

Period	BAU scenario	Low scenario	High scenario
2016-2020	6.7%	6.2%	7.4%
2021-2025	8.2%	6.0%	9.0%
2026-2030	7.2%	5.6%	8.7%
2030-2035	5.9%	5.1%	7.2%
2016-2025	7.5%	6.1%	8.2%
2026-2035	6.6%	5.3%	7.9%
2016-2035	**7.0%**	**5.7%**	**8.1%**

Source: Updated projection results by the Development Strategy Institute, Ministry of Planning and Investment

Figure 1-7: Forecast of GDP growth across 3 scenarios in the period 2016 – 2035

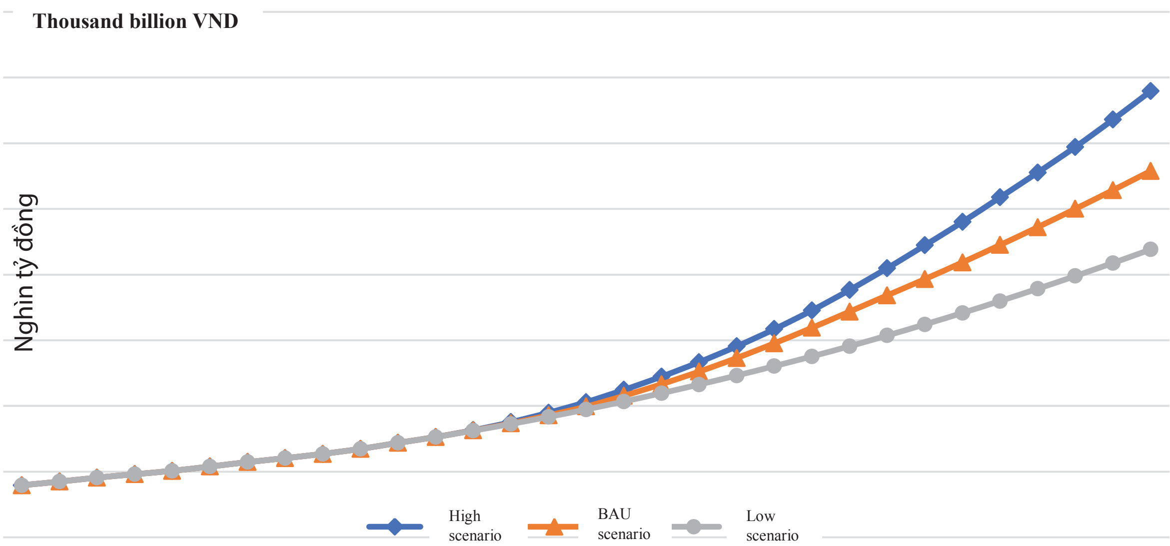
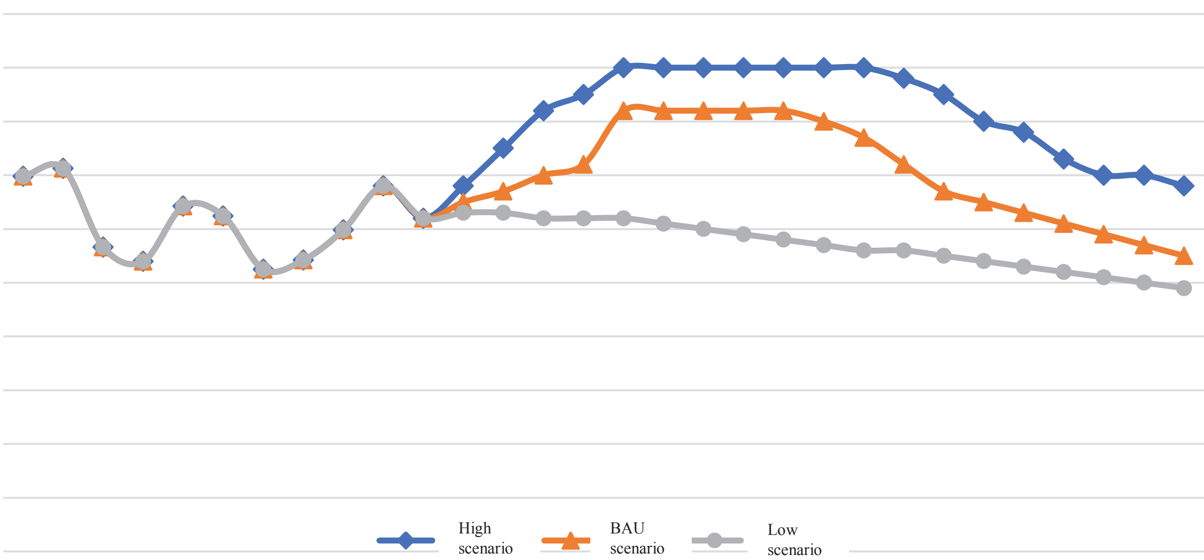


Figure 1-8: Forecast of GDP growth rate across 3 scenarios in the period 2016 - 2035



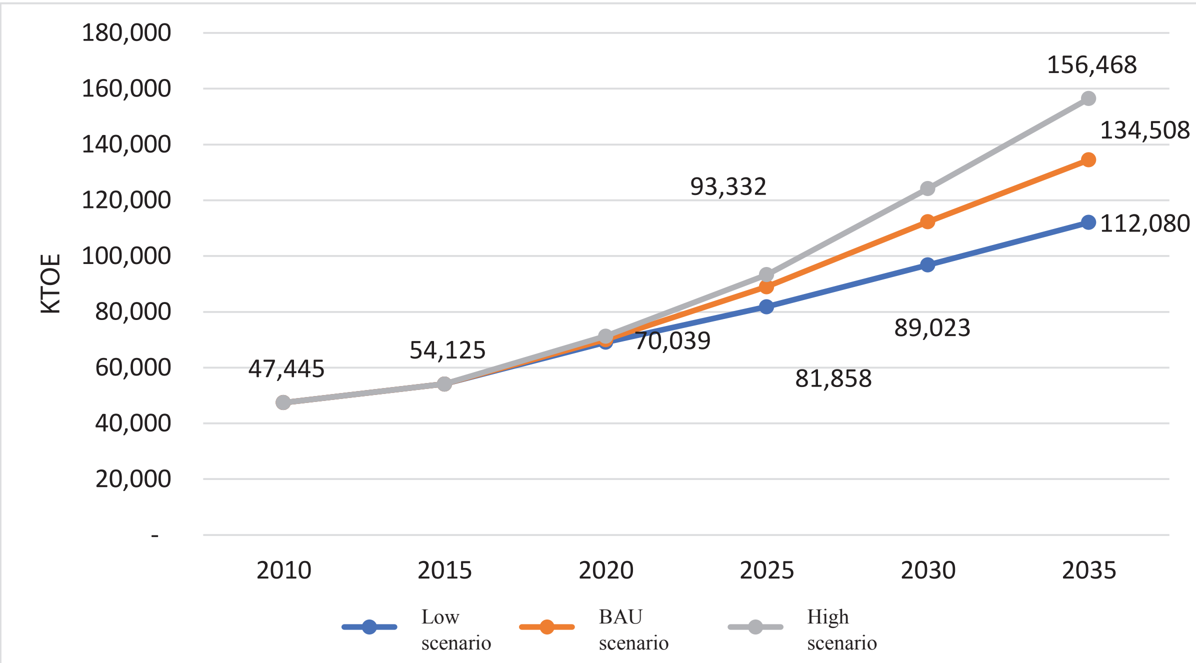
Results of the BAU scenario show that Vietnam could achieve the average growth of 7.0%/year in the period 2016-2035 due to the feasibility in mobilizing funds for development investment as well as improved efficiency of capital use.

The Vietnamese economic growth mainly depends on the growth of industrial and service sectors. This will result in faster transition of the economic structucture, increasing share of industrial and service sectors, and decreasing share of the agricultural sector.

1.2.2 Energy demand forecast

The final energy demand is projected based on the system of multiple regression equations relating the energy demand for economic sub-sectors to macro-economic variables. As a result, the total final energy demand could rise from 54 MTOE in 2015 to 81.9 MTOE, 89.0 MTOE and 93.3 MTOE in 2025 in the low, baseline and high scenarios respectively. The final energy demand in 2035 could reach 112.0 MTOE, 134.5 MTOE and 156.5 MTOE respectively in these three scenarios.

Figure 1-9: Forecast of total final energy demand in the period 2016-2035 in 3 scenarios



Throughout the period 2016-2035, the final energy demand increases by 4.7%/year in the baseline scenario (in the Low scenario and High scenario, the increase is 3.7%/year and 5.5%/year respectively). In general, the growth of final energy demand tends to gradually decrease in the later periods in conformity with the continued fall of GDP growth and the economic structure transformation.

Table 1-8: Growth rate of final energy demand across 3 scenarios in various periods

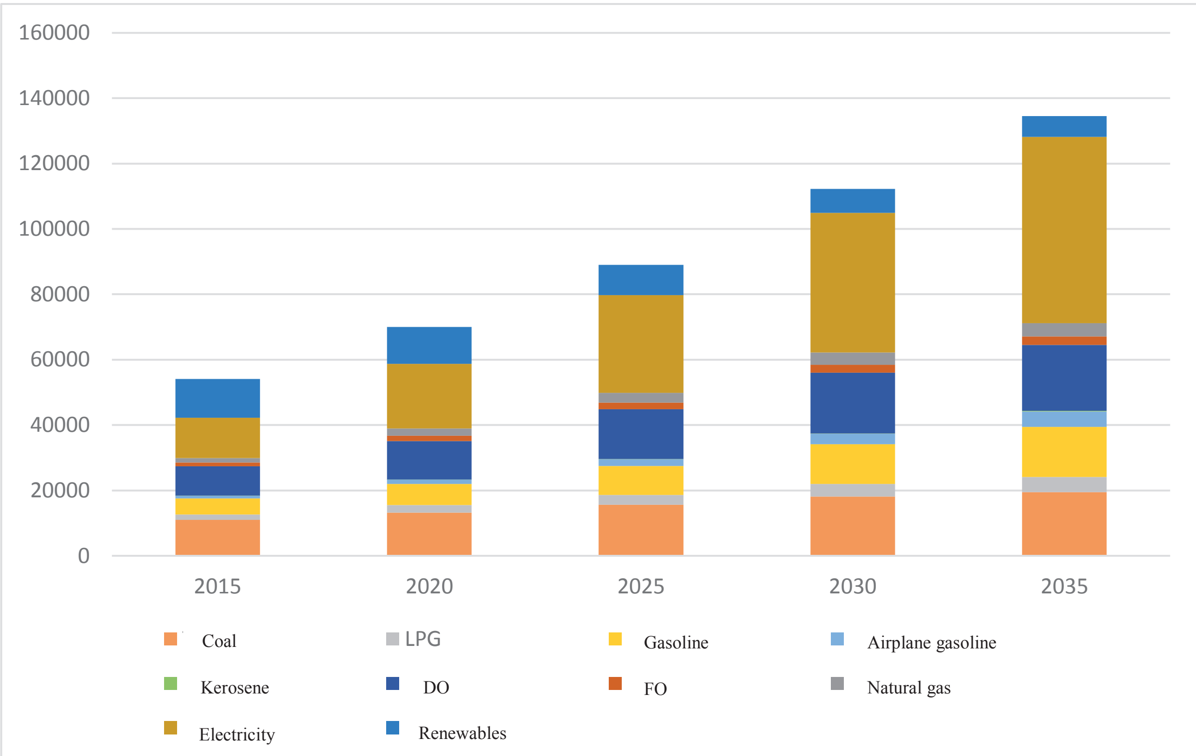
	5-year period				10-year period		Period 2016-2035
	2016-2020	2021-2025	2026-2030	2031-2035	2016-2025	2026-2035	
Low scenario	5.0%	3.4%	3.4%	3.0%	4.2%	3.2%	**3.7%**
Baseline scenario	5.3%	4.9%	4.8%	3.7%	5.1%	4.2%	**4.7%**
High scenario	5.7%	5.5%	5.9%	4.7%	5.6%	5.3%	**5.5%**

Source: Calculation results of the Energy Institute

In the period 2016-2035, the elasticity coefficient of the final energy demand to the GDP in the baseline scenario is 0.67. This coefficient tends to gradually decrease in the 10-year periods, from 0.68 in the period 2016-2025 to 0.64 in the period 2026-2035.

Under the baseline option, the demand forecast results show that total final energy demand will increase to 4.7%/year in the period 2015-2035 and reach 134.5 million TOE in 2035. The growth rate in each period is respectively: 5.3%/year in the period 2015-2020, 4.9%/year in the period 2020-2025, 4.8%/year in the period 2025-2030, and 3.7%/year in the period 2030-2035.

Figure 1-10: Forecast of final energy demand per type of fuel in the period 2015-2035



Among various types of fuels, electricity has the highest growth at 7.9%/year in the period 2016-2035. Natural gas, oil products and coal grow at 5.7%/year, 5.1%/year and 2.9%/year respectively.

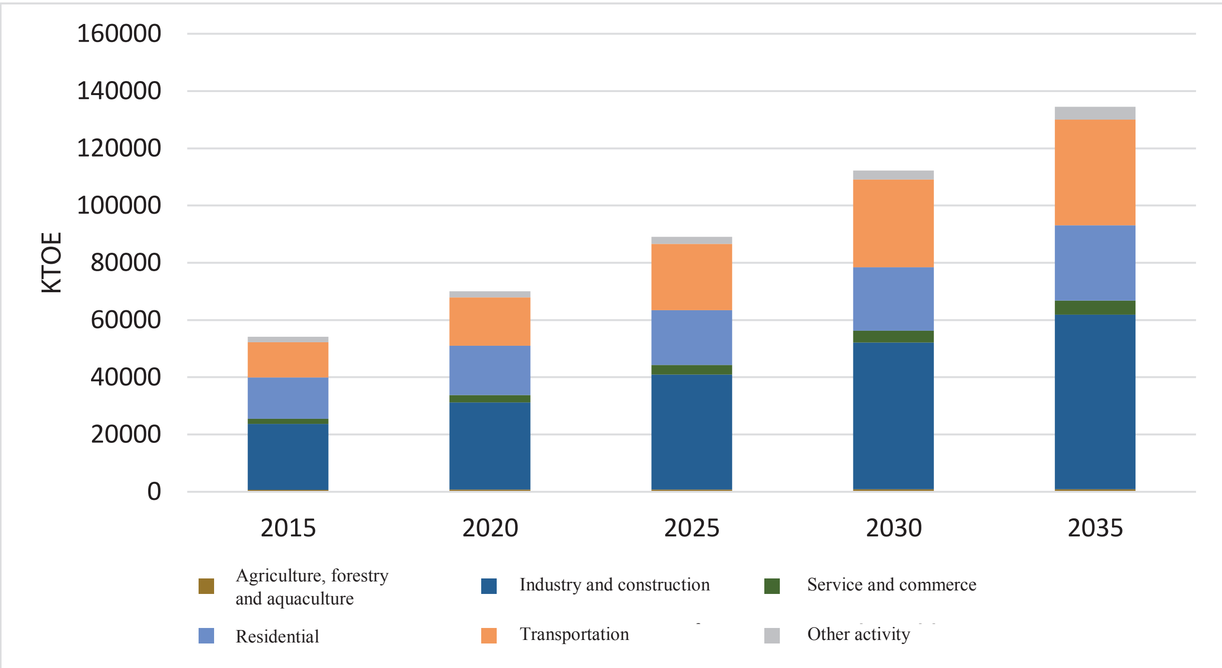
Table 1-9: Growth rate of final energy demand per fuel type (%/year)

	2016-2020	2021-2025	2026-2030	2031-2035	2016-2035
Coal	3.7	3.4	3.0	1.4	**2.9**
Oil products	6.1	5.8	5.2	3.4	**5.1**
Natural gas	10.4	6.4	4.4	1.6	**5.7**
Electricty	9.8	8.6	7.4	5.9	**7.9**
Total	**5.3**	**4.9**	**4.8**	**3.7**	**4.7**

Source: Calculation results of the Energy Institute

In the BAU scenario, in terms of economic sectors, the final energy demand of the transportation sector will gain the *highest increase* from 12.3 million TOE in 2015 to 36.9 million TOE in 2035. The industrial sector still achieves the *highest energy consumption* at 40.2 million TOE in 2025 and up to 60.9 million TOE in 2035.

Figure 1-11: Forecast of final energy demand per economic sector



The proportion of energy consumption by the transportation sector is projected to rapidly increase from 22.7% in 2015 to 26.1% in 2025 and 27.5% in 2035. The energy demand of the industrial sector is the highest in the economy with a proportion of more than 40% of the total final energy demand.

The transportation sector achieves the highest growth of final energy demand with the average rate of 5.7%/year in the period 2016-2035 followedby the service sectors and industry both with a growth rate of 5.0%/year.

