THAILAND ENERGY OUTLOOK 2016

MINISTRY OF ENERGY

Thailand Energy Outlook 2016

Policy and Strategy Management Office, Office of the Permanent Secretary

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Introduction

Fluctuations of world's economy and energy prices, political conflicts, and environmental impact are among the most significant factors affecting energy consumption and provision. Thus, the conventional approach of relying merely on GDP growth for energy planning is insufficient. Scenario approach therefore become inevitable for government agencies, private companies, and academicians. Although scenario method is not wholly accurate, it can give a clearer sense of the coming future and how to handle the expected obstacles.

The content of TEO2016 includes energy's current and future state analysis and forecast for primary source of energy such as petroleum, electricity, coal and alternative energy. In addition, scenario modeling would illustrate the picture of Thailand's energy sector from 2014 to 2036. This analysis was compiled in 2015 based upon the data of 2014. The first scenario is Thailand Integrated Energy Blueprint (TIEB) that reflects the objectives to be achieved within 2015-2036 timeframe. The other scenario is Possible Risk (RISK) scenario that reflects possible risks that can prevent the TIEB to realize its goals by taking negative views based on likelihood of occurrence in the future. Such scenario illustrates the plausible risks and impacts so that Thailand can prepare for the possible obstacles promptly and appropriately.

Policy and Strategy Management Office
Office of the Permanent Secretary
2016

The Future of Thailand's Energy Sector

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The Future of Thailand's Energy Sector

There has been a significance change in energy sector in the previous year. The reasons include stumbling oil and coal prices due to excess supply and economic volatility, the production of natural gas from shale and the growth of liquefied natural gas (LNG) market, and the technological development and increasing availability of renewable energy. Still, the infrastructure of energy demand and provision has not remarkably shifted yet as fossil fuels is still the world's main energy supply.

The ever-changing factors from both international and domestic levels have inevitably affected Thailand's energy sector. Such factors, varying from the decreasing oil and coal prices to the increasing use of LNG, have made the appropriate provision planning even more essential. Ministry of Energy had prepared the Thailand Integrated Energy Blueprint (TIEB) during the fourth quarter of 2015 by taking both energy consumption and resource management into consideration. Ministry of Energy also revised Energy Efficiency Plan (EEP), Alternative Energy Development Plan (AEDP), and Power Development Plan (PDP) to be more integrated and to be based on the same basis. In addition, Oil Plan and Oil Plan have been also produced in order to complete the whole dimension of energy planning. The three main objectives (Figure 1) include:

1. **Energy Security** - Energy supply and allocation have to be in line with economic, population and urban boundary growth.
2. **Economy** - Energy pricing restructuring has to be adjusted to optimal point to balance cost and benefit so that it would not obstruct the economic and prevent over-usage of the nation's energy reserve.
3. **Ecology** - The increasing usage of renewable energy and the development of more efficient technologies can lead to lower impact on the environment and communities.

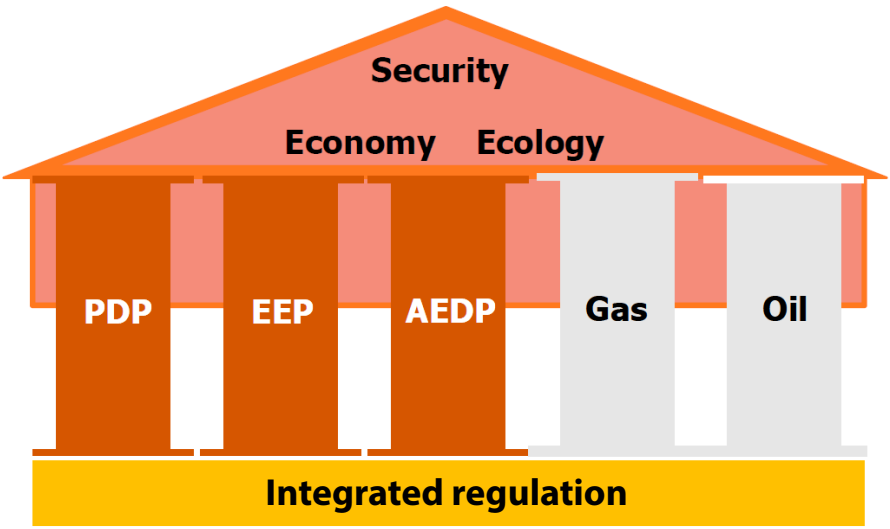

Figure 1 : The Concept of Thailand Integrated Energy Blueprint (TIEB)

The direction of the TIEB is in line with both domestic and international situations. The fact that Thailand relies heavily on imported energy along with economic growth makes it vital for us to focus on renewable energy. Thailand's reliance on fossil fuel, especially natural gas, is as high as 70 percent of Total Primary Energy Supply (TPES) for electricity generation making diversification sources of energy supply to become essential. In addition, world's coal price has been continuously declining and the development of clean coal technology has made coal to become, once again, important for Thailand's energy sector like many other ASEAN countries. Moreover, Thailand experiences a positive sign of energy provision improvement in order to support consumption growth from joining the ASEAN community.

However, the key success factor to achieving the Thailand Integrated Energy Blueprint's objectives is its implementation. The challenges are that the energy sector requires contribution from many different stakeholders and various risks including world's oil price fluctuation, continuation of government's policy, domestic energy infrastructure development, and the participation of private sector. Hence, two scenarios are employed to illustrate the case as shown in Figure 2. One scenario is Thailand Integrated Energy Blueprint (TIEB) that accentuates the integration of different energy policy plans while another scenario is Possible Risk (RISK) scenario that includes plausible risks obstructing the plan's realization.

Thailand Integrated Energy Blueprint (TIEB)	Possible Risk (RISK)
• Thailand Integrated Energy Blueprint (TIEB) that accentuates the integration of different energy policy plans • Goals are set based on the challenges of Energy Efciency (EE) developement and production capacity in practice • Commercialized technology development that yields economic benets and likely to be enhanced in the future is the focus point	• A scenario that reflects possible risks preventing the TIEB to achieve its targeted objectives • Negative impacts from problems and obstacles are taken into account • Risks are calculated based on impact level and likelihood of each factor occurring

Figure 2 : Definition and Description of Thailand's Future of Energy Sector Scenarios

The concept of RISK scenario is to reflect possible risks that might obstruct the TIEB to achieve its targeted objectives. Negative impacts from problems and obstacles are taken into account by experts in various areas of study. Such risks are calculated based on impact level and likelihood of each factor occurring.