Table 1-10: Growth rate of final energy demand per sector (%/year)

	2016-2020	2021-2025	2026-2030	2031-2035	2016-2035
Agriculure, forestry, aquaculture	3.0	1.2	1.6	1.4	**1.8**
Industry and construction	5.7	5.7	5.0	3.5	**5.0**
Service and commerce	6.8	5.2	4.6	3.5	**5.0**
Residential	3.6	2.2	3.0	3.5	**3.1**
Transportation	6.6	6.5	5.7	3.8	**5.7**
Other	2.6	2.3	5.7	7.1	**4.4**
Total	**5.3**	**4.9**	**4.8**	**3.7**	**4.7**

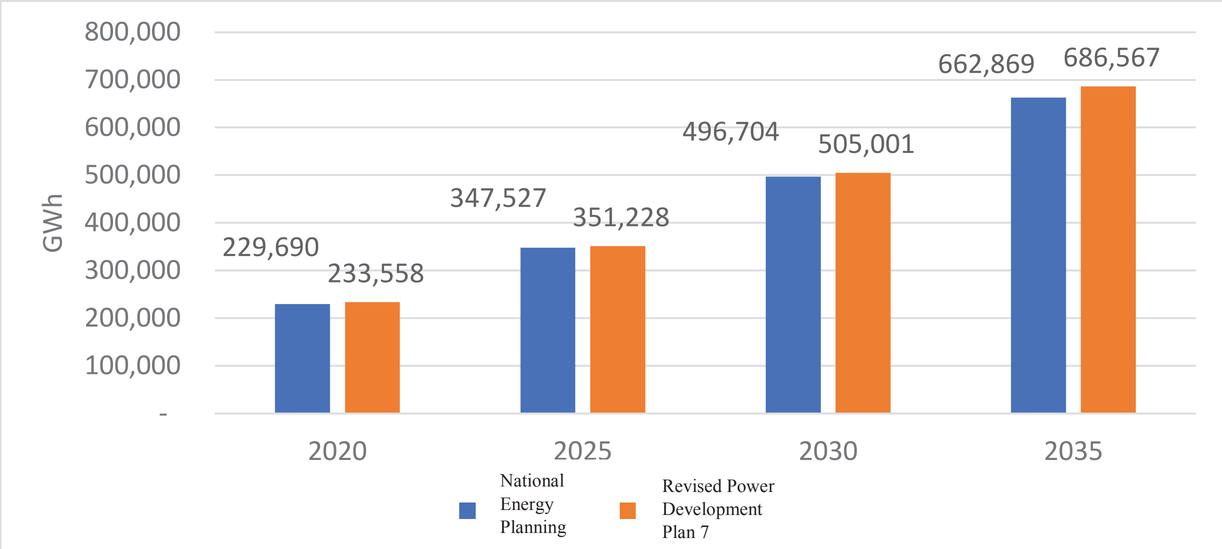
1.2.3 Electricity demand forecast

In the BAU scenario, the demand for commercial electricity is projected to increase by about 7.9 %/year in the period 2016-2035, which is higher than the GDP growth of 7%/year in the same period. However, in the period 2026 - 2035 the electricity demand growth is much lower, at about 4.3%/year (the projected electricity demand in this report is lower than that in the forecast of the revised Power Development Planning 7). Detailed electricity demand of each sub-sector is as below:

Table 1-11: Forecast of electricity demand in the period 2015-2035 per sector

Item	2015		2020		2025		2030		2035	
	GWh	%	GWh	%	GWh	%	GWh	%	GWh	%
Agriculure, forestry, aquaculture	2.327	1.6	3.946	1.7	4.550	1.3	5.182	1.0	5.781	0.9
Industry and construction	77.189	54.0	126.979	55.3	203.584	58.6	299.840	60.4	402.461	60.7
Service and commerce	7.547	5.3	13.248	5.8	19.395	5.6	26.840	5.4	35.501	5.4
Residential use management	50.377	35.3	76.411	33.3	105.258	30.3	140.919	28.4	179.250	27.0
Other activity	5.437	3.8	9.106	4.0	14.741	4.2	23.923	4.8	39.876	6.0
Total commercial energy	**142.877**	**100.0**	**229.690**	**100.0**	**347.527**	**100.0**	**496.704**	**100.0**	**662.869**	**100.0**

Figure 1-12: Comparison of electricity demand forecast results with the revised PDP 7



1.2.4 Assesment of energy saving potential

Apart from impacts of socio-economic development and energy prices, the energy efficiency and conservation (EE&C) measures create positive influence on energy demand adjustment. The mentioned solutions are results summarized and reviewed from energy saving programs implemented within various projects in the period 2011-2015. These are rationales for establishment of an assumption on impacts of EE&C measures on the final energy demand as forecasted above.

Residential sector

For the residential sector, the electricity demand increases mainly because of improved living conditions and growing population. In fact, in the last years, the increase in electricity use is partly caused by the transition from other forms of energy such as coal, oil or biomass mainly used for cooking into electricity. For electricity use, the recognizable saving measure is investment in high-performance equipment to replace the existing one.

The number of solar water heaters will soon be saturated; partly due to the limitation in installation area (e.g. at high-rise apartment buildings, there are many apartments but the maximum number of solar water heaters that could be installed only meets the demand of a very small number of households) and partly due to regional climate conditions. However, this is a significantly effective measure for power consumption reduction. A recent metering survey conducted by the Institute of Energy shows that a family with 4 members will consume on average about 1.8-2.5 kWh/day for hot water, and this amount of electricity covers about 16-21% of daily electricity demand.

As a result, some recognizable fundamental measures in the residential sector include:

- Using solar water heaters to replace electric (or gas-fired) heaters;
- Promoting high performance electric appliances, in replacement of low performance ones. Besides, the Minimum Energy Performance Standard (MEPS) needs to be improved following a defined roadmap to create a motive for research on technology renovation;

- According to the trend, biomass will no longer be popular in cooking and is currently being replaced by other types of fuels in this regard. However, biogas, especially in household cattle-breeding, is an alternative that could effectively make full use of existing fuel sources while requiring low investment and allowing immediate identification of reduction of CO_2 emission into the environment.

Building sector

The building sector has a significantly increased demand for electricity use and electricity covers a major part in the energy use mix. Therefore, the recognizable saving measure is promotion of high performance electric appliances. Besides, the design and materials of partition walls and ceiling of the buildings could also affect the electricity use, mainly the demand for air ventilation and lighting. As a result, there are two basic measures in the building sector that could be recognized as below:

- Promoting the use of high performance equipment in replacement of low performance one;
- Applying the designs in accordance with new buiding codes (e.g. Vietnamese building code QCVN 09:2013/BXD on energy efficient buildings) with the target of energy conservation in buildings even before the building operation.

Agriculture

In Vietnam, the agricultural production sector consumes relatively small amounts of energy. In fact, there are very few activities on energy saving recorded in this sector.

The Ministry of Agriculture and Rural Development promulgated the Circular No. 19/2013/TT-BNNPTNT, dated 15 March 2013 on Guideline for EE&C measures in agricultural production in which many EE&C measures are listed in various agricultural sub-sectors, such as cropping, plant protection, cattle-breeding, veterinary, irrigation, aquaculture, forestry, salt farming and seafood catching. However, in this report, only two of the measures mentioned in the Circular are identified, mainly focusing on the most energy-consuming agricultural sub-sectors which could enable development of calculation assumptions, including:

- The Fishing sector: using high performance lighting devices and solar PV to reduce power production (from DO) in offshore fishing vessels;
- Irrigation: using high performance pumps to reduce power consumption.

Transportation

Transportation is a sector having a relatively complex energy use mix, due to a large range of transportation types and subjects. In terms of purposes, it can be classified into two types: *passenger transportation* and *goods transportation*. In terms of forms, it can be classified into 5 types: Road, Railway, Domestic waterway, Sea route and Air route.

Road transportation allows participation of many types of vehicles. Nevertheless, it can be grouped into two major types: personal vehicles and public vehicles.

For each form, subject and vehicle as above, it is possible to formulate various measures to minimize fuel use. The Ministry of Transportation promulgated the Circular No. 64/2011/TT-BGTVT dated 26 December 2011 to provide EE&C mesures for transportation activities.

Several recent studies by the World Bank (assistance of applying EFFECT tool), ADB (TA support) and the UK Energy Agency (Vietnam Calculator2050 tool) identified some general measures that can be applied for Vietnam, including:

- Promoting the use of biological gasoline and oil (e.g. E5 gasoline);
- Promoting high performance vehicles or those using clean fuels (e.g. electric cars, hybrid);
- Promoting public vehicles (buses, metro system) and reducing traffic flow of personal vehicles;
- Transition of the goods transportation mix from road to railway and waterway.

Industrial production

Industry is currently the biggest energy-consuming sector and will continue to be so in many years ahead as Vietnam is still in the process of industrialization. Therefore, many programs and projects on industrial energy efficiency have been implemented over the past years with significant support from many international organizations. In addition, the Ministry of Industry and Trade issued a number of circulars providing instructions and energy-saving measures that can be applied in industrial production in general and some specific sub-sectors, such as:

- Circular No.02/2014/TT-BCT dated 16 January 2014 regulating EE&C measures for industrial sectors;
- Circular No.19/2016/TT-BCT dated 14 September 2016 regulating energy consumption benchmarks for industrial sectors manufacturing beer and soft drinks;
- Circular No.38/2016/TT-BCT dated 28 December 2016 regulating energy consumption benchmarks for the plastic sector.

Based on local typical successful lessons and comparisons with international experience, it can be said that the Vietnamese industrial sector still has a very large potential for energy saving while facing many challenges.

It can be summarized into the following 6 groups of saving measures:

- Promoting development of energy management systems (e.g. ISO 50001 certification system). This group of measures mainly addresses the top level of enterprises, i.e. investment decision-makers. Besides, a management system will directly affect the operation of equipment, enhancing monitoring capacity, and seek opportunities to improve efficiency inside enterprises;

- Optimization of auxiliary systems (air compression system, vapor system, cooling or freezing system): this group of measures addresses normal auxiliary systems with large potential for energy saving. A recent statistic study by the Institute of Energyon assessment of several energy audit reports show that the number of measures within this group often accounts for nearly half of the total number of measures recommended for enterprises;

- Increased engine efficiency (e.g. replacement with higher performance engine/pump or installation of additional frequency converters). This is also one of the popular and frequently proposed measures in energy audit reports;

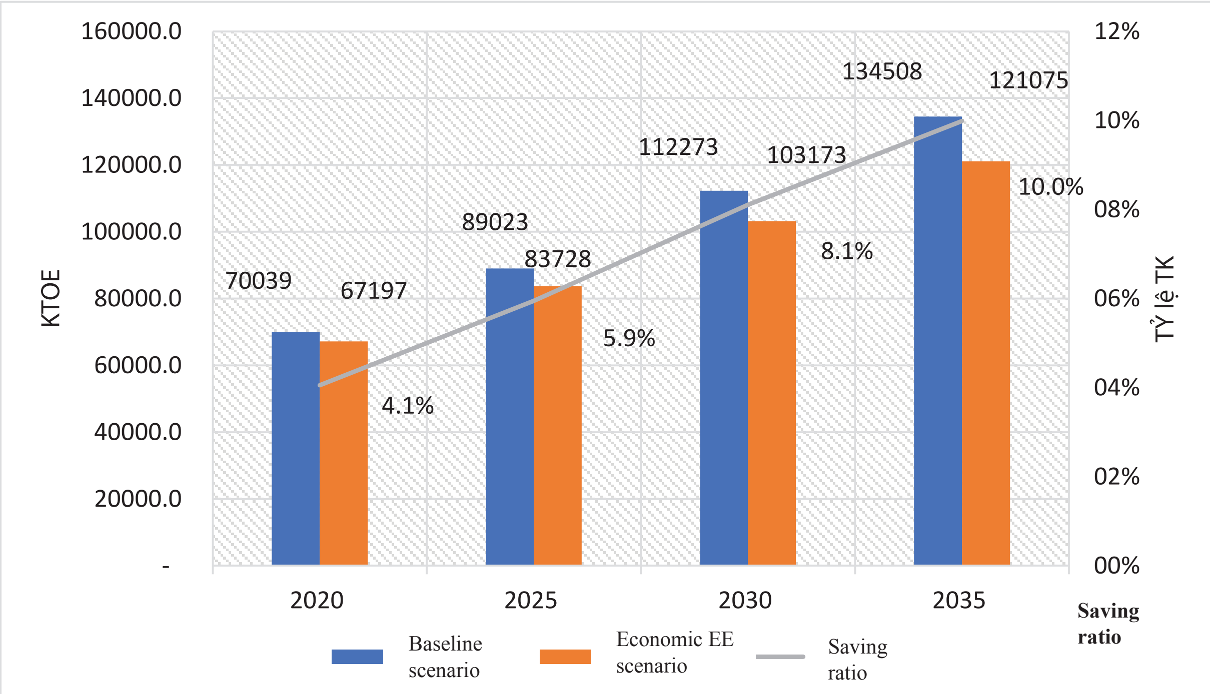
- Heat recovery: in cement production, recovered heat can be used for power production, but at relatively high costs. In some other applications which require lower costs, exhaust heat can be recovered for providing process heat for other phases such as fuel drying;

- Fuel replacement: mainly in the water vapor system, such as replacing coal with cashew nut husk, DO with coal gasification (this particular application can reduce operation cost of enterprises, but it results in more negative environmental impacts);

- Technology change (new technology with high efficiency replacing the old one, e.g. replacement of vertical kiln with rotating kiln for cement production, replacement of traditional brick kiln with vertical kiln etc.). In a certain perspective, the abolishment for new construction is not absolutely a measure to improve energy efficiency. However, the choice of new technology will definitely increase competitiveness of products via reducing fuel costs and meeting increasingly stricter environmental requirements.

Summary results of energy savings from sectors as assessed above show that the economic energy saving scenario enables the saving levels compared to the BAU scenario at 4.1%, 5.9%, 8.1% and 10.0% in the years 2020, 2025, 2030 and 2035 respectively. As a result, the total final energy demand in the economic energy saving scenario is 67.2 MTOE, 83.7 MTOE, 103.2 MTOE and 121.1 MTOE in the years 2020, 2025, 2030 and 2035 respectively.

Figure 1-13: Summary of assessment results of energy savings (KTOE)



The detailed energy consumption for each type of fuel and each sub-sector in various scenarios is presented in the Annex.

1.3 Assessment of energy supply-demand balance

1.3.1 Primary energy potential

Coal

According to the revised Vietnam Coal Development Planning until 2020 with the vision to 2030 (revised Coal Planning) [5], the total coal resource and reserve capacity of Vietnam as surveyed, assessed and explored is 48,877,952 thousand tons. In which:

- Reserve capacity is 2,260,358 thousand tons, accounting for 5%;
- Secure and reliable resource capacity is 1,298,464 thousand tons, accounting for 3%;
- Estimated resource capacity is 2,686,834 thousand tons, accounting for 5%;
- Projected resource capacity is 42,632,295 thousand tons, accounting for 87%.

The production capacity of commercial coal in the whole sector in 2016 would be about 41 million tons/year, reaching about 48 million tons/year in 2020, about 56 million tons/year in 2030 and about 60 million tons/year in 2035. This exploitation option indicates the domestic coal exploitation capacity.

Oil

- Period 2016 - 2020: The annual domestic oil production is 10 - 15 million tons/year; oil production in foreign countries is 2 - 3 million tons/year; and gas exploitation volume is 10 - 11 billion m^3/year.
- Period 2021 - 2025: The annual domestic oil production is 6 - 12 million tons/year; oil production in foreign countries is over 2 million tons/year; and gas exploitation volume is 13 - 19 billion m^3/year.
- Period 2026 - 2035: The annual domestic oil production is 5 - 12 million tons/year; oil production in foreign countries is over 2 million tons/year; and gas exploitation volume is 17 - 21 billion m^3/year.

Gas

- Period 2016 – 2020: producing 11 - 15 billion m^3/year.
- Period 2021 – 2025: producing 13 - 27 billion m^3/year.
- Period 2026 – 2035: producing 23 - 31 billion m^3/year.
- Import of LNG after 2020 with the capacity of:
    - Period 2021 – 2025: importing 1 - 4 billion m^3/year;
    - Period 2026 – 2035: importing 6 - 10 billion m^3/year.

Renewable energy (RE)

Recent assessments on RE show promising potential of RE sources for power generation, especially solar energy, wind energy and biomass. However, there is still a big gap while converting the above technical potential into economic-technical potential, which requires sufficiently strong financial support measures as well as technical solutions to create favourable conditions for developing these types of RE. The technical potential and mobilization capability in 2035 in various scenarios of various RE types for power generation is assessed as follows:

- Biomass: technical potential of 10.3 GW (development of 2.9 – 3.7 GW in 2035);
- Biogas: technical potential of 5.3 GW;
- Solid waste: technical potential of 1.55 GW;
- Wind energy: technical potential of 26.7 GW (development of 10 - 12 GW in 2035);
- Solar energy: technical potential of about 300 GW (development of 21 - 40 GW in 2035);
- Tidal energy: technical potential of 2.3 GW.

1.3.2 Energy balance

While the final energy demand and domestic primary energy potential is assessed in the above sections, an optimal energy development scenario is developed to propose the energy supply-demand balance as well as to meet the target of reducing GHG emission by 15% compared to the BAU scenario. Analyses on this proposed energy development scenario is discussed in details in the following sections.

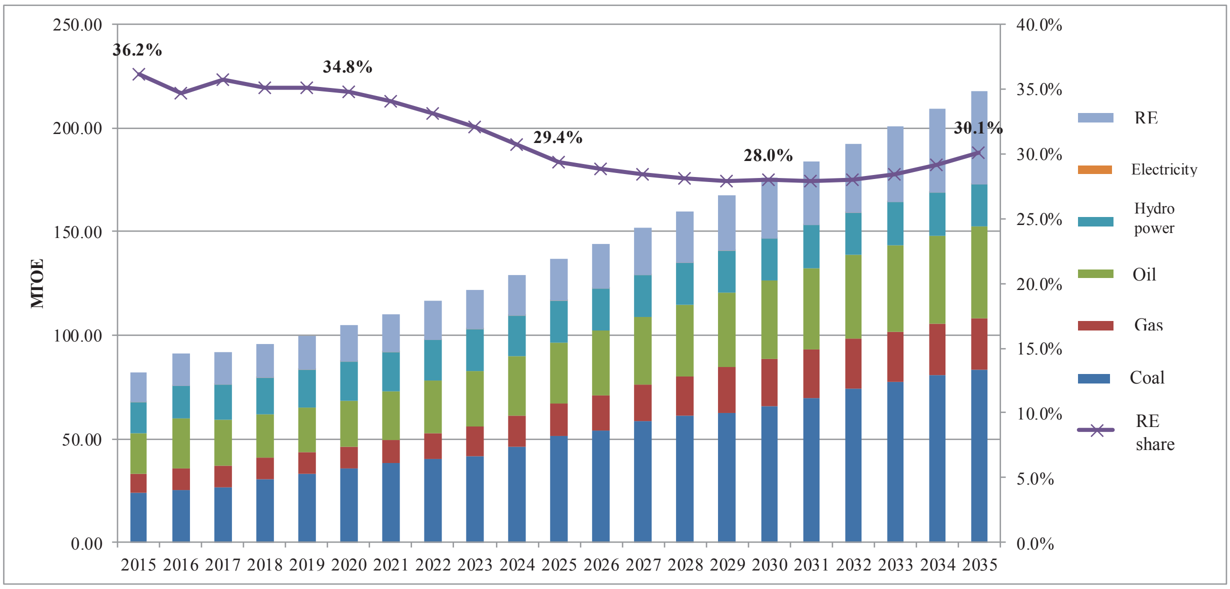
Table 1-12: Energy development scenarios

No.	Scenario	Explanation
1	BAU scenario (baseline scenario)	Baseline economic growth
2	**Proposed scenario**	**Adjusting the energy demand based on assessments of economic energy savings in various economic sectors + the target of CO_2 emission reduction of 15% in 2030 compared to the BAU scenario**

In this scenario, there is a reduction of the final energy demand, the decrease of 5% of CO_2 emission in 2020 and then 15% in 2030 compared to the BAU scenario. Total cumulative CO_2 emission in the period 2016-2035 will decrease by 956 million tons. Among primary energy types, coal and oil consumption falls by 204.7 MTOE and 51.6 MTOE respectively while RE and natural gas use increases by 17.1 MTOE and 13.5 MTOE respectively. It can be clearly realized that the combination between EE&C promotion and low carbon policies results in changes towards a "cleaner economy" orientation via promoting clean energy types such as RE and natural gas.

The total primary energy supply will go up from 80.7 MTOE in 2015 to 136.8 MTOE in 2025 and 217.9 MTOE in 2035. The growth of primary energy in the period 2016-2025 will be 5.3%/year and then fall to 4.8%/year in the later period 2026-2035. The growth rate of primary energy in the whole period 2016-2025 will be 5.0%/year. Among various fossil fuels, coal will achieve the highest growth rate of 7.9%/year in the period 2016-2025, followed by natural gas and oil with the rate of 5.7%/year and 4.4%/year respectively. In the period 2016-2025, the total primary energy to be mobilized will be 1,098 MTOE. This value in the period 2026-2030 is 1,803 MTOE.

Figure 1-14: Primary energy supply in the proposed scenario



Regarding the primary energy mix per fuel type, coal still covers the major part but tends to be stable in the following years of the planning period at the proportion of 37.3% in 2025 and 38.4% in 2035. This is a result of applying low carbon policies to promote RE development. Hydro power experiences a significant reduction while gasoline and oil products cover over 20-22% and natural gas accounts for about 11-13% of the total primary energy.

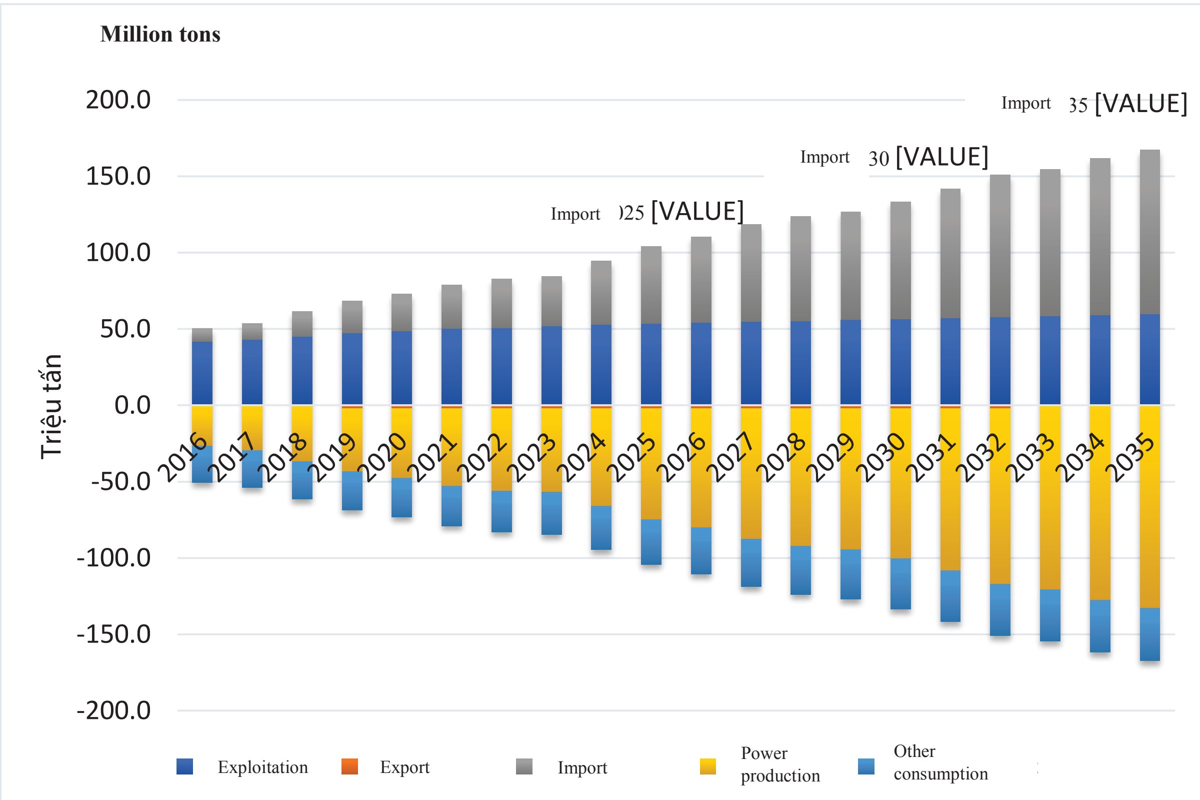
With the proposed scenario, the share of RE in the total primary energy supply could reach 28% in 2030, and then increase to 30.1% in 2035. This ratio is remarkably higher than the one under the BAU scenario, but still fails to meet the required target in the RE Development Strategy. Thus, it is important to have robust supporting policies to enable sooner introduction of RE solutions in the period 2026-2035.

Table 1-13: Primary energy supply in the proposed scenario

	2020	2025	2030	2035	Period 2016-2025	Period 2026-2035	Period 2016-2035
Coal	35.47	51.02	65.65	83.57	7.9%	5.1%	6.5%
Gas	10.66	15.78	23.02	24.36	5.7%	4.4%	5.1%
Oil	22.11	29.79	37.96	44.27	4.4%	4.0%	4.2%
Hydro power	18.81	19.89	20.23	20.57	2.5%	0.3%	1.4%
Electricity	0.03	0.04	0.04	0.06	12.2%	5.0%	8.5%
RE	17.69	20.32	29.03	45.08	3.7%	8.3%	6.0%
Total	104.77	136.84	175.93	217.90	5.3%	4.8%	5.0%

The import coal demand in the proposed scenario considerably decreases compared to the BAU scenario. Total coal exploitation volume and import volume in the period 2016-2025 will be 485.9 million tons and 278.7 million tons respectively. Total coal exploitation volume and import volume in the period 2016-2035 is 1056.4 million tons and 1085.1 million tons respectively. The proposed scenario helps enable significant reduction of coal import (reducing by about 32% compared to the BAU scenario).

Figure 1-15: Coal supply-demand balance in the proposed scenario



Calculation results show that the domestic coal exploitation volume is fully used up in accordance with the revised Coal Planning with the exploited capacity of about 60 million tons in 2030. The coal import volume will increase to 50.4 million tons in 2025 and 107.2 million tons in 2035.

Table 1-14: Coal supply-demand balance in the proposed scenario (million tons)

	2016-2025	2026-2035	2016-2035
Exploitation	485.9	570.5	1,056.4
Export	14.8	14.3	29.1
Import	266.2	818.9	1,085.1
Power production	475.3	1,046.7	1,522.0
Other consumers	262.1	328.3	590.4

The LNG import volume goes up to 9.3 billion m³ in 2030 and 14.8 billion m³ in 2035. The gas supply-demand balance is illustrated in the following figure:

Figure 1-16: Gas supply-demand balance in the period 2016-2035 in the proposed scenario

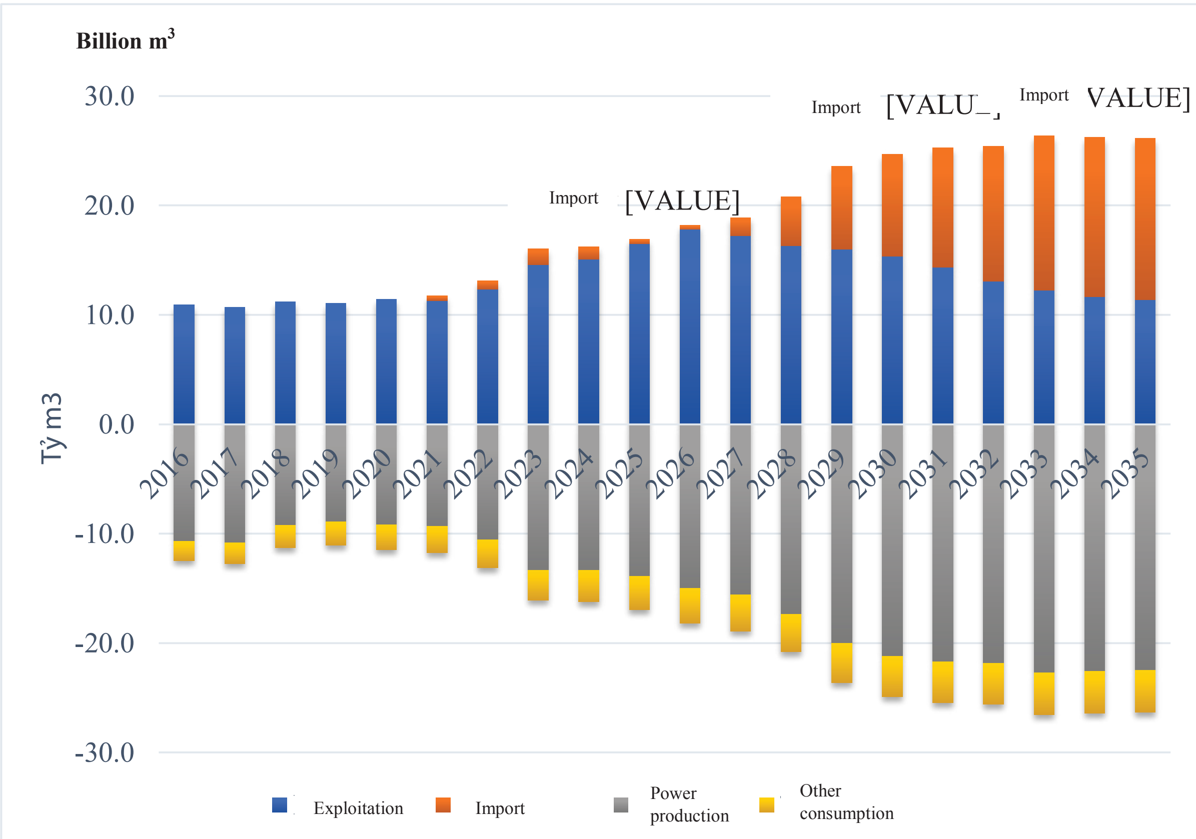


Table 1-15: Gas supply-demand balance in the periods in the proposed scenario (billion m3)

	2016-2025	2026-2035	2016-2035
Exploitation	125.2	145.4	270.6
Import	4.2	90.2	94.4
Power production	109.3	200.4	309.7
Other consumers	23.7	36.2	60.0

Total domestic gas exploitation volume in the period 2016-2025 reaches 125.2 billion m^3. In the period 2016-2035, the gas exploitation volume is 270.6 billion m^3 (covering 92% of the total mobilized natural gas in the baseline option of gas supply of about 295 billion m^3). The gas supply volume is 109.3 billion m^3 for power production and 23.7 billion m^3 for other consumers in the period 2016-2025. Other gas consumers use on average 3-4 billion m^3 gas/year.

In general, the exploited oil is fully used up in accordance with the option of crude oil exploitation inside and outside the country. The crude oil import volume is nearly similar to the results of the BAU scenario. However, due to lower energy demand, there are some changes to reduce the oil import volume as the products of oil refinery plants mainly meet the domestic demand. In particular, with the two oil refinery plants including Dung Quat (even including the expanded project) and Nghi Son, the crude oil demand for oil filtration is about 18.2 million tons/year. The demand for crude oil increases to 28.0 million tons upon the establishment of Vung Ro oil refinery plant in the period until 2025. The demand for crude oil will increase to 36 million tons/year when Nam Van Phong oil refinery plant comes into operation in the period until 2030. In this scenario, it can be considered to futher invest in Long Son oil refinery plant in the period until 2035.

Table 1-16: Crude oil supply-demand balance in the proposed scenario (million tons)

	2016-2025	2026-2035	2016-2035
Exploitation	136.5	42.6	179.1
Import	103.4	330.6	434.0
Export	51.6	-	51.6
Oil refinery plants	185.4	373.2	558.6

The total domestic exploitation volume of crude oil in the period 2016-2025 reaches 136.5 million tons. In the whole period 2016-2035, the oil exploitation volume is 179.1 million tons (covering 100% of total crude oil volume mobilized in the option of crude oil supply capability). The crude oil supply volume for oil refinery plants in the period 2016-2015 is 185.4 million tons.

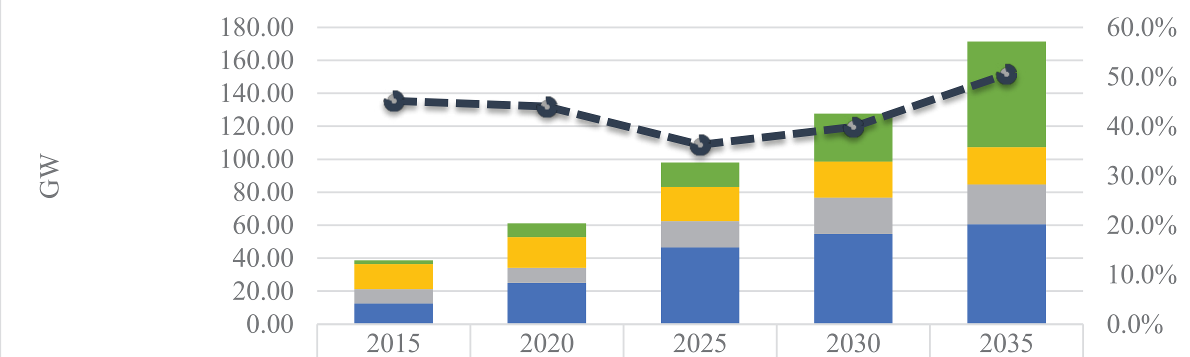
Crude oil export will gradually go down until 2022 to reserve fuel for domestic oil refinery plants. By 2025 the crude oil export volume is 51.6 million tons, creating a foreign currency revenue in the context of low oil demand from the oil refinery plants. Due to the establishment of Nghi Son oil refinery plant using imported crude oil, the flow of crude oil import will increase to 18 million tons in 2025 and 38 million tons in 2035. The proprosed scenario uses the option of crude oil exploitation inside and outside the country as in the Petroleum Planning, so if failing to meet this required level of crude oil exploitation, then the demand of crude oil import for oil refinery plants will be higher.

1.3.3 Power source development orientation

Power production

According to results of the proposed scenario, the total installed capacity of power plants in the system will reach 61.1 GW in 2020, 98 GW in 2025, 127.7 GW in 2030, and 171.3 GW in 2035. It can be concluded that despite the reduction of power demand, more RE sources connect to the grid, so the installed system capacity of the proposed scenario is not much lower than that of the BAU scenario.