Assumptions for Thailand's Future of Energy Sector Scenario

1. Thailand Integrated Energy Blueprint (TIEB) Scenario

Thailand Integrated Energy Blueprint (TIEB) scenario reflects the goals to be achieved between 2015 and 2036 to be in line with the National Economic and Social Development Plan. The five energy related plans include the Energy Efficiency Plan (EEP), Power Development Plan (PDP), Alternative Energy Development Plan (AEDP), Oil Plan and Gas Plan with a summary of each plan's concepts[1] and assumptions as illustrated in Table 1.

[1] Thailand Integrated Energy Blueprint 2015 – 2036, Policy and Strategy Management Office, Ministry of Energy.

Table 1 : Summary of TIEB's Assumptions

	Objective	Policy	Assumption
Energy Efficiency Plan (EEP)	To decrease energy intensity to 30% of final energy consumption compared to 2010 (Figure 3) by 2036	• More strict policies and law enforcement • Incentive schemes including pricing mechanism, tax, and investment promotion • Transportation development policy improvement	Energy intensity decrease by sectors: • Transport by 58% (including rail systems) • Industry by 29% • Public and Private real estate by 8% • Residential by 4%
Alternative Energy Development Plan (AEDP)	To increase alternative energy usage allocation to 20% by 2036	• Area-based management in order to achieve the most efficiency such as energy crop zoning and waste management • Focus more on local production and consumption such as net-metering • Focus on integration and engagement of stakeholders	To improve renewable energy (Figure 4) • Renewable energy for electricity generation • Renewable energy for heat • Biofuel

	Objective	Policy	Assumption
Power Development Plan (PDP)	To improve electricity generation capacity to be sufficient with future consumption by taking cost, environmental impact and stability into account	• Consider the impacts from Energy Efficiency Plan, Alternative Energy Development Plan, and natural gas reserve in order to increase electricity generation capacity in the future • Allocate sources and types of energy by reducing the reliance on natural gas, while increasing renewable energy, clean coal and energy import from neighboring countries (Figure 5)	• Include Energy Efficiency Plan's result in electricity demand forecast • Under a condition of electricity reserve being not less than 15% • Capacity is accordingly with Power Development Plan 2015 (electricity from natural gas 37%, coal 23%, renewable and hydropower 20%, energy import 15%, nuclear power 5% in 2036)

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	Objective	Policy	Assumption
Gas Plan	Natural gas usage management and provision to be sufficient with future demand	• Reduce natural gas for electricity generation and improve on energy saving policy for industrial sector • Manage concessions that are about to expire • Improve current sources and explore new ones both domestically and internationally • Develop LNG terminal to meet future demand	• Include the impacts of Energy Efficiency Plan and natural gas reliance reduction in the Power Development Plan in order to limit the declining rate of domestic natural gas production to 2-5% annually (compared to former 11% a nnually) • Natural gas reserve at 2P (P1+P2) level. • Natural gas import through pipes is accordingly with plan • Import LNG in case of insufficient natural gas

	Objective	Policy	Assumption
Oil Plan	Manage both petroleum consumption and provi sion to be at the optimal level, and hedge the external risks at the same time	• Petroleum type management and LPG and NGV pricing restructure • Improve oil quality standard • Develop oil pipeline transport • Consider strategic plan for oil reserve	• The consumption allocation for biofuel and renewable energy increase accordingly with Alternative Energy Development Plan while the consumption of LPG and NGV decreases • No growth of oil refinery capacity within the plan's period (before 2036)

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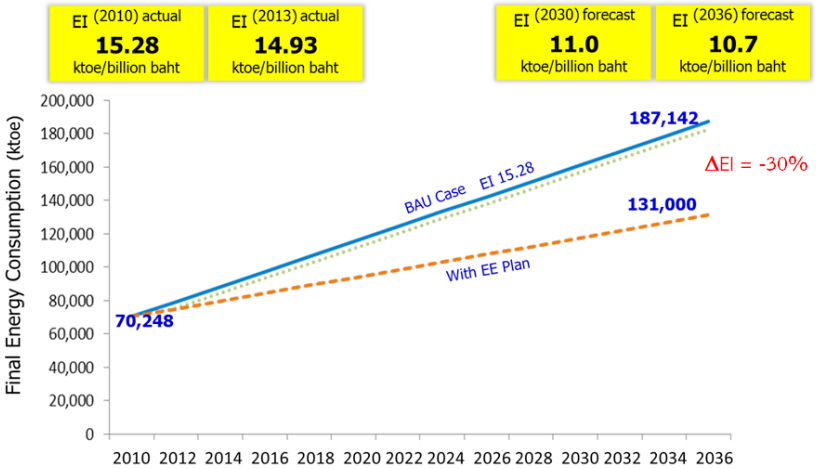


Figure 3 : Energy Efficiency Plan 2015

Energy Type	Status (end of 2014)*	Target (2036)
Electricity	MW	MW
1. Solar	1,298.51	6,000
2. Biomass	2,457.82	5,570
3. Wind	244.47	3,002
4. Large Hydropower	-	2,906.40
5. Biogas (energy crop)	-	680
6. Biogas	311.50	600
7. Municipal Solid Waste	65.72	500
8. Industrial Waste	-	50
9. Small Hydropower	142.01	376
Total	4,494.03	19,684.40
RE for electricity generation ratio (%)	9.41%	20.11%

* Large hydro is not included

(a) Renewable energy for electricity generation

Energy Type	Status (end of 2014)	Target (2036)
Heat	ktoe	ktoe
1. Solar	5.12	1,200
2. Biomass	5,184	22,100
3. Biogas	488.10	1,283
4. Municipal solid waste	98.10	495
5. Other Alternative Energy*	-	10
Total	5,775.32	25,088
RE for heat generation ratio (%)	17.28%	36.67%

* Such as Geothermal, Pyrolysis oil from used tires

(b) Renewable energy for heat

Energy Type	Status (end of 2014)		Target (2036)	
Biofuel	ML/d	ktoe	ML/d	ktoe
1. Solar	3.21	872.88	11.3	2,103.50
2. Biomass	2.89	909.28	14.0	4,404.82
3. Biogas	-	-	0.53	170.87
4. Municipal solid waste	-	-	4,800	2,023.24
5. Other Alternative Energy*	-	-	-	10
Total	-	1,782.16	-	8,712.43
RE ratio (%)	6.65%		25.04%	