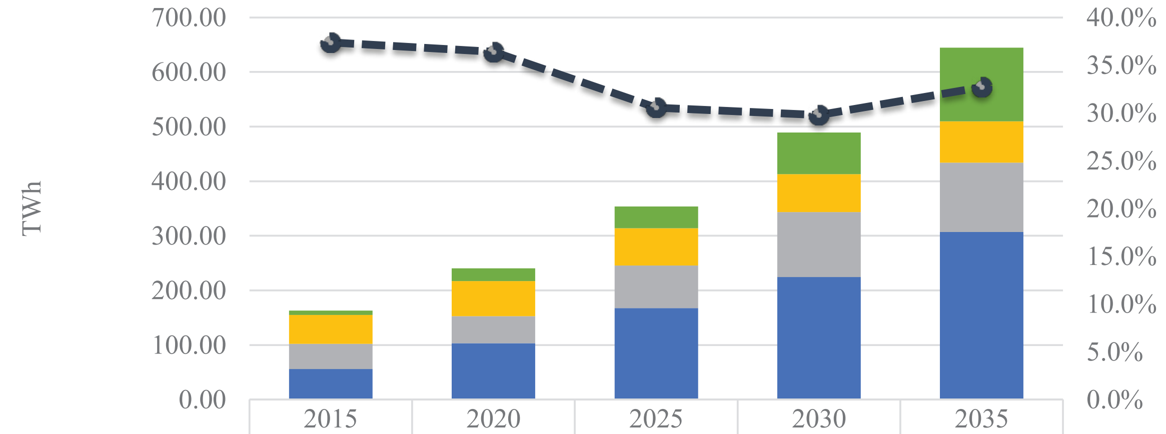
Figure 1-17: Capacity of power plants in the proposed scenario



	2015	2020	2025	2030	2035
Small hydro +RE	2.22	8.25	14.73	29.19	63.93
Hydro power	15.26	18.63	20.79	21.74	22.69
Gas + oil	8.70	9.23	15.98	22.08	24.17
Coal	12.51	24.99	46.45	54.71	60.53
RE share	45.2%	44.0%	36.3%	39.9%	50.6%

Power production capacity in the proposed scenario will increase to 354 TWh in 2025, 489 TWh in 2030, and 645 TWh in 2035. This capacity is lower than that in the BAU scenario due to power demand reduction.

Figure 1-18: Power production capacity per fuel type in the proposed scenario



	2015	2020	2025	2030	2035
RE	7.74	23.17	40.10	76.60	135.29
Hydro power	53.15	64.36	68.06	69.21	75.62
Gas + oil	45.80	49.36	77.83	119.21	126.83
Coal	56.23	103.52	167.83	224.45	306.96
RE share	37.4%	36.4%	30.6%	29.8%	32.7%

In the proposed scenario, the proportion of power produced from RE in 2030 (including large hydro power) is 29.8%, approximately equivalent to the required level in the RE Strategy. However, it is necessary to consider differences in power demand forecasts (with the estimated power production of 580 TWh in 2030 in the RE Strategy). If taking into account the absolute value, the power production from hydro power and other RE sources will be higher than the required levels in the RE Strategy.

1.3.4 RE development orientation

The considered scenarios have significant impact on RE share in the primary energy and power system generation. The below table presents the RE share in the total primary energy in the BAU and the proposed scenarios:

Table 1-17: RE share in the total primary energy supply across scenarios (%)

	2020	2025	2030	2035
BAU scenario	33.7%	27.9%	25.6%	23.5%
Proposed scenario	**34.8%**	**29.4%**	**28.0%**	**30.1%**

If considering the target for RE share in the primary energy consumption as proposed in the Decision No. 2068 at 32.3%, then this target could only be achieved in 2030 under the scenario of reducing CO_2 emission by 25%. Therefore, the proposed scenario is an appropriate development scenario to create a premise for completing the commitment of CO_2 emission reduction and national RE development targets.

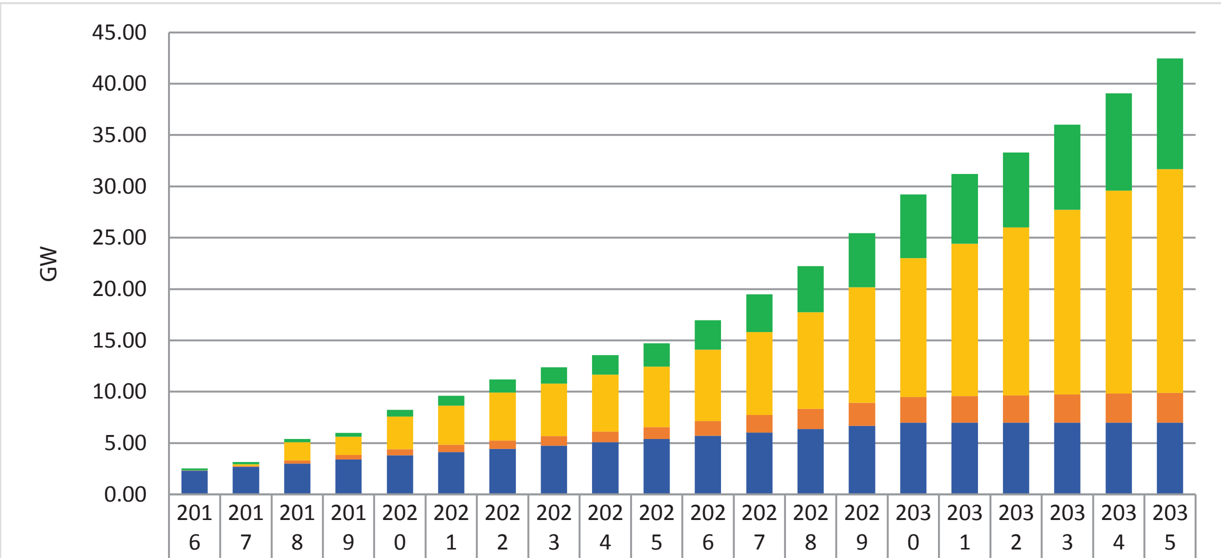
The proportion of power produced from RE in the total power production is presented in the below table:

Table 1-18: The proportion of power produced from RE in the total power production across scenarios (%)

Scenario	RE type	2015	2020	2025	2030	2035
BAU scenario	Wind + Solar	0.3%	2.4%	3.6%	6.2%	7.7%
	RE + small hydro	4.7%	9.3%	10.6%	13.8%	13.7%
	RE + hydro	**37.4%**	**35.0%**	**28.6%**	**26.6%**	**23.8%**
Proposed scenario	Wind + Solar	0.3%	2.5%	3.8%	6.8%	13.3%
	RE + small hydro	4.8%	9.6%	11.3%	15.6%	21.0%
	RE + hydro	**37.4%**	**36.4%**	**30.6%**	**29.8%**	**32.7%**

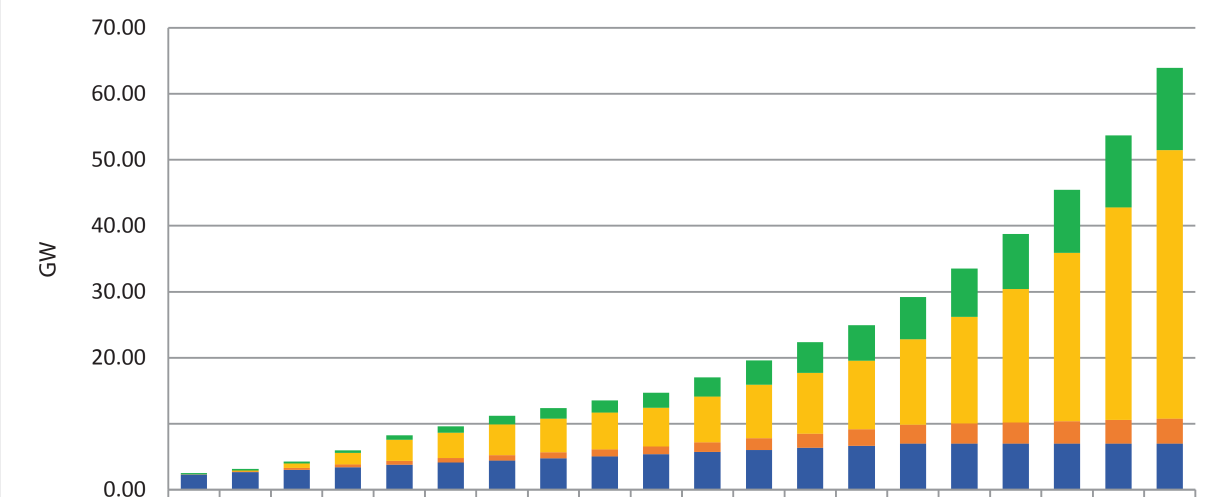
The world trend shows the significant contribution of RE in power generation for development of the low carbon economy (even zero carbon). Similarly, RE development in the power production in Vietnam will be a key drive for promoting RE use. The growth of RE installed capacity in power generation under the BAU and the proposed scenario is illustrated as follows:

Figure 1-19: Growth of RE power capacity in the BAU scenario



	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Wind	0.18	0.23	0.32	0.38	0.68	0.98	1.28	1.58	1.88	2.28	2.88	3.68	4.48	5.28	6.22	6.77	7.30	8.30	9.46	10.7
Solar	0.00	0.15	1.76	1.76	3.17	3.81	4.66	5.11	5.56	5.89	6.95	8.09	9.42	11.2	13.5	14.8	16.3	17.9	19.7	21.7
Biomass	0.05	0.08	0.32	0.45	0.60	0.71	0.82	0.93	1.04	1.16	1.42	1.69	1.96	2.23	2.49	2.57	2.65	2.74	2.82	2.90
Small hydro	2.30	2.70	3.00	3.40	3.80	4.12	4.44	4.76	5.08	5.40	5.72	6.04	6.36	6.68	7.00	7.00	7.00	7.00	7.00	7.00

Figure 1-20: Growth of RE power capacity in the proposed scenario



	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Wind	0.18	0.23	0.32	0.38	0.68	0.98	1.28	1.58	1.88	2.28	2.88	3.68	4.63	5.38	6.39	7.32	8.34	9.56	10.9	12.4
Solar	0.00	0.15	0.65	1.76	3.17	3.81	4.66	5.11	5.56	5.89	6.95	8.09	9.23	10.3	12.9	16.1	20.2	25.5	32.2	40.7
Biomass	0.05	0.08	0.32	0.45	0.60	0.71	0.82	0.93	1.04	1.16	1.46	1.79	2.13	2.49	2.87	3.04	3.21	3.39	3.58	3.77
Small hydro	2.30	2.70	3.00	3.40	3.80	4.12	4.44	4.76	5.08	5.40	5.72	6.04	6.36	6.68	7.00	7.00	7.00	7.00	7.00	7.00

In terms of economic feature of RE power sources in the period until 2030, it is difficult for them to compete with traditional power sources, and certan support is still required. However, after 2030, with the the fossil fuels' increasing price tendency, the investment cost of fossil fuel power sources will increase due to stricter environmental standards while the power production cost of RE sources will fall as a result of technology improvement.As a result, RE could be able to compete with traditional power sources.

There are various challenges for solar power and wind power to integrate them into the power system (fluctuation level, reactive power generation capability, land use, etc.). Therefore, it requires cautious consideration for even development of these two main types of RE for power generation to ensure safe and stable operation of the power system.

It can be considered that the formulation of carbon tax aims at adjusting market behaviours that reflect external impacts in fossil fuel production and use. As a result, the economic feature of RE sources reflects more correctly the cost paid by the society, and solar and wind energy will become significant factors in GHG emission reduction scenarios.

At present, Vietnam has some fixed FIT mechanisms for RE power sources. When assessing the necessary subsidies based on the gap between the existing FIT and average power purchase price of EVN (VND 1,190/kWh in 2016), the main subsidies for various RE sources are as below:

Table 1-19: Estimated subsidy costs for RE on annual basis (billion USD)

Item	RE type	2020	2025	2030	2035
Power production (GWh)	Solar	3.88	7.62	18.86	24.77
	Wind	4.31	7.97	17.55	55.45
	Biomass	1.67	5.59	15.67	30.54
Subsidies (billion USD) (difference between the existing FIT and average power purchase price of EVN in December 2016)	Solar	0.16	0.31	0.77	1.01
	Wind	0.11	0.20	0.44	1.39
	Biomass	0.01	0.03	0.08	0.16
	Total	**0.28**	**0.54**	**1.29**	**2.56**

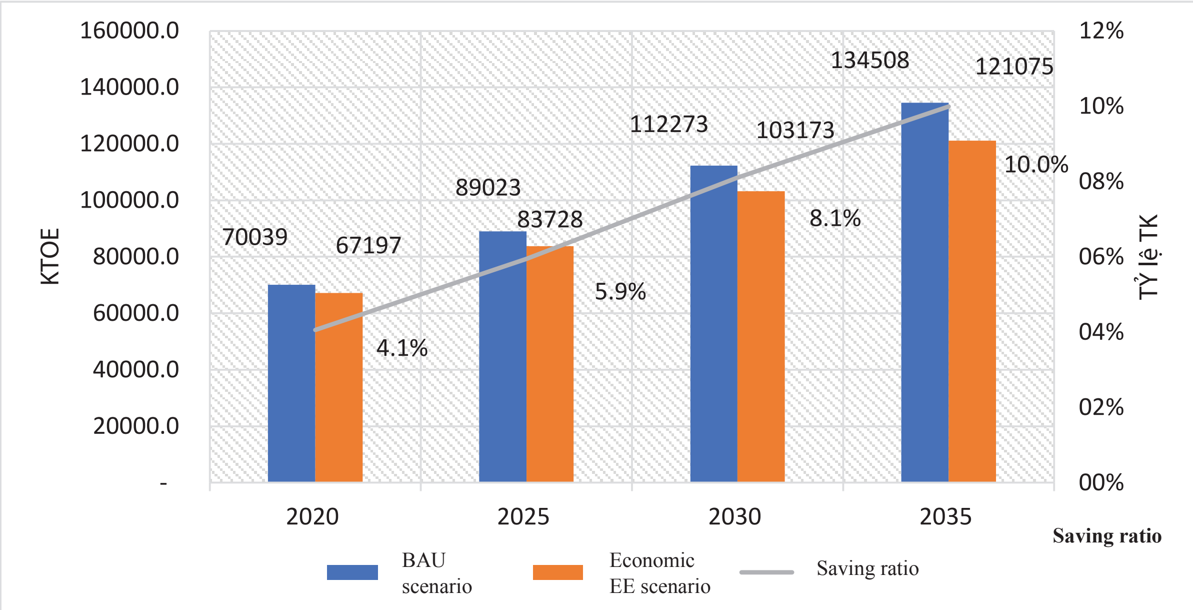
For these three types of RE sources, the size of subsidies go up to USD 540 million in 2025 and USD 2.56 billion in 2030 (the power purchase price is assumed to be the same as the current price). Thus, it is significant to consider a sustainable financial source from the Sustainable Energy Development Fund based on the revenue from taxes/fees for fossil fuels. For instance, a carbon tax of 5 USD/ton could be considered to impose on fossil fuels such as coal, oil products and natural gas based on their consumption levels in the proposed scenario to create a revenue for the Sustainable Energy Development Fund.

Vietnam is now at a significant transition point in energy development while moving to a net energy import economy in the climate change context. RE development plays a key role in energy sustainable development in the future.

1.3.5 EE&C orientation

The final energy demand in the proposed scenario experiences a decrease of 6.6% in 2025 and 11% in 2035 compared to the BAU scenario.

Figure 1-21: Comparison of final energy demand between 2 scenarios

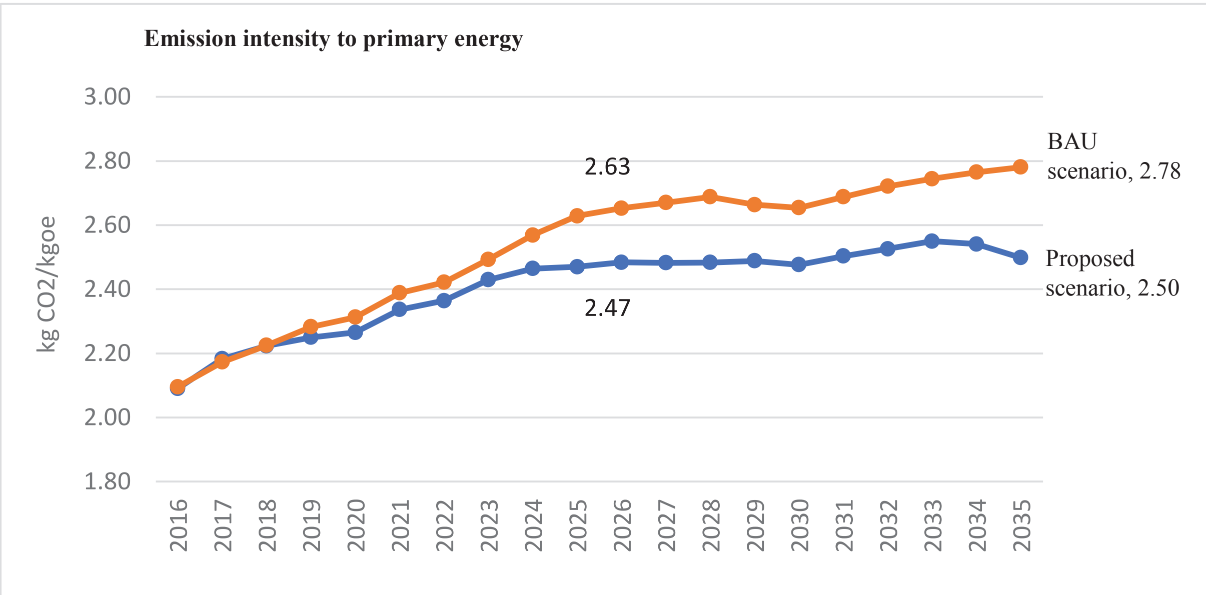


In the proposed scenario, the growth of final energy demand is 4.1%/year in the period 2016-2035, with a declining growth from 4.4%/year in the period 2016-2025 to 3.7%/year in the period 2026-2035.