* Such as Bio-oil, Hydrogen

(c) Biofuel

Figure 4 : Alternative Energy Development Plan 2015

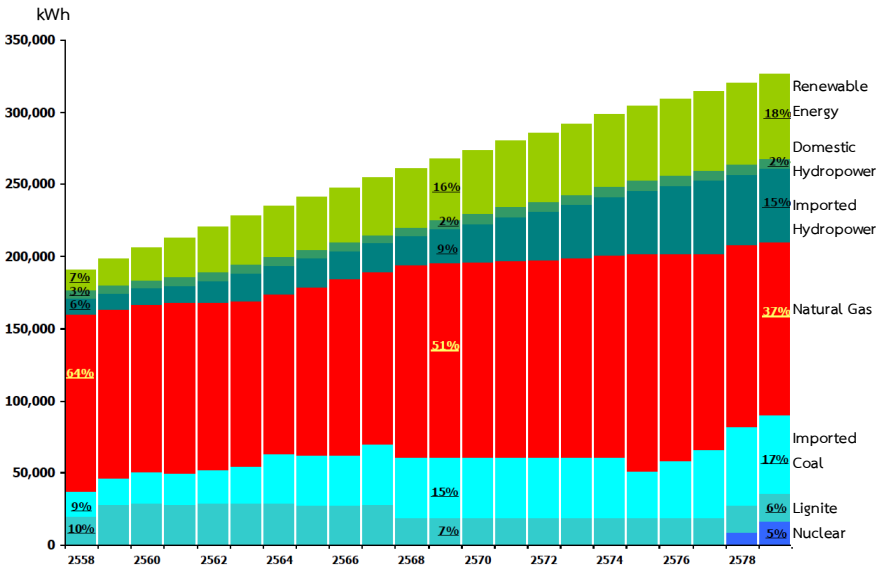


Figure 5 : Sources of Electricity Allocation of Power Development Plan (PDP)

If Thailand can successfully enforce and implement the Thailand Integrated Energy Blueprint (TIEB), various positive impacts will occur such as nationwide energy cost reduction and less reliance on energy import resulting in higher disposable income to invest in improving energy pipeline and related infrastructure as illustrated in Figure 6. Also, more jobs will be created for local people as well as the decrease in carbon dioxide emission. Primarily, investment from energy sector will inject as much as 500,000 million Thai baht each year to the economy as shown in Figure 7.

Cost Saving	● Reducing energy consumption by 842,130 million baht per year on average ■ Reducing electricity plant development by around 10,000 MW ■ Reducing transport energy consumption ○ Gasoline of 30 million liters per day (forecasted 47 ML/d in 2036) ○ Diesel of 46 million liters per day (forecasted 77 ML/d in 2036) ○ LPG of 9 million kilograms per day (forecasted 35 ML/d in 2036) ○ Natural Gas of 434 million cubic feet per day (forecasted 1,034 MSF/d in 2036) ● Reducing oil transport through pipelines by 1,351.06 baht per million liter -
Import Reduction	● Reducing fuel import by using alternative energy around 512 billion baht per year ● Reducing LPG import by 14 billion baht per year ● Reducing LNG import by 40 billion baht per year * Ethanol 11 million liters per day (gasoline 17 million liters per day) * Biodiesel 14 million liters per day (diesel 31 million liters per day)
Investment	● Creating investment of 1.22 trillion baht (AEDP) ● Creating power plant and infrastructure investment of 6.4 trillion baht (PDP) ● Creating gas infrastructure investment of more than 1 trillion baht (Gas Plan) ● Creating oil pipeline investment of 64,768 million baht (Oil Plan)
Employment	● Creating employment with the value of 24,400 million baht per year ● Agriculture money circulation of 80,000 million baht per year
Environment	● CO2 emission reduction of 177 million tons (EEP) ● CO2 emission reduction of 140 million tons (AEDP)

Figure 6 : Thailand Integrated Energy Blueprint's Impact

Investment and Money Injected to the Energy Sector from 2015-2017

Sector	2015 Gov**	2015 Private	2015 Total	2016 Gov**	2016 Private	2016 Total	2017 Gov**	2017 Private	2017 Total
1. Electricity									
- EGAT	42,075	-	42,075	67,125	-	67,125	81,958	-	81,958
- PEA	17,566	-	17,566	19,357	-	19,357	25,681	-	25,681
- MEA	16,654	-	16,654	22,277	-	22,277	28,000*	-	28,000
- IPP/SPP	-	81,104*	81,104	-	76,681*	76,681	-	35,716*	35,716
2. Petroleum									
- E&P***	51,372	170,244	221,616	78,120	179,892	258,012	76,068	181,512	257,580
- PTT****	40,000*	-	40,000	50,839	-	50,839	67,514	-	67,514
3. Renewable Energy	1,482	55,877	57,359	1,412	66,828	68,240	2,000	56,562	58,562
4. Energy Conservation	8,892	4,000	12,892	8,047	9,000	17,047	8,000	9,000	17,000
Total	178,041	311,225	489,266	247,177	332,401	579,578	289,221	282,790	572,011

Note : * preliminary estimation
** Gov. = Government budgets consist of energy conservation fund, enterprise budget, and national oil company
*** E&P = Exploration and Production
**** PTT and companies that PTT holds 100% shares

Figure 7 : Investment and Money Injected to the Energy Sector from 2015-2017

2. Possible Risk (RISK) Scenario

Possible Risk (RISK) scenario reflects risks that can prevent the TIEB from realizing its goals. Negative views that are likely to emerge are included to estimate impact level and likelihood of each factor. Such risks are as follow:

1) Energy Efficiency Plan

Based on the evaluation of related problems that can occur, critical risks for Energy Efficiency Plan is pricing policy and the management and enforcement of regulations for transport sector. The reasons are that more than 58% of the plan's overall goal is towards developing efficiency for transportation purpose and that many of the related stakeholders are outside of Ministry of Energy's authority. Moreover, there are uncontrollable risks such as energy price fluctuations, resistance from organizations that are affected by tax policies, and slow rail system development due to local citizen's lack of understanding for instance. Another critical risk is policy and law enforcement such as building standards, energy management for buildings and factories, and assistance for new commercialized technology (Figure 8).

When factoring[2] in impact level[3] and likelihood, different related risk determinants can affect the Energy Efficiency Plan as much as 46%. However, despite the risk that could emerge, Thailand's energy capacity development will manage to continuously grow.