1.3.6 GHG emission in energy development

In the proposed scenario, the emission intensity of the energy sector over the primary energy consumption reduces by 10% in 2035, equivalent to the decrease from 2.78 $kgCO_2/kgOE$ to 2.5 $kgCO_2/kgOE$.

Figure 1-22: Comparison of GHG emission intensity between 2 scenarios



In the proposed scenario, the total CO_2 emission rises to 338 million tons in 2025 and 544 million tons in 2035 (compared to the levels of 385 million tons and 663 million tons respectively in the BAU scenario). This development scenario enables the CO_2 emission reduction by 12% in 2025, 15% in 2030 and 18% in 2035 compared to the BAU scenario. The estimated growth of CO_2 emission in the whole period 2016-2025 is 5.9%/year, which is 1% lower than the BAU scenario. The overall impact of energy efficiency and RE development in the proposed scenario is the major cause of CO_2 emission reduction in this scenario.

The contribution of CO_2 emission from power production in the total emissions of the energy sector is 54.5% in 2025 and 62.0% in 2035. CO_2 emissions for energy activities across sectors and fuel types in the period 2015-2035 is as below:

Table 1-20: CO_2 emission per sector in the proposed scenario (million tons)

	2015	2020	2025	2030	2035
Agriculture	1.4	1.2	1.1	1.1	1.1
Service	4.1	4.3	4.7	5.1	5.2
Industry	47.3	56.9	66.5	75.2	76.4
Residential	6.9	9.3	13.1	16.8	21.0
Transportation	37.0	47.8	64.8	84.6	100.1
Other	4.5	4.3	3.6	3.5	3.2
Power production	72.0	113.6	184.2	249.3	337.3
Total	**173.2**	**237.3**	**338.0**	**435.7**	**544.4**

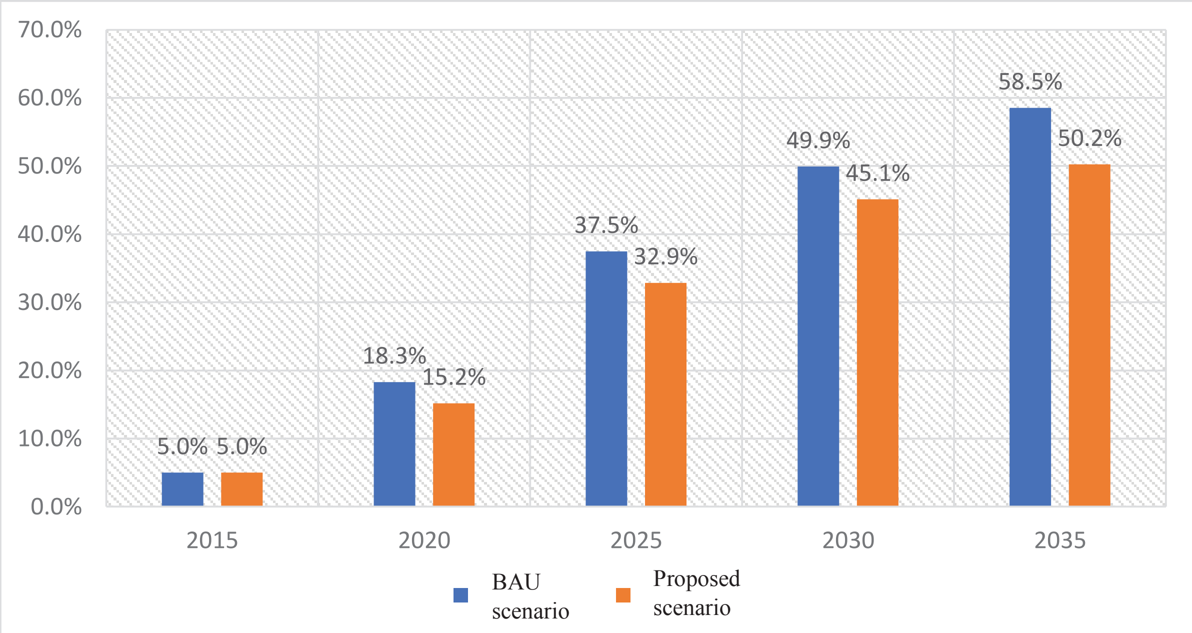
Table 1-21: CO_2 emission per fuel type in the proposed scenario (million tons)

Fuel	2015	2020	2025	2030	2035
Coal	86.0	100.3	122.9	148.0	172.5
Oil products	70.2	120.8	189.3	255.2	311.2
Gas	17.0	16.2	25.8	32.5	62.6
Total	173.2	237.3	338.0	435.7	546.3

1.3.7 Conclusions on long-term energy supply-demand balance

In general, in the scenarios, the domestic energy exploitation is always mobilized at the full or nearly full capacity. The major change is on energy import from other countries. The progress of energy import dependence is illustrated in the figure below, where it is expected that the import share of total primary energy supply is due to increase to 37.5% in 2025 and 58.5% in 2035 in the BAU scenario:

Figure 1-23: Net energy import ratio in the BAU scenario and the proposed scenario



Regarding diversification of primary energy supply sources, in the BAU scenario, the HHI indicator of primary energy significantly increases up to 2902 in 2035, reflecting high concentration with a relatively large proportion of coal consumption. With the proposed scenario, the energy system will less depend on coal while the supply sources are more diversified with higher share of RE and gas. As a result, the HHI indicator of primary energy only slightly increases to 2526 in 2035.

Based on forecasts of major orientaions for macro economic development, the country's total final energy consumption is nearly 54.1 MTOE in 2015, from 83 to 89 MTOE in 2025; and from 120 to 135 MTOE in 2035.

The proposed scenario on the national total energy supply suggests the orientation towards the national commited target at COP21 on CO_2 emission reduction. The national total primary energy supply in 2025 for the proposed scenario and the BAU scenario is from 137 to 147 MTOE; in 2035 from 218 to 238 MTOE.

Analysis results show that in the proposed scenario, the share of RE in the total primary energy supply will reach about 29% in 2025 and over 30% in 2035, approximately equivalent to the target in the RE Development Strategy. The proposed scenario also contributes to the CO_2 emission reduction of about 12% in 2025 and about 15% in 2030 and 18% in 2035 compared to the BAU scenario. The proposed scenario also contributes to strengthening the national energy security via reducing dependence on energy import and enhancing the diversification of energy supply sources.

2 Results of power source development scenarios using Balmorel model

This section of the report presents analyses on power source development based on various scenarios on supply capability, energy price, power demand, RE technology costs, GHG emission reduction. These analyses are developed based on the use of the Balmorel model, an optimal power system planning model which allows thorough assessment of integration of RE sources, especially the variable wind and solar energy, into the power system of Vietnam in the future.

These analyses were extracted from [8] a study on Vietnam power system development in the period 2014 – 2050 by using the Balmorel model – an open-source modelling framework with detailed modelling data of the current Vietnamese power system as well as projected future developments to simulate least-cost investments under potential future development scenarios. This study shall continue implementing under the cooperation agreement in the next 3 years between Vietnam and Denmark.

2.1 Power source development scenarios

The following scenarios were considered for assessment:

- "Stated policies" scenario: based on targets of PDP7 and the renewable energy strategy.
- "Unrestricted" scenario: Assuming no restrictions other than least cost optimization (no RE targets or other constraints).
- "CO_2 price" scenario: This scenario suggests replacing the RE strategy by a CO_2 price. The price is fixed at a level which produces the same level of CO_2 emissions as obtained in the "Stated policies" scenario.
- "CO_2 price high" scenario: a higher CO_2 price is suggested to test how effectively this policy mechanism is to drive down CO_2 emissions.
- "CO_2 cap" scenario: This scenario tests the implications of replacing the renewable energy strategy with a policy of setting a CO_2 cap.
- "No coal" scenario: This scenario suggests a stop for new coal generation plants beyond 2034. Existing as well as new plants up to 2035 may continue operating until the end of their life time.

Power Development Planning No.7 (PDP 7)

The PDP 7 scenario analyses the entire power and transmission system development plan as laid out by PDP 7 revised towards 2030. The key features of the scenario are the following:

- PDP 7 revised generation and transmission system capacity is represented until 2030;
- No model-based investments (dispatch modelling only);
- Runs in 5-year periods until 2030;
- No RE goal requirement implemented.

Stated Policies

The Stated Policies scenario is based on PDP 7 revised power system development plan for the nearterm, while allowing model-based investments in generation and transmission thereafter. The model-based optimisation uses input data and assumptions, that are based on best available information, and is required to comply with binding national policies (e.g. the RE goals). The key features of the scenario are as follows:

- PDP 7 revised generation and transmission system capacity is represented until 2020;
- Model-based investments are allowed:
- In generation capacity - from 2020;
- In transmission capacity - from 2030.
- Runs in 5-year periods until 2050;
- RE goal requirements implemented in line with RE Strategy.

Alternative scenarios

The alternative scenarios are all based on the Stated Policies scenario and are designed so that only one parameter is varied compared to the Stated Policies scenario, i.e. any and all differences in outcomes in the alternative scenario vis-à-vis the Stated Policies scenario can be attributed to the change in the single parameter.

The following characteristics are shared across all alternative scenarios:

- PDP 7 revised generation and transmission system capacity is represented until 2020;
- Model-based investments are allowed:
- In generation capacity - from 2020;
- In transmission grid - from 2030.
- Runs in 5-year periods until 2050.

The following sections present the alternative scenarios and their differences vis-à-vis the Stated Policies scenario.

Unrestricted

The Unrestricted scenario represents a mere hypothetical future perspective wherein no environmental or RE policies are being pursued in Vietnam. This can be used as a baseline to evaluate the difference made by the various alternative policies investigated. The parameter variation of the scenario vis-a-vis the Stated Policies scenario is: no RE goal requirement implemented.

CO_2 Cap

The CO_2 Cap scenario is the 'CO$_2$ emission equivalent' scenario of the Stated Policies scenario. CO_2 Cap scenario investigates the implications of substituting the RE goals with a CO_2-focused policy, wherein a limitation is set on the total power system CO_2 emission level. This also allows for the calculation of CO_2 emission shadow price. The parameter variations of the scenario vis-a-vis the Stated Policies scenario are as follows.

- CO_2 emission cap is introduced in line with the CO2 emission level generated in the Stated Policies scenario;
- No RE goal requirement is implemented.

CO_2 Price

The CO_2 Price scenario represents an environmental policy alternative to the RE goals, wherein CO_2 emissions are associated with an additional cost (which can be interpreted as CO_2 price, CO_2 planning value, CO_2 tax, etc.). The parameter variations of the scenario vis-a-vis the Stated Policies scenario are as follows:

- A CO2 price is implemented: 7 USD/tonne in 2020, 20 USD/tonne thereafter. This price is based on estimated CO2 externality value in Vietnam;
- No RE goal requirement is implemented.

Selection of CO_2 price for the scenario:

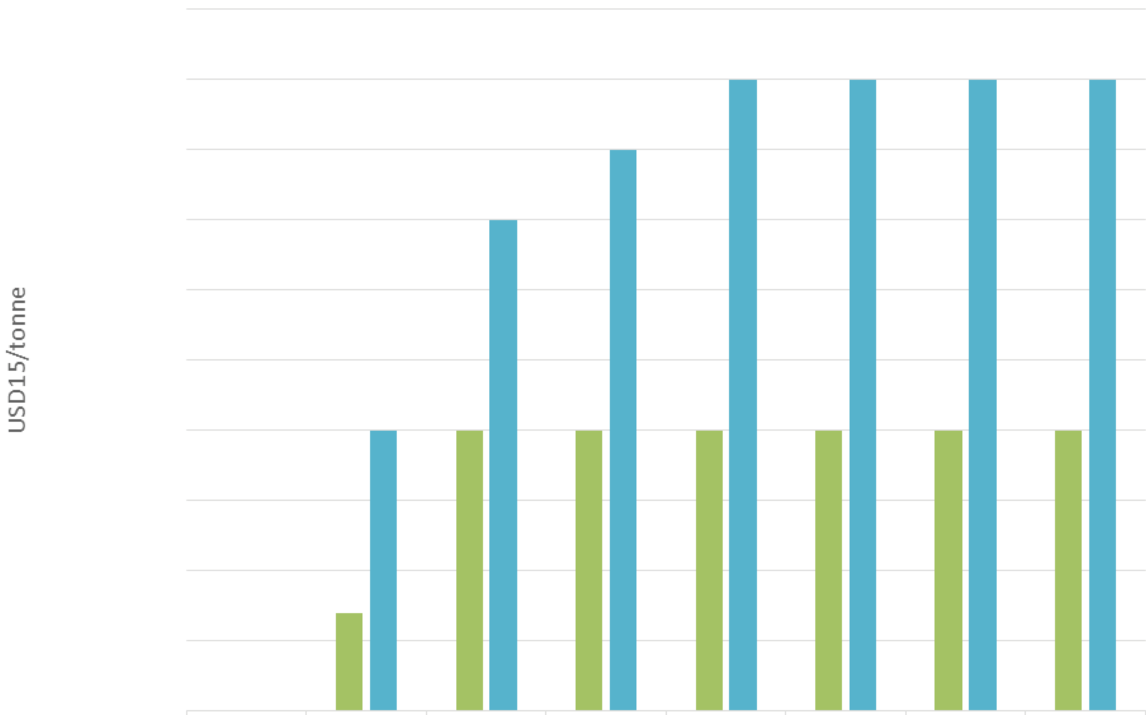
The assumed CO_2 price level of 7 USD/tonne in 2020, 20 USD/tonne thereafter was set based on the study 'Low Carbon Scenario for the Power Sector of Vietnam: Externality and Comparison Approach'.. 7 USD/tonne was the value corresponding to the monetary benefits that power producers could earn if they reduced CO_2 emission in electricity generation, and deemed approporate for historical and near-term calculations. For long-term projections, the study sets forth average CO_2 externality cost of 20 USD/tonne.

CO_2 Price High

The CO_2 Price High scenario is a variation of the CO_2 Price scenario, wherein the level of costs associated with CO_2 emissions is higher than in the CO_2 Price scenario. The parameter variations of the scenario vis-a-vis the Stated Policies scenario are as follows:

- A higher CO2 price is implemented;
- No RE goal requirement is implemented.

Figure 2-1: CO_2 price levels represented in the CO_2 Price scenario and CO2 Price High scenario, respectively (USD 2015/tonne CO_2)



	2015	2020	2025	2030	2035	2040	2045	2050
CO2 price	0	7	20	20	20	20	20	20
CO2 price high	0	20	35	40	45	45	45	45

Selection of CO_2 price for the scenario

CO_2 price levels for the CO_2 Price High scenario were selected so that they would exhibit a significantly more ambitious environmental policy pathway than the Stated Policies scenario. With the implied CO_2 shadow prices of the Stated Policies scenario as the starting point, additional CO_2 cost of 20 USD/tonne was added to the resulting CO_2 shadow price[10] levels within each year modelled (for years 2030 and 2035 the added cost was 35 USD/tonne in order to maintain the CO_2 price growth trend in the CO_2 Price High scenario, whilst the CO_2 shadow prices for the Stated Policies scenario show a decrease in the respective period).