[2] Evaluated based on sub-policies under Energy Efficiency Plan

[3] Evaluated by energy sector experts

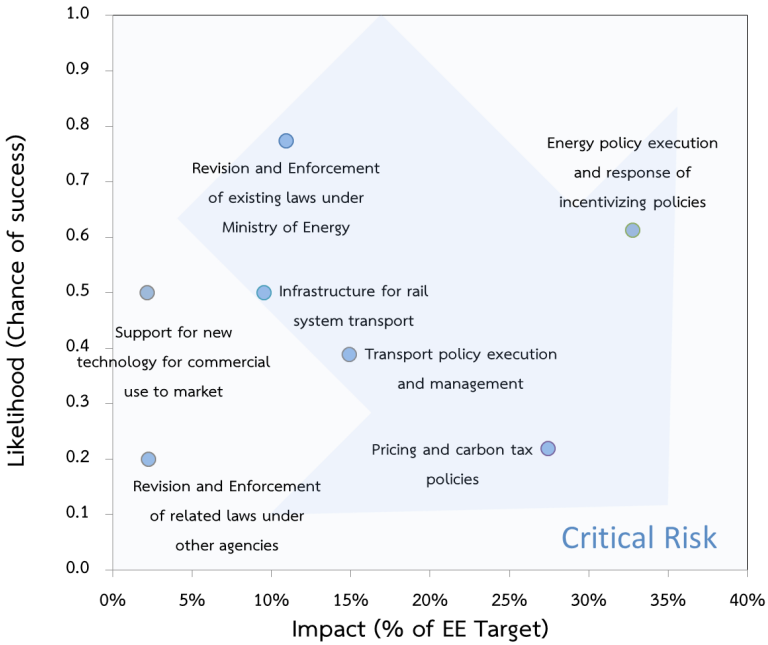


Figure 8 : Impact and Likelihood of Success for Each Policy Under Energy Efficiency Plan

2) Alternative Energy Development Plan

Based on the evaluation of related problems that can occur, the first critical risk for Alternative Energy Development Plan is raw material provision for biofuel production which accounts for 65% of the whole plan. The key factor is the area-based management such as zoning and incentive for growing energy crops. The process would involve a lot of agricultural stakeholders' commitment. The allocation between different sources of biofuel and the crops' price fluctuations also inevitably increase the risk level (Figure 9).

Another risk factor is the effect of fluctuating oil prices that touches upon biofuel sector, technological development and waste management while solar and wind power are considered to be unstable. When factoring[4] in impact level[5] and likelihood, different related risk determinants can affect the Alternative Energy Development Plan as much as 44%.

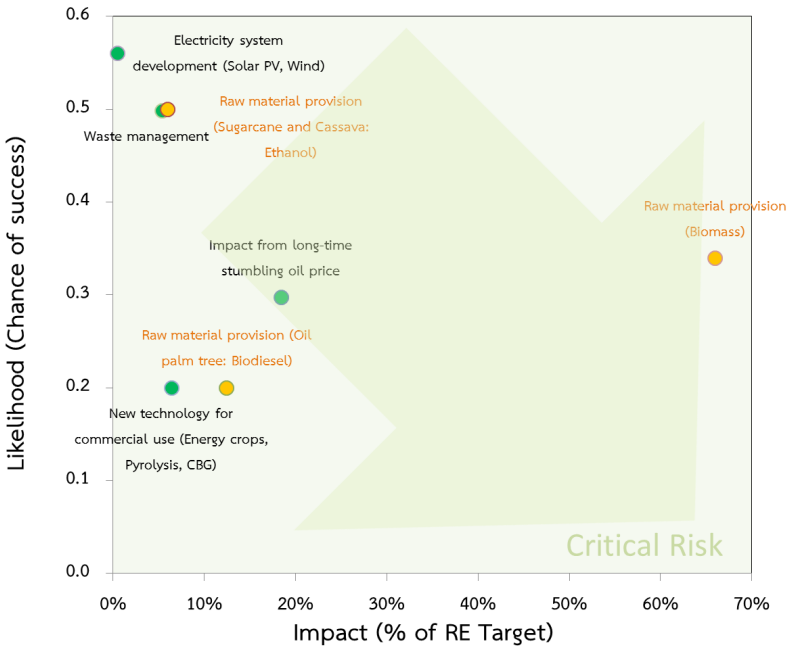


Figure 9 : Impact and Likelihood of Each Policy Under Alternative Energy Development Plan

[4] Evaluated based on sub-policies under Alternative Energy Development Plan

[5] Evaluated by energy sector experts

3) Power Development Plan

Based on the evaluation of related problems that can occur, critical risks for Power Development Plan is coal power plant development. Although Thailand's policy on reducing the reliance on natural gas has made coal power plant become more essential, there is still resistance from the people and private sector that obstructs the planned development (Table 2).

Possible Risk scenario then opts for natural gas for future plants in the areas that resistance persists. Another factor is the sluggish development of nuclear power plant. Import energy also bears some risk from the possibility of international level conflict. Possible Risk scenario therefore needs to include natural gas power plant in order to maintain the reserve margin of no less than 15%.

Table 2 : Possible Risk (RISK) for Power Development Plan

Alternative	Risk Level	Assumption
Electricity Import	Low	Be able to connect the network with neighboring countries as much as 80% of the goal
Coal Power Plant	High	• Coal power plant in the South (Krabi and Thepa) cannot be developed while Mae Mo is finished as planned • Newer coal power plant whose location is to be announced can achieve 50% of the goal
Nuclear Power Plant	High	Nuclear power plant cannot be developed

4) Gas Plan

Based on the evaluation of related problems that can occur, critical risks for Natural Gas Plan range from exploring new sources of petroleum, managing the concessions that are about to expire, to natural gas import from Myanmar and LNG terminal development to meet excess demand in the future (Table 3).

Possible Risk scenario then assumed that management of soon to be expired concessions to be 80% and natural gas import from Myanmar and new source exploration to be at 50% risk level6.

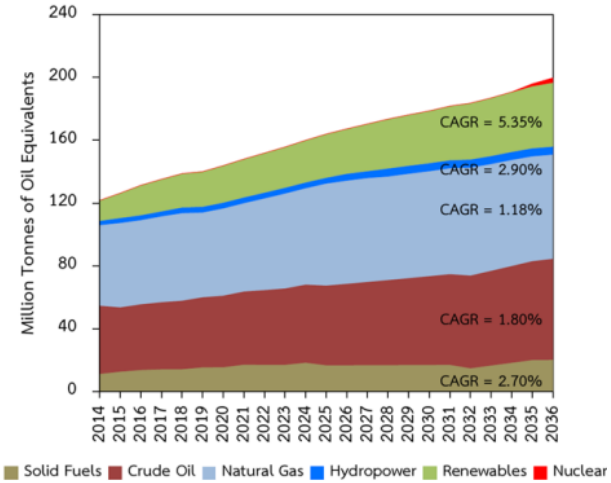
Table 3 : Possible Risk (RISK) for Gas Plan

Alternative	Risk Level	Assumption
Manage concessions that are about to expire	Low	Be able to achieve at least 80% of the goal
Improve current and explore new sources	Medium	Be able to achieve at least 50% of the goal
Narural Gas Import from Myanmar (Yadana, Yetagun and Zawtika)	Low	Energy import decreases as forecasted and there is a chance of abnormality that natural gas miss the forecast (80% of the goal)

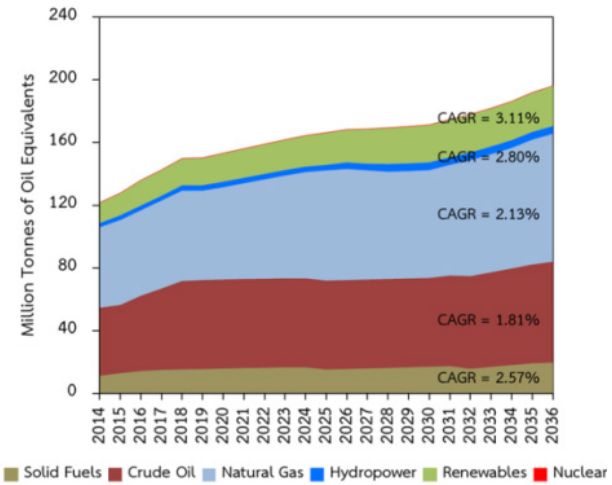
[6] Evaluated from the definition of probable reserve (P2) with likelihood of 50%

3. Primary Energy Demand

Figure 10 illustrates Thailand's primary energy demand that tends to be on the rise in the future both for Blueprint (TIEB) and Possible Risk (RISK) scenarios. Crude oil and natural gas are still the main sources of Thailand's primary demand especially for transport and electricity generation. However, alternative energy has also increased due to the Alternative Energy Development Plan. The growth of each type of primary energy demand (Figure 11) between 2014 and 2036, crude oil demand increases at 1.8% per year on average for both scenarios, while natural gas would grow at only 1.18% per year on average for Blueprint and 2.13% per year on average for Possible Risk as natural gas is still essential under the TIEB. As for renewable energy, the growth is remarkable at 5.35% and 3.11% per year on average for Blueprint and Possible Risk respectively which is in line with the Alternative Energy Development Plan and the world's trend of rising climate change awareness. In addition, increasing renewable energy demand has also become an alternative to solve Thailand's energy sector problem especially in reducing the reliance on crude oil and excessive natural gas for electricity generation import. However, the development of renewable energy market has many limitations so it cannot completely replace fossil fuel. Thus, oil and natural gas will remain their dominance in Thailand's primary energy demand while nuclear energy could be another option in the long future.

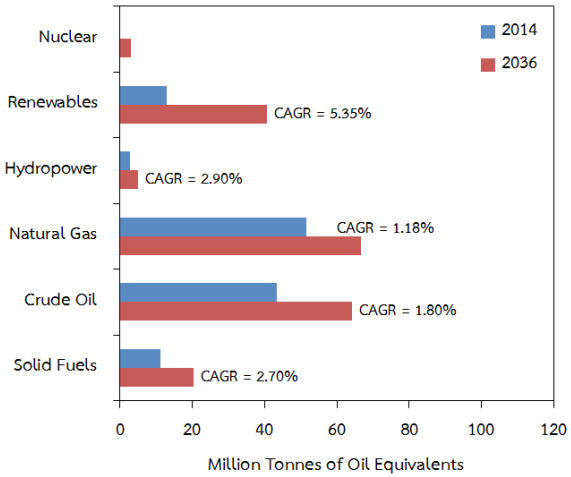


(a) Blueprint (TIEB)

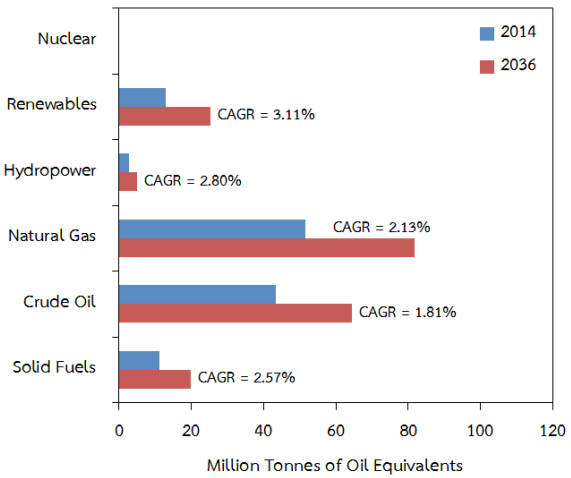


(b) Possible Risk (RISK)

Figure 10 : Primary Energy Demand



(a) Blueprint (TIEB)



(b) Possible Risk (RISK)

Figure 11 : Primary Energy Demand by Energy Type

4. Final Energy Demand

Final Energy Demand (Figure 12) has shown that transport and industrial consumes the most energy for both Blueprint (TIEB) and Possible Risk (RISK). Especially for transport sector that relies largely on petroleum products regardless of the rising consumption of bioethanol and biodiesel. Electricity consumption, especially for rail system, has increased but still accounted for a small portion of overall transport consumption. Although the consumption of every type of fuel increases due to economic growth, petroleum products tend to grow at slower rate due to the price fluctuations. As for residential use, the growth rate is the lowest compared to other sectors due to slower pace of population and household growth in the long-run. Firewood and charcoal consumption is on declining trend while Liquefied Petroleum Gas (LPG) and electricity show increasing trend. Also, agriculture sector still has to rely on diesel for machinery. As for Possible Risk (RISK) scenario, the result shows that final energy consumption has to rely largely on petroleum products just like at the present.

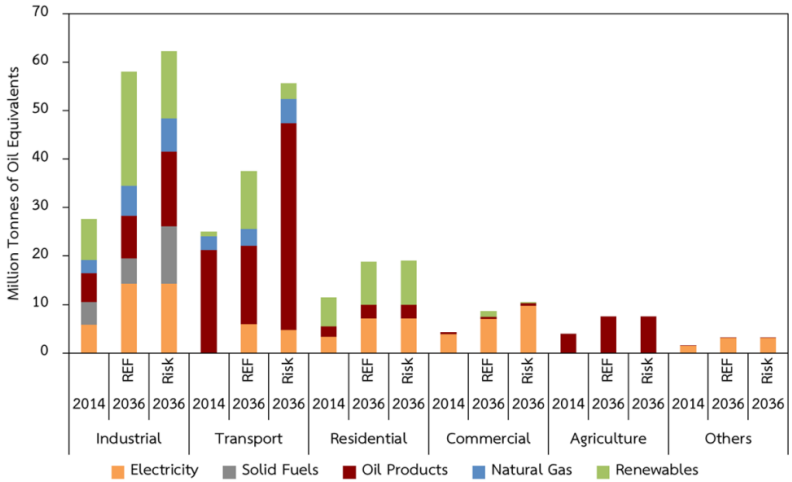
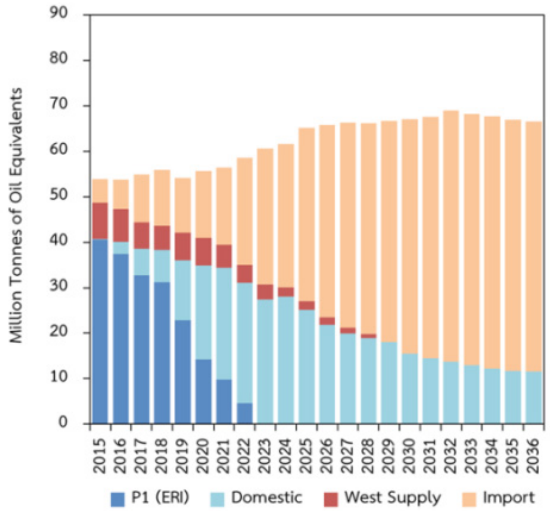