No New Coal

The No New Coal scenario represents an ambitious, hypothetical environmental policy alternative whereby the expansion of coal-fired power generation capacity stops from 2035 onwards (whilst allowing the existing coal-fired power plants to remain operational beyond 2035). The No Coal scenario is comprised of the Stated Policies scenario with an addition of a restriction on new coal-fired power plant construction as of 2035. Investments in CCS coal-fired technology would still be permitted. The parameter variation of the scenario vis-a-vis the Stated Policies scenario is as follows:

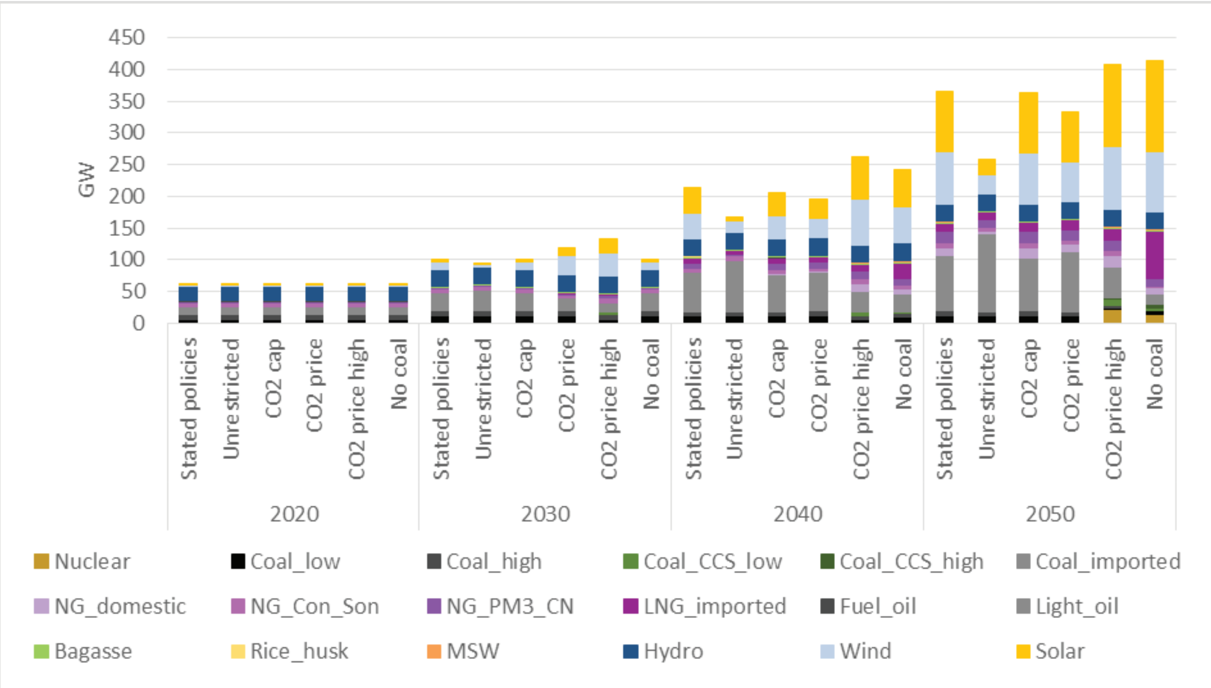
- No new investments in coal-fired technology allowed after 2035.

[10] The CO_2 shadow price can be interpreted as the equivalent of a tax that should be added to fuels, to realise the required (low) emission level in the Stated Policies scenario, or the subsidy given to clean energy to reach the clean energy goal (in the absence of the RE goals). In the current study, due to the Balmorel modelling setup fô Vietnam, the CO_2 shadow prices were obtained using the CO_2 Cap scenario (CO_2 emissions of which were identical to those of the Stated Policies scenario).

Analyses of results of scenarios show that the absence of environmental policies (Unrestricted scenario) results in very limited investment in RE, combined with the highest share of coal-fired power capacity (based on imported coal). However, in the Unrestricted scenario, towards 2030 the investment in wind power capacity of 2.7 GW takes place (1.9 GW thereof in the high-wind resource area in the Central region). It indicates that the projected RE technology improvements and continued cost reductions would make the best wind resource sites in Vietnam cost-competitive with conventional power generation sources. By 2050, in the unrestricted scenario, cumulative investment capacity of wind and solar PV reach 30 GW and 25 GW on purely cost-competitive basis.

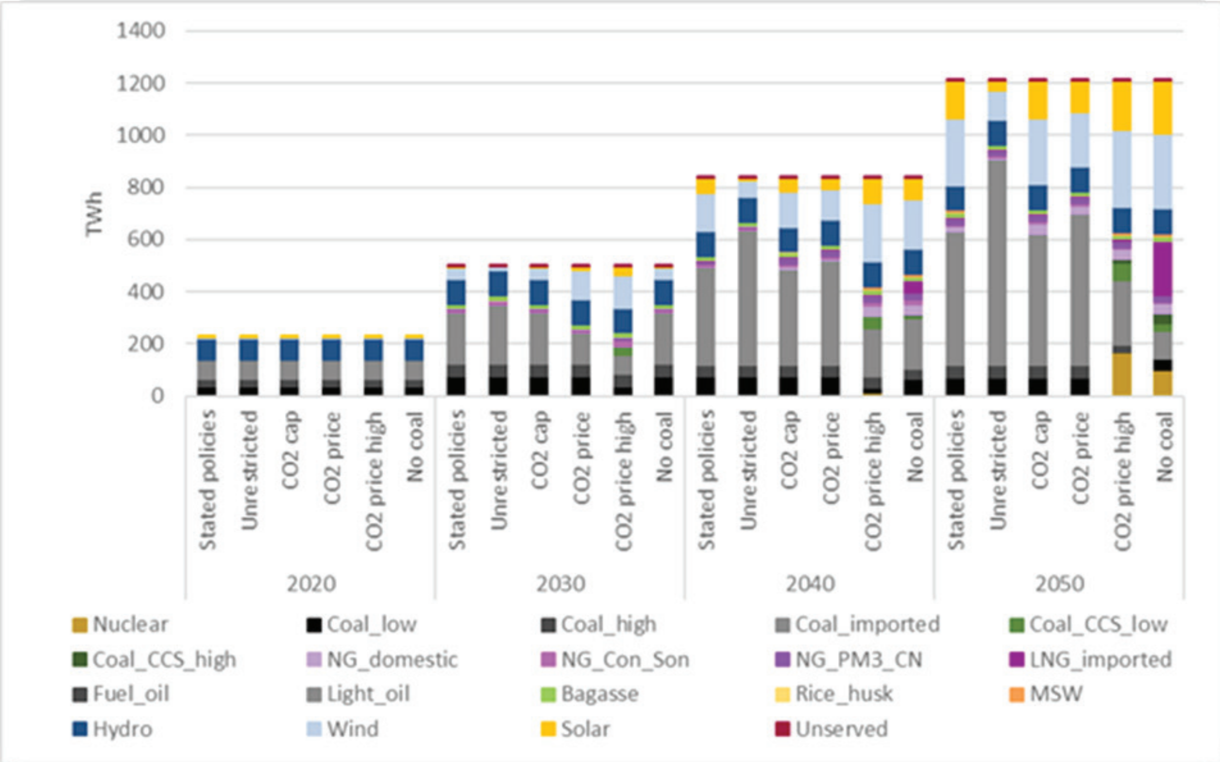
CO_2 Cap, whilst achieving the same CO_2 emissions as Stated Policies, results in slightly lower coal-fired capacity investments (instead investing in more gas-fired capacity, which is less carbon-intensive). The impact of CO_2 pricing can be observed in the CO_2 Price scenario, whereby relatively low CO_2 price level in the long term (20 USD/tonne) yields similar effect as the ambitious RE requirements (in line with the RE Strategy) mandated in the Stated Policies scenario. A significantly higher CO_2 price level (CO_2 Price High scenario), in turn, results in much less carbon-intensive power system, wherein investments in coal-fired capacity are minimal, and instead investments in other zero-carbon technologies take place (nuclear, coal CCS, MSW). Similar developments are observed in the No Coal scenario, with the notable difference of significant natural gas-fired generation capacity being added.

Figure 2-2: Total generation capacity across scenarios



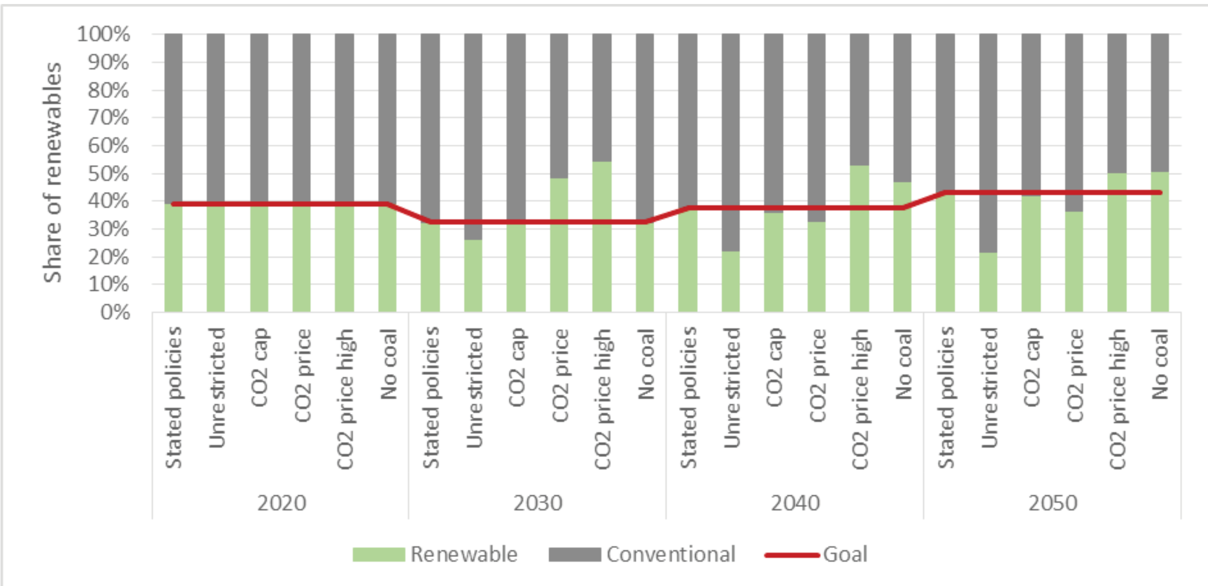
The impact of full-load hours of generation is evident, whereby the RE sources (most notably wind and solar) are less dominant in the generation landscape compared to the capacity mix; whilst the opposite is true for the traditionally baseload generation technologies (most notably coal and nuclear).

Figure 2-3: Power generation across scenarios, based on Balmorel model



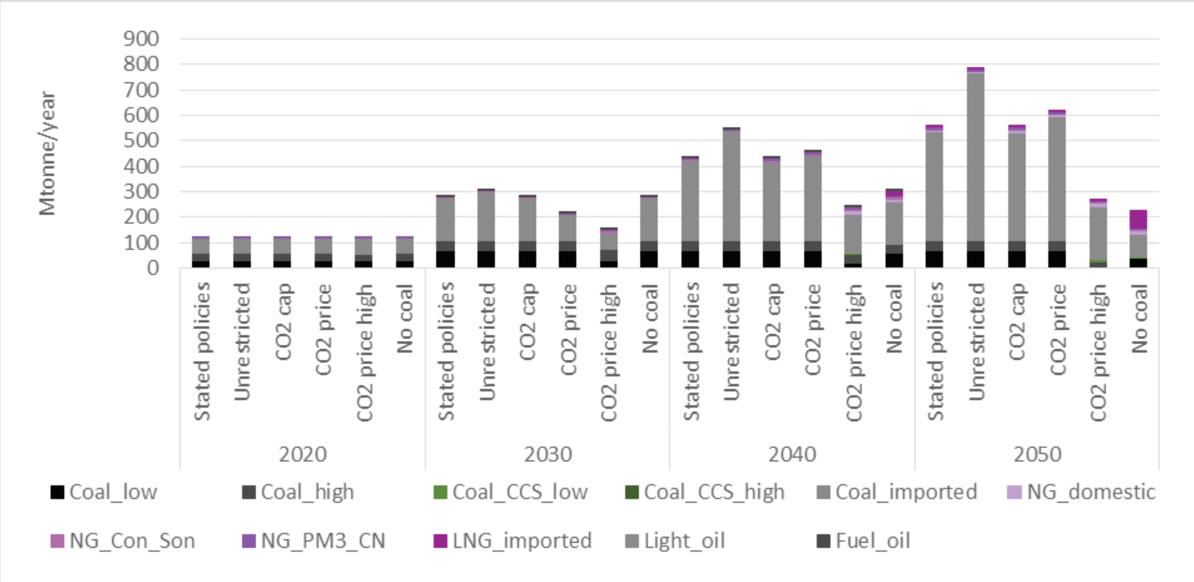
Stated Policies scenario, as expected, meets the RE targets exactly over time. Unrestricted scenario, in the absence of any environmental policies, fails to meet the RE Development Strategy goals beyond 2020, and the discrepancy keeps increasing throughout the projection period. CO_2 Price and CO_2 Cap scenarios both result in comparable RE shares to those attained in Stated Policies scenario in the long term. CO_2 Price High and No Coal scenarios, in turn, result in the highest shares of RE generation in the long term, significantly exceeding the targets set by the RE Development Strategy.

Figure 2-4: Renewable shares (including large hydro) across scenarios. The Goal represents the targets set by the RE Development Strategy



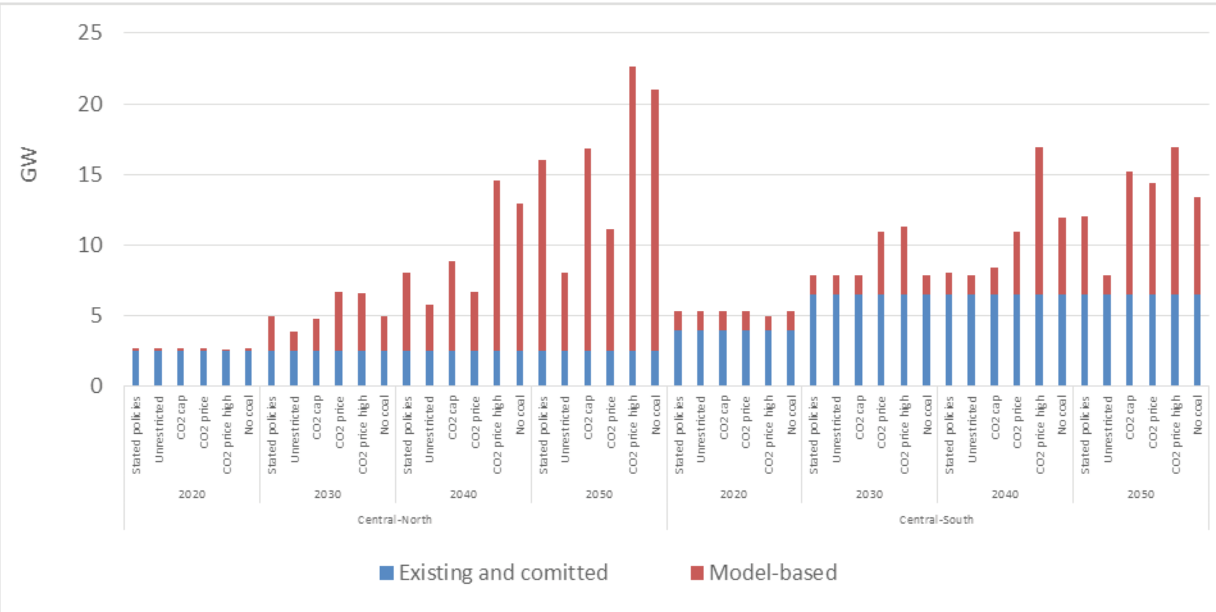
The Unrestricted scenario results in the highest CO_2 emissions, significantly exceeding the levels of Stated Policies scenario (and CO_2 Cap and CO_2 Price scenarios), while CO_2 Price High and No Coal scenarios after 2035 result in the most significant CO_2 emission reductions in the long term, respectively.

Figure 2-5: CO_2 emissions across scenarios, based on Balmorel model



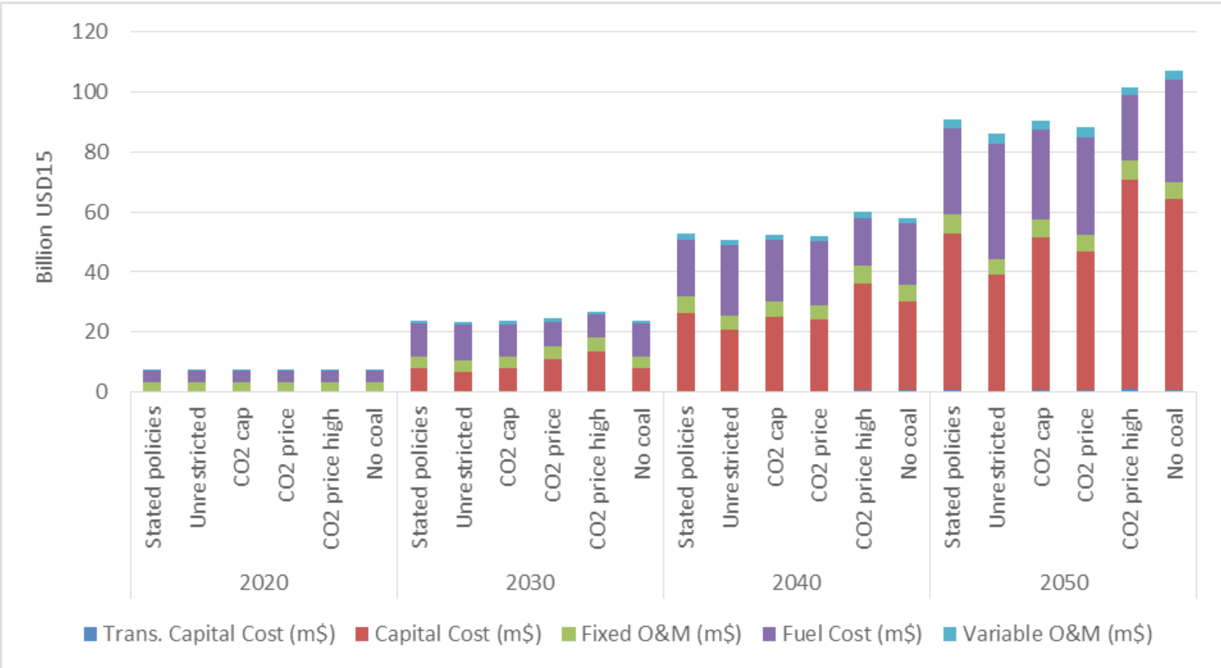
The scenarios featuring the least RE capacity investments (Unrestricted scenario) result in the lowest corresponding transmission capacity investments. The scenarios with the highest RE investments (both CO_2 Price scenario in 2030, and CO_2 Price High and No Coal scenarios from 2040 onwards) exhibit the highest transmission capacity investments, respectively.

Figure 2-6: Total transmission capacity across scenarios



Noticeably, the total system cost differences are relatively minor across a number of scenarios. For instance, in 2040, the Stated Policies scenario has a higher total cost than that of the Unrestricted scenario, with the difference of USD 2 billion (4%). In 2050, the corresponding value is USD 4.9 billion or 5.6% increase in costs. This can be interpreted as the additional annualized system cost for the implementation of the RE Strategy. The relatively little additional cost can be explained by the fact that while the Unrestricted scenario results in lower annualized generation capacity investment costs (Capital Cost) compared to Stated Policies, the latter realizes significant fuel expenditure savings (the higher investment-cost renewables, e.g. wind and solar PV, have no fuel costs).

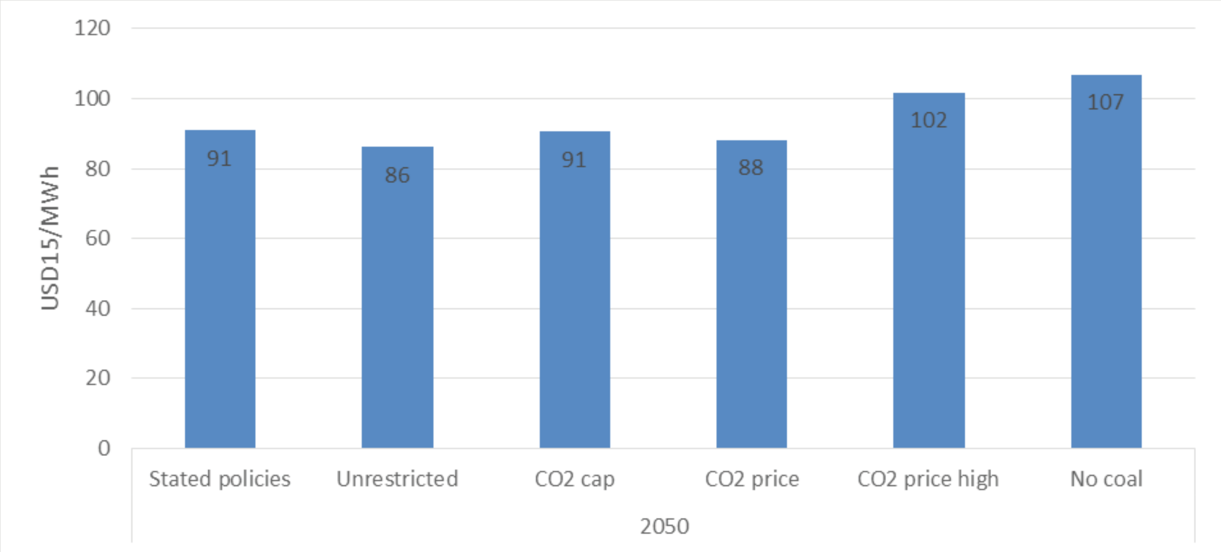
Figure 2-7: Total system costs per annum (capital costs for generation and transmission are annualized) across scenarios



CO_2 Cap and CO_2 Price scenarios appear to have very comparable total system cost levels to that of Stated Policies. It should though be noted that the CO_2 cap allows the Unrestricted scenario to have slightly lower total system costs than Stated Policies scenario (USD 0.38 billion in 2050), even though both scenarios achieve the expected CO_2 emission levels. On the contrary, CO_2 Price High and No Coal scenarios achieve the lowest CO_2 emission levels and the highest total system costs.

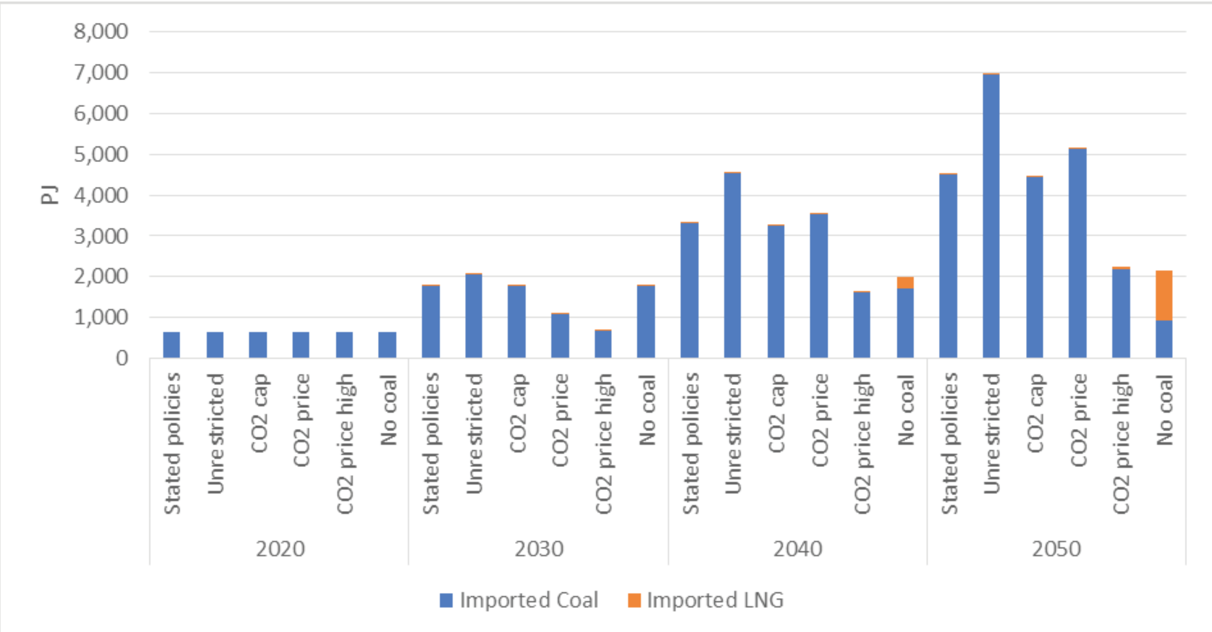
As expected, Unrestricted scenario produces the lowest cost per MWh. Stated Policies and CO_2 Price scenarios are very close, additional cost only comprising 4.9 and 2.1 USD/MWh, respectively. Imposition of a higher CO_2 price (CO_2 Price High scenario) and new technology coal-fired generation (No Coal scenario) result in higher power generation costs, exceeding the cost of the Unrestricted scenario by 16 and 21 USD/MWh, respectively.

Figure 2-8: Cost of generation across scenarios, total system costs per annum divided by total generation in 2050 based on Balmorel model



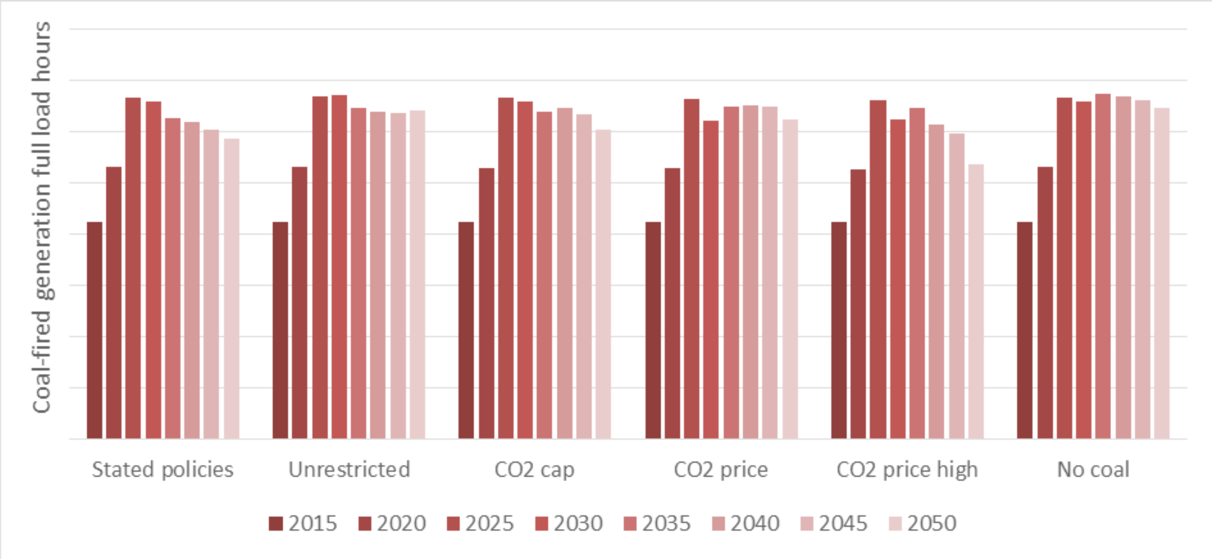
The results clearly indicate that absence of environmental policies (Unrestricted scenario) significantly increases the reliance on imported fuels. The most restrictive policy alternatives (CO_2 Price High and No Coal scenarios), in turn, result in the lowest volumes of imported fossil fuels, due to largest shares of the power demand being covered by domestic renewable resources. The below figure presents the volumes (in PJ) of coal and natural gas imports across the scenarios.

Figure 2-9: Imported coal and natural gas across scenarios, based on Balmorel model



In all of the scenarios except Unrestricted (where the RE penetration rate is low), the results illustrate the impact of increasing RE generation entering the system and thereby reducing the utilisation of the conventional coal-fired generation. The below figure provides an overview of the development in the full-load hours of coal-fired generation across the scenarios over time.

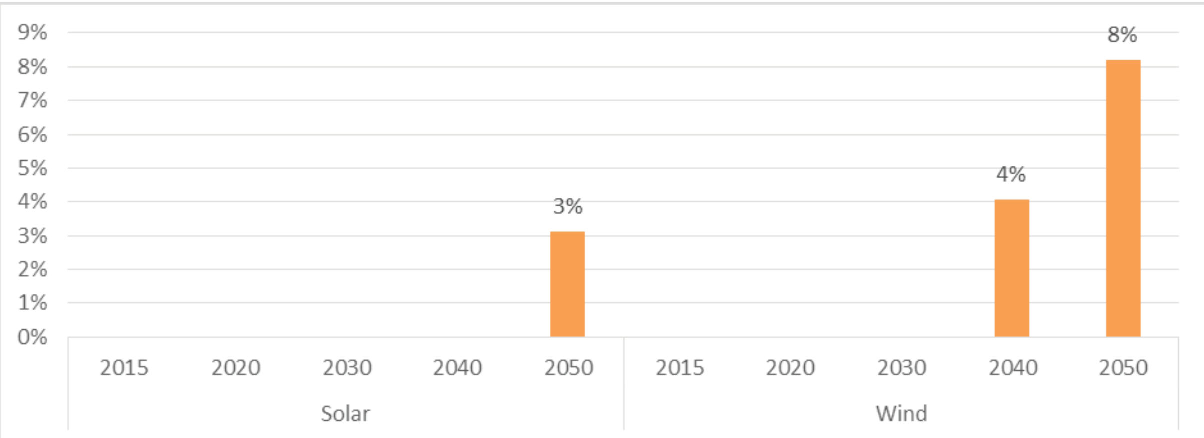
Figure 2-10: Full load hours for coal-fired generation across scenarios, based on Balmorel model



2.2 Integration of renewable energy into the power system

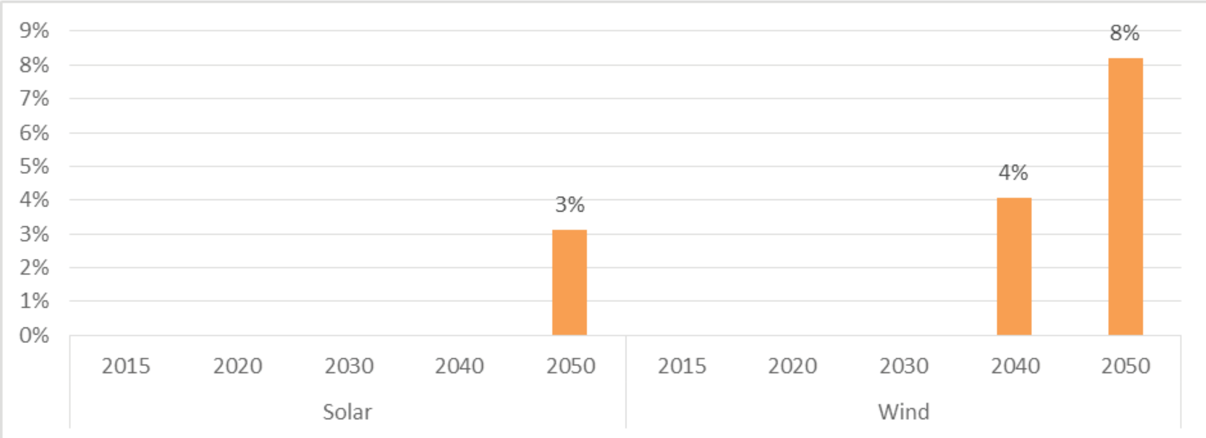
The below figure provides an hourly dispatch example for week 40 simulated in the Central region in year 2050 with unit commitment restrictions activated. The simulation illustrates in an example of a specific week how wind and solar generation is balanced by hydro production and gas-fired generation – at very high RE generation penetration rates.

Figure 2-11: Example of hourly dispatch with unit commitment activated. Balmorel modelling results for Stated Policies scenario in Central region, week 40, year 2050



The below figure summarizes the curtailment rates of wind and solar power in the hourly dispatch simulation version of the Stated Policies scenario (with unit commitment activated). The results indicate that curtailment is negligible until 2030 (and until 2040 for solar PV), despite the high total installed capacity levels in both generation technologies. The curtailment rates increase for wind power towards 2040 and 2050, reaching 4% and 8%, respectively, whereas the curtailment rate of solar PV generation stays at 3% in 2050.

Figure 2-12: Wind and solar PV curtailment rates in the hourly dispatch simulation of the Stated Policies scenario with unit commitment optimization



It should be noted that additional measures for RE integration could be undertaken, in addition to the ones employed in the model, e.g. demand response, electric storage technologies as well as increased interconnectivity and export to neighbouring countries; these could additionally improve the RE integration and thereby reduce the potential curtailment rates.

International experience

Historically, there have been concerns on the part of power system operators regarding the 'critical level' of RE generation share. In Germany in 1993 and Ireland in 2003 (where the current variable RE generation shares exceed 20% and 23%, respectively), the 'maximum' and 'critical' shares were deemed to be at 4% and 2%, respectively. The initial concern towards variable RE system generally can be associated with the notion of load not being controllable, hence fully controllable generation must be used to operate the system (and since variable RE sources are intermittent, they cannot be relied upon). However, given that the system operation already deals with variable and only partially predictable load, the same resources that balance load can also be utilised to integrate variable RE into the power system.

International experience suggests addressing the following issues at an early stage of RE generation integration (IEA, 2016):

- Ensure that the technical standards (grid codes or connection standards) for variable RE power plants are up to date and already contain appropriate provisions for technical capabilities that can become critical once variable RE comprises a larger portion of the generation fleet;

- Forecast production from variable RE using centralised forecast method and effectively use forecasts when planning the operation of other power plants and the grid;
- Ensure that system operators have access to real-time production data and that a sufficient share of variable RE generators can be controlled remotely by them (priority should be given to large-scale variable RE plants). This may require power market development as well as the installation of smart-grid hardware;
- Avoid unintended local concentrations of variable RE power plants, both in one region of a country as well as in certain parts of the grid within a given region, to avoid technical challenges in connection and operation in these regions.

Power systems with variable RE generation shares above 10% are increasingly common (over 50% in Denmark, 23% in Ireland, and 21% in the Iberian Peninsula), and these levels have been achieved predominantly by enhanced operation of the existing power system assets rather than significant additional investments. However, beyond a certain point, additional measures are needed, including investment in additional flexibility resources. Policy, market and regulatory frameworks have a critical impact on the success of RE integration. In addition, flexibility can also be provided by sources outside of the electricity sector e.g. electrification of transportation whereby electric vehicles can provide storage. The role of operational procedures should also be considered, e.g. by expanding the balancing area reduces the aggregate variability and consecutively the need for active balancing (IEA, 2016).

A common and important issue in RE integration is that of making the dispatchable fleet, especially coal-fired power plants, more flexible. Power plant flexibility is expressed in a number of capabilities: starting up production at short notice; operating at a wide range of different generation levels; and quickly moving between different generation levels (IEA, 2016).

The adaptations made in the power systems with the highest variable RE generation shares (Denmark, Germany and Spain) have largely been improvements in the way each system is operated, including more advanced market designs allowing for trading very close to real time, upgrades to thermal power plants to cope with more rapid swings in demand, and active use of interconnections where available. International experience also suggests that a comprehensive and systemic approach of this kind is the most cost-efficient and secure answer to system integration challenges, as opposed to viewing the role of variable RE in the power system in isolation. The latter perspective likens the variable RES as to 'traditional' generation sources by e.g. favouring addition of storage or dedicated power plants to balance RE generation. IEA analysis has demonstrated that the isolated approach results in 'significantly higher costs than a more system-wide strategy' (IEA, 2016).