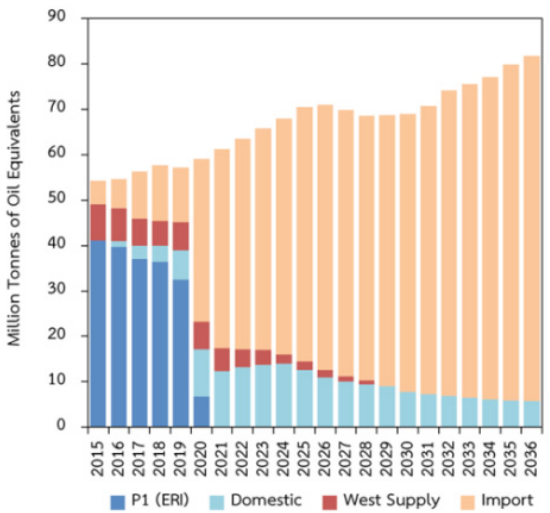
Figure 12 : Final Energy Consumption

5. Net Energy Import and Petroleum Import

Thailand's Future of Energy Sector scenario was based on meeting energy consumption demand thus natural gas has been included. Natural gas provision comes from three sources including 1) Domestic, 2) Import from Myanmar, and 3) LNG import. Domestic source is evaluated by modeling in addition to concession management and energy reserve expansion (Gas Pan). Hence, LNG import is calculated by total natural gas demand minus by domestic source and import from Myanmar (Figure 13a and b).



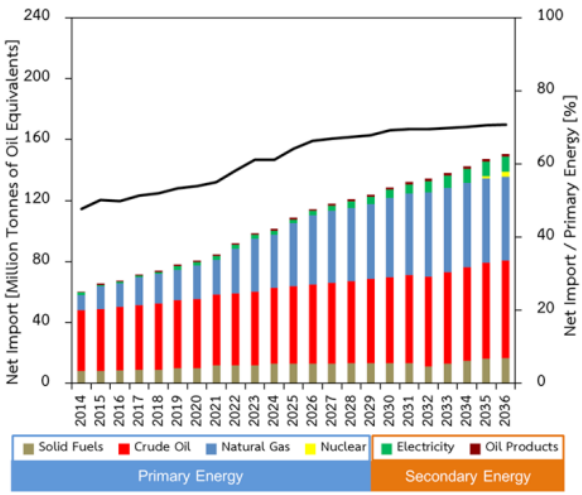
(a) Blueprint (TIEB)



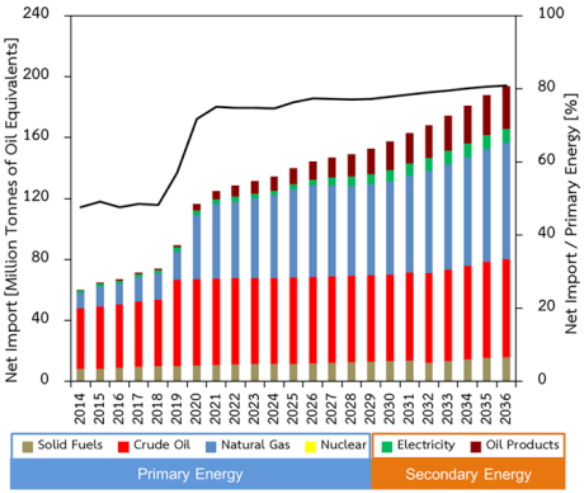
(b) Possible Risk (RISK)

Figure 13 : Natural Gas Provision

With continuously increasing demand along with limitations of domestic energy sources, the trend of energy import of any type has been on the rise as shown in Figure 14a (net import contributed 50% of 2014 primary energy demand). Crude oil will remain the main source of energy in the long-run. With the said high energy import and domestic limitations, Thailand would have to rely fully on crude oil import by 2022. As for natural gas, the fact that Thailand can produce some for domestic consumption makes the import portion of 20%. However, in the long-run, higher demand will result in higher import portion for natural gas resulting in a sudden spike of natural gas import in 2020 as shown in Figure 14b. Likewise, demand for petroleum products is increasing according to Possible Risk scenario due to refinery's limitations which brings net energy import to 81% as opposed to Blueprint's 71%.



(a) Blueprint (TIEB)



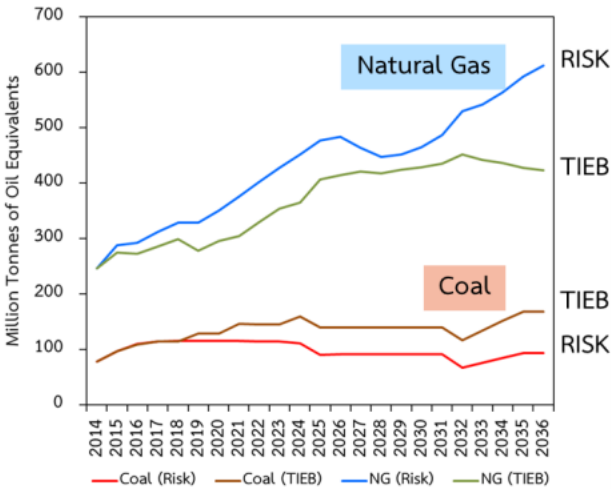
(b) Possible Risk (RISK)

Figure 14 : Net Energy Import

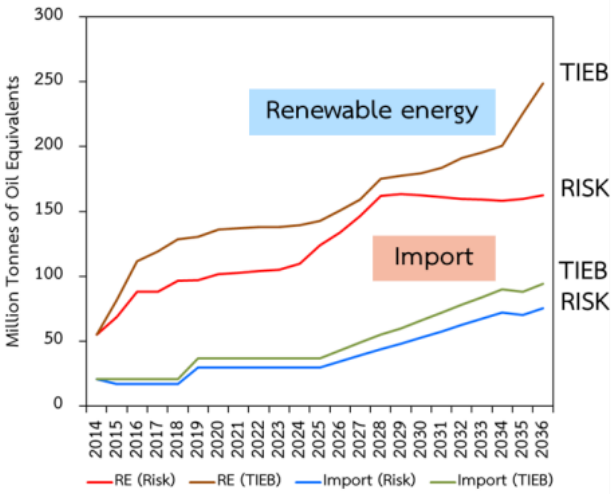
6. Electricity Generation Sector

The main sources used to generate electricity include natural gas, coal, renewable energy and import from neighboring countries. From Figure 15, the demand for natural gas for electricity in RISK generation is higher than TIEB scenario which is different than the demand for coal, renewable energy and import from the TIEB.

The investment in electricity system involves three main costs: generation, transmission and distribution costs. From Figure 16, the total investment values from TIEB and RISK are not very different from each other. Thus, investing in electricity is less likely to deviate from TIEB's plan in the long future. The difference of investment values derives from 1) higher reserved margin under TIEB than RISK and 2) lack of nuclear and fewer coal power plants under RISK than TIEB.



(a) Natural Gas and Coal



(b) Renewable and Imported Energy

Figure 15 : Primary Energy Demand for Electricity generation

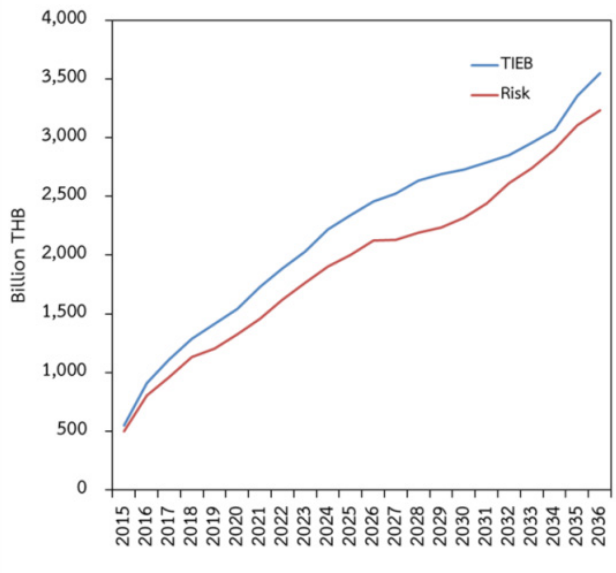


Figure 16 : Value of Electricity System Investment

7. Oil Refining Sector

The maximum points of oil refinery's capacity (green dashes) and output (red dashes) are shown in Figure 17. In the case of Blueprint (TIEB), oil product demand including diesel and gasoline (blue line) remains constant making the current capacity suffices future demand. Still, for Possible Risk (RISK), oil product demand (red line) has been rising so that demand will meet supply in 2016 and Thailand will have to import energy afterwards.

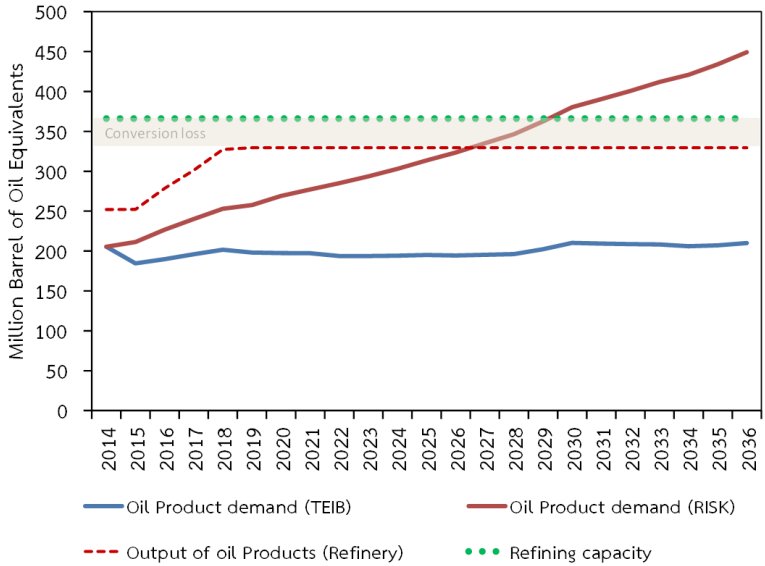
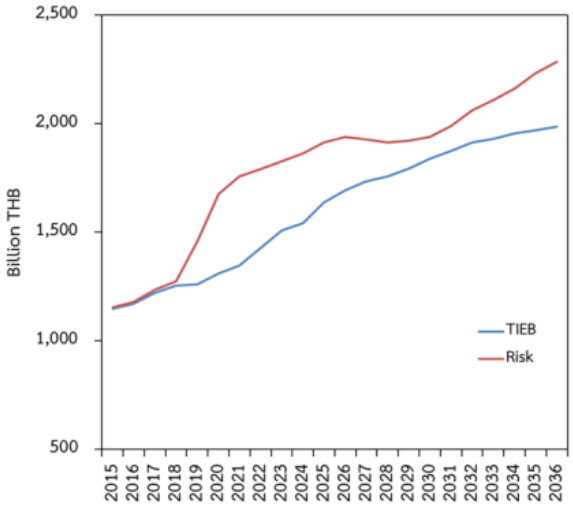


Figure 17 : Oil Refinery's Capacity and Demand

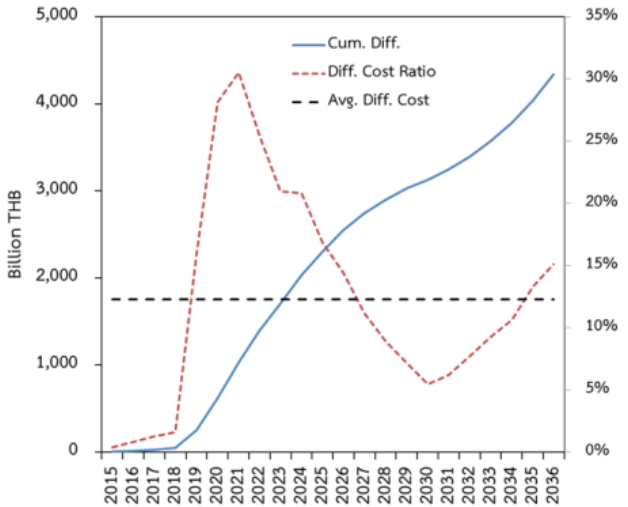
8. Fossil Fuel Expenditure

The annual expenditure on fossil fuel (Figure 18a) is higher for Possible Risk (RISK) than Blueprint (TIEB). The accumulated difference of each year is shown by the blue line in Figure 18b that will reach as high as 4,000 million baht in 2036. The red line representing different cost ratio also shows that the ratio jumps by 30% during the first periods and slowly drops to 5% before increasing again to 12.3%. Thus, the major problematic period would be only between 2018 and 2021.