The case of Denmark

System operation and the power market represent the two central pillars on which the successful Danish integration of wind power has been built (Danish Energy Agency, 2015):

- System operation with accurate wind forecasts and adequate reserve capacity for periods with little wind and a demand side that automatically adapts in situations where there is too little or excess production from wind power;

- A well-functioning power market – in which players trade themselves into balance, i.e. supply equals projected demand (intra-day market) and a market for balancing power (the regulating power market) operated by the TSO.

The increased amount of wind power has displaced some of the large central power stations and thus the system services these systems have changed. It therefore became necessary to make increased requirements regarding the connection of wind turbines and their system characteristics (such as low voltage fault ride-through capability, power and frequency control), which had previously been delivered from thermal power plants. Technical regulation must be in place in appropriate detail to ensure the physical grid functioning and system security. According to the Danish Energy Agency (2015), the transmission grid could be designed to require wind turbines to:

- Disconnect during abnormal voltage and frequency events;
- Remain connected to the grid in case of fault;
- Be controllable remotely;
- Curtail if necessary.

A strong transmission and distribution grid with strong interconnections to neighbouring power markets is an important element in large scale wind deployment. In the Danish case the interconnectors to Norway and Sweden are especially important as the interconnectors to these two countries make it possible to balance wind power and hydro power. When Danish wind turbines generate more power than required, surplus power is often transmitted to Norway or Sweden, which reduces the draw on the water reservoirs. When the wind calms down, the hydro power stations increase production, transmitting power to Denmark. Robust interconnections and an efficient market and cooperation between the Scandinavian TSOs have proved to be important in importing and exporting environmentally friendly power and in increasing the share of wind power in Denmark (Danish Energy Agency, 2015).

Accurate wind forecasting is becoming increasingly important as the share of wind power generation increases. One meter per second deviation in wind speed, and the corresponding unexpected sudden increase or decrease in wind power generation, may be quite noticeable as well as costly in the system. However, today's wind forecasts are so advanced that it is possible to estimate production with high certainty up to 36 hours prior to the actual production hour – although quite large prognosis errors can still occasionally occur (requiring balancing up to and within the hour of operation). Another important aspect is how the prognoses are used in the system operation. Every six hours the prognoses are updated due to new weather forecasts, and as the hour of operation approaches, the prognoses are also updated with real-time information (Danish Energy Agency, 2015).

2.3 Key conclusions of analyses of power source development scenarios using Bamorel model

RE integration

The analysis results indicate that it is possible to operate the Vietnamese electricity system with high levels of variable renewable energy. The dispatchable power sources could contribute to the system flexibility. The modest amount of curtailment (curtailment for solar PV and 4% curtailment for wind in 2040 in the Stated Policies scenario at 42 GW and 39 GW respectively in the system) indicates an efficient integration of wind and solar power in the system. Part of the reason for this is that all economic investment in cross-region transmission has been included which will contribute to accommodating the variable renewable energy.

Curtailment can be reduced further, e.g. with additional measures that presently have not been included in the analyses, like demand response and interchange with neighbouring countries.

Environmental policy alternatives

In the absence of environmental policies (Unrestricted scenario), the modelling results indicate a highly coal-dominated power system in Vietnam towards 2050, which does not meet the RE Strategy goals and features high levels of CO_2 emissions.

The Stated Policies scenario, which features the RE Strategy goals as a requirement, exhibits significant shares of wind and solar PV generation, and delivers CO_2 emission reductions at minor additional system cost. For instance, in 2040, the difference between Unrestricted and Stated Policies is USD 2 billion USD, or a 4% increase compared to the total costs of Unrestricted scenario. In 2050, the corresponding value is USD 4.9 billion or 5.6% increase in costs.

The above figure can be interpreted as the additional (annualized) system costs for the implementation of the RE Strategy. The relatively little additional cost can be explained by the fact that while Unrestricted scenario results in lower annualized generation capacity investment costs (Capital Cost) compared to Stated Policies scenario, the latter realizes significant fuel expenditure savings (the renewables, e.g. wind and solar PV, have no fuel costs).

The CO_2 cap allows the Unrestricted scenario to have slightly lower total system costs than Stated Policies scenario (USD 0.38 billion in 2050), even though both scenarios achieve the expected CO_2 emission levels. On the contrary, CO_2 Price High and No Coal scenarios achieve the lowest CO_2 emission levels and the highest total system costs.

It is a political decision whether these increases in cost are worth the outcome (lower emission levels). The analyses indicate how emission reduction can be achieved most efficiently, other things being equal.

Reliance on imported fuels

Absence of environmental policies (Unrestricted scenario) significantly increases the reliance on imported fuels, particularly imported coal. The most restrictive policy alternatives (CO_2 Price High and No Coal), in turn, result in the lowest volumes of imported fossil fuels required, due to largest shares of the power demand being covered by domestic renewable resources.

RE resource potential

This study provides land-based wind resource potential estimates based on the interim results of the wind resource mapping project supported by the GIZ in collaboration with the Danish Energy Agency, 'Macroeconomic Cost-Benefit Analysis for Renewable Energy Integration' (Ea Energy Analyses and DHI GRAS, 2017). Based on the preliminary results, significant feasible wind power potential is available in Vietnam (27 GW) – and further large potential (144 GW) is unlocked in the long term if siting restrictions on croplands are removed.

Competitiveness of RE system (wind and solar PV)

The results indicate that already in the medium-term (i.e. towards 2030) significant investments in wind power capacity (exceeding 2.7 GW) could take place in Vietnam on cost-competitive basis, provided the materialization of continued RE technology cost reduction and improvements. The cumulative capacity of cost-competitive investments in wind and solar PV by 2050 in the Unrestricted scenario reaches 30 GW and 25 GW, respectively.

Electricity demand growth

Whilst appreciating the high degree of uncertainty associated with making long-term projection of electricity demand, historical international perspective could be applied when evaluating the current power demand projec-tions for Vietnam that are characterised by continuous high growth rates also in the long term. Structural shifts (away from energy-intensive heavy industries and towards more service-based economy) as well as advances in energy efficiency (both in industry and buildings, as well as in household appliances and lighting), among other drivers, have contributed to a disconnect between power demand and GDP growth observed globally, once a certain level of economic development has been achieved. In Vietnamese context, this could warrant (potentially significantly) lower power demand growth rate projections towards 2050.

Power demand projections

The results indicate an extremely high impact of the demand projections on the eventual optimal power system setup and size. Both Stated Policies scenario and all of the demand projection variation scenarios (High, Low, Very Low) meet the required RE Strategy targets, but achieve this goal with very different total RE resources required (from 48 GW of wind and solar PV in Very Low Demand scenario by 2050 to 235 GW in High Demand scenario, respectively). The total capacity installed also varies substantially in response to the demand development planning assumptions applied. As expected, the demand projections have a direct impact on the total system costs as well, again emphasizing the importance of both the planning assumption selection, as well as the potential economic benefit of improving energy efficiency practices.

The demand projections also have a significant impact on the resulting CO_2 emission levels, thereby illustrating e.g. the potential environmental benefits of energy efficiency improvement measures.

Fuel prices

Fuel price assumptions are another powerful driver of the optimal power system setup. Provided lower natural gas prices, more gas-fired capacity and less coal-fired capacity (a decrease of 12.8 GW of imported coal-fired capacity compared to Stated Policies scenario in 2050) would be the least-cost solution system-wide, whilst maintaining the high shares of wind and solar PV generation. Materialization of a lower natural gas price development projection also results in lower CO_2 emissions, due to the natural gas-fired technologies being less carbon-intensive.

RE technology costs

The continuation of cost reductions in RE technologies would result in higher RE installed capacities (solar PV making up a much larger share thereof), whilst reducing coal-fired generation capacity in favour of gas-fired capacity. Low RE costs make solar PV in particular (but also wind) more cost-competitive relative to the other generation technologies, resulting in some RE capacity additions taking place purely on a competitive basis (e.g. in 2030 where the RE target is exceeded for the Low RE Cost scenario).

3 RECOMMENDATIONS

Legal framework in the power sector

In order to secure the energy supply sufficient capital for financing infrastructure investments must be ensured to keep up with the surging demand for energy.

In the revised National Power Development Planning for the period 2011 – 2020 with vision to 2030, the expected investment need of nearly US$10 billion for the period 2016-2030 is a major challenge for Vietnam. Moreover, the Government of Vietnam does not wish to make further direct investments in the sector while state-owned companies such as the Vietnam National Oil and Gas Group (PetroVietnam) and the Vietnam National Coal and Minerals Industry Group (Vinacomin), which have invested in power projects in the past, are expected to gradually reduce investment. There is a need for Vietnam to improve the legal framework as well as restructure the power sector, develop an appropriate policy for power tariff, and ensure a fair competitive environment to attract domestic and foreign private investors in power generation.

Power market development

A competitive power generation market is being implemented, in which power plants with the generation capacity of more than 30 MW (excluding renewable energy plants and BOT plants), must participate in this market.

Currently, 80% of the power is supplied on the basis of long-term PPA contracts, while the remaining is sold at the spot market. The large multi-purpose hydropower plants, which serve several functions including flood prevention and irrigation, operate at cost based prices revised on an annual basis by MOIT.

According to the Roadmap for power market development approved by the Prime Minister, the competitive wholesale power market is now being developed and expected to come into operation in 2019 and the competitive retail power market is expected to come into operation in 2023.The directions for market development set out in the roadmap for power market reform are important steps to secure funding of the infrastructure investments required in the power sector.

Mobilising energy efficiency potentials

Assessment on energy efficiency potentials shows that the energy savings in the period 2025-2035 could reach from 5.9% to 10.0%. As a result, such savings can meet the target of reducing the energy intensity by at least 1% per year as set forth in the Green Growth Strategy. A national program on energy efficiency in the coming time, if implemented, should follow the VNEEP 2. At the same time, it requires several changes to focus on quality of activities. The following policy mechanisms should be implemented:

Inter-sector area:

- Monitoring, implementing and assessing EE&C policies and measures;
- Developing strategies, programs, action plans;
- Developing the data collection system and target formulation.

Building sector:

- Enforcing mandatory building codes;
- Improving energy efficiency of the building envelope and systems inside the building;
- Implementing the green building evaluation systems.

Energy-use equipments:

- Improving the minimum energy performance standard (MEPS) and expanding the subjects of energy labeling;
- Creating markets for high performance energy equipments.

Industrial sector:

- Formulating energy benchmarks for some areas; developing the roadmap, action plan and technology transfer;
- Developing a monitoring and management system for energy consumption by production units, encouraging and step by step further enforcing compliance of advanced benchmarks of energy consumption per product unit;

Transportation sector:

- Developing the public passenger transportation system and mass passenger transportation system;
- Combining means of goods transportation, giving priority to development of mass transportation means which use fuel efficiently;
- Formulating and applying the standard for minimum fuel consumption;
- Promoting the use of bio-fuels.

RE development

Assessments show the need to implement supporting policies to achieve the targets of the RE Development Strategy in order to increase the share of RE in total primary energy consumption by about 31.0% in 2020; about 32.3% in 2030 and increasing to about 44.0% in 2050.

To realize the targets of the RE Development Strategy of Vietnam and the National Energy Development Planning, it is necessary to develop a **RE Development Program** to further specify and expand measures to promote RE development.

RE development policies will include the policy mechanisms mentioned in the RE Development Strategy, including:

- Formulating the RE market;
- Power tariff and investment secure policy;
- Obligation to ensure RE development via meeting the Renewable Portfolio Standard – RPS;
- Net Metering;
- Incentives and supporting policies for RE development and use, including: tax incentive (import tax and enterprise income tax), preferential land use, priorities for studies related to RE development and use;
- Environmental protection policy: environmental fee applicable to fossil fuels for develop**ment** of the Sustainable Energy Development Fund.

In addition, it is significant to implement various policy mechanisms to promote RE development:

- Legal framework:
  - Institutionalizing RE development to ensure long-term legal basis for mobilizing resources for RE development;
  - Developing the RE Development Program with specific measures in short term and medium term with specific assignment for state management agencies to promote RE development to achieve the set targets;
  - Establishing the RE development planning based on energy demand balance and potential of RE sources nationwide;
  - Developing national standards and norms on RE technologies and equipments to formulate a sustainable market for domestic RE industry development.
- Financial incentives:
  - Creating **a sustainable financial source for RE development** via funds from international donors, preferential loans from financial institutions and developing the capital market from commercial banks for RE development investments;
  - Developing the **RE certification mechanism** (Tax credit) including RE production or investment certificates.
- Defining the support mechanism:
  - Developing the **RE bidding mechanism** to set up separate criteria of competitive bidding for each type of RE technology to reduce RE prices. Besides, the fixed price for awarded projects is a guarantee for investors in the long term;
  - **Finalization of the fixed price mechanism: FIT** can be adjusted periodically for each type of RE to make it a drive to promote RE development. FIT mechanism should be evaluated at fixed periods to ensure an appropriate level of support to accomplish RE development targets at the lowest possible cost;

- o Considering development of flexible FIT mechanism to ensure the flexible change of FIT in accordance with the market price when the competitive power market is complete.

Integrated energy sector planning

Vietnam is in the process of building up an overall energy sector planning to optimize resources and costs of various energy sub-sectors. The planning should particularly be strengthened by the following measures:

- Strengthen the mapping of the energy demand on a geographical as well as a sector level for the purpose of forecasting energy consumption as well as to design and implement interventions to reduce or substitute energy;
- Strengthen the capabilities to forecast energy consumption in view of such factors as economic growth of the individual economic sectors, technology uptake and technology development, energy pricing etc.;
- Develop and update the energy efficiency potentials of all sectors of the economy. In an economy like the Vietnamese investing heavily in buildings and infrastructure, which lock in high energy consumption for many years, energy efficiency investment policies are of particular importance. This goes for all sectors including buildings, energy supply infrastructure and transport infrastructure;
- Further develop the database of RE potentials on a geographical scale, preferably in GIS format, to support planning for integration of RE sources;
- Further develop, train and transfer analysis tools in energy planning.

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ANNEXES

Annex Table 1: Results of final energy demand forecasts per fuel type – Baseline scenario

Item	Unit	2020	2025	2030	2035
Coal	KTOE	13,228	15,665	18,146	19,455
LPG	KTOE	2,289	2,925	3,803	4,611
Gasoline	KTOE	6,472	8,911	12,219	15,406
Airplane gasoline	KTOE	1,306	2,024	3,116	4,723
Kerosene	KTOE	87	112	128	127
DO	KTOE	11,744	15,206	18,592	20,188
FO	KTOE	1,609	2,043	2,454	2,630
Natural gas	KTOE	2,197	2,999	3,720	4,032
Electricity	KTOE	19,753	29,887	42,717	57,007
Renewable energy	KTOE	11,353	9,250	7,379	6,329
Total energy demand	**KTOE**	**70,039**	**89,023**	**112,273**	**134,508**

Annex Table 2: Results of final energy demand forecasts per sector – Baseline scenario

Item	Unit	2020	2025	2030	2035
Agriculture, forestry and aquaculture	KTOE	738	782	847	908
Industry and construction	KTOE	30,490	40,174	51,298	60,925
Services and commerce	KTOE	2,558	3,299	4,130	4,908
Residential	KTOE	17,198	19,144	22,186	26,394
Transportation	KTOE	16,927	23,239	30,663	36,929
Other	KTOE	2,129	2,385	3,150	4,445
Total energy demand	**KTOE**	**70,039**	**89,023**	**112,273**	**134,508**

Annex Table 3: Results of final energy demand forecasts per fuel type – Proposed scenario (TOE)

	2020	2025	2030	2035
Coal	12,586	13,844	14,381	14,147
LPG	2,094	2,902	3,669	4,563
Gasoline	5,608	7,126	8,028	8,815
E5 gasoline	294	787	2,658	4,121
Airplane gasoline	1,306	2,024	3,116	4,723
Kerosene	59	66	72	73
DO	10,928	13,651	16,104	15,832
Biological DO	-	194	597	1,921
FO	1,562	1,957	2,354	2,496
Natural gas	2,147	2,947	3,647	3,936
Electricity	19,053	28,130	39,615	51,798
Non-commercial biomass energy	11,412	9,582	8,377	8,057
Biogas	146	513	556	593
Total	**67,198**	**83,728**	**103,173**	**121,075**

Annex Table 4: Results of final energy demand forecasts per sector – Proposed scenario (TOE)

	2020	2025	2030	2035
Agriculture	708	734	777	813
Services	2,273	2,837	3,503	4,191
Transportation	15,858	21,468	28,141	33,309
Households	16,514	17,765	19,331	22,611
Industry	29,716	38,539	48,271	55,706
Other	2,129	2,385	3,150	4,445
Total	**67,198**	**83,728**	**103,173**	**121,075**

Danish Energy Agency

LCEE LOW CARBON TRANSITION IN THE ENERGY EFFICIENCY

Vietnam-Denmark government cooperation in the energy sector