Likewise, the expenditure on fossil fuels for electricity generation (Figure 19) also shares the same pattern. The average difference cost is 25.3% with the peak of 52.6% during the troubled period between 2018 and 2021.

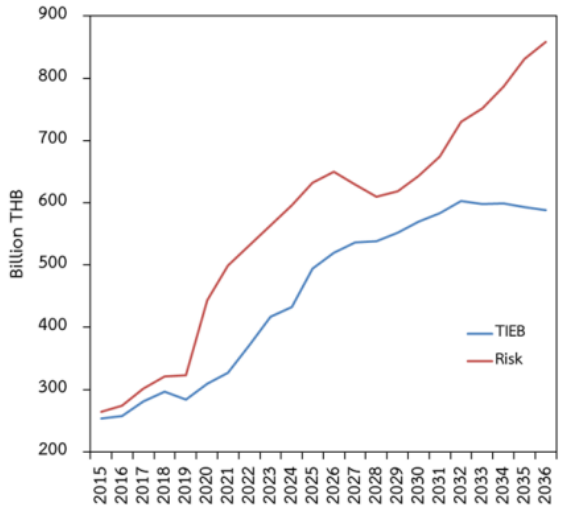


(a) Annual Expenditure

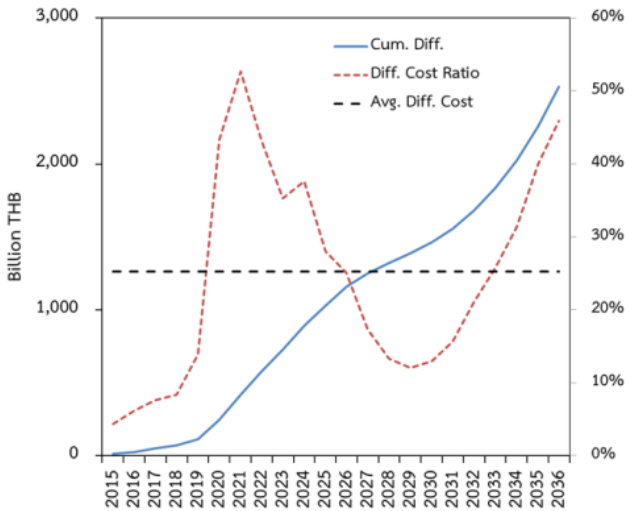


(b) Accumulated Expenditure

Figure 18 : Expenditure on Fossil Fuels



(a) Annual Expenditure

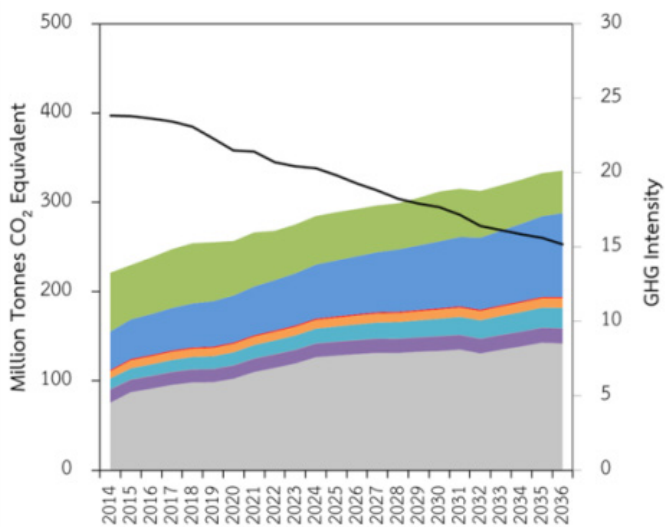


(b) Accumulated Expenditure

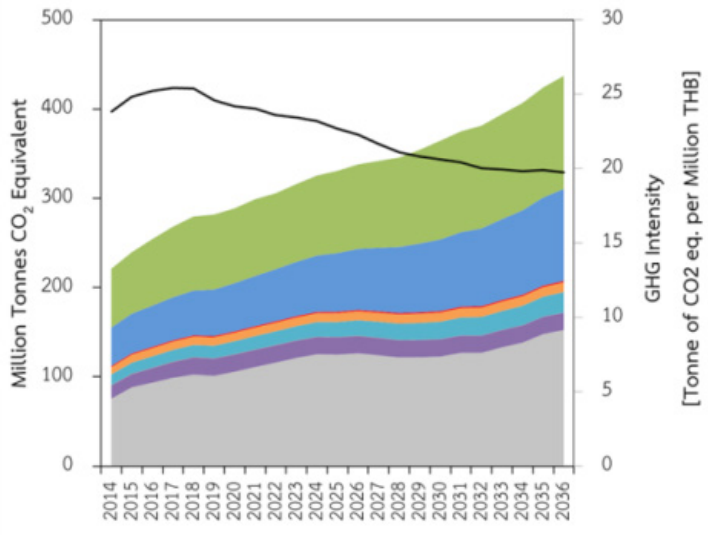
Figure 19 : Expenditure on Fossil Fuels for Electricity Generation

9. Energy Sector's Greenhouse Gas Emission

Energy demand is one of the main activities that has caused greenhouse emission. The greenhouse gas emission is as high as 220 million metric tons of carbon dioxide equivalents (MTCO2 Eq.) which the TIEB has demonstrated the decrease to 336 million MTCO2 Eq. from RISK's 437 million MTCO2 Eq. Consequently, greenhouse gas (GHG) intensity would be down from TIEB's 24 metric tons per million baht to RISK's 19.8 metric tons per million baht as shown in Figure 20.



(a) Blueprint (TIEB)



(b) Possible Risk (RISK)

Figure 20 : Energy Sector's Greenhouse Gas Emission

Summary

1. The Trend of World's Energy Sector

Driving Force The World Economic Forum has published Global Risk 2015 research to study risks that have effects on the Earth in five main areas including economic, environmental, geopolitical, social and technological. Oil price crisis can be very impactful to the world's economy as shown in the International Energy Agency (IEA)'s World Energy Outlook 2015 report which projected Low Oil Price Scenario and the consequences from higher oil consumption in the long-run and lower energy efficiency investment. Also, the 2015 World Energy Issues Monitor analysis has concluded that the main issues affecting world's energy sector vary from the United Nations Framework Convention on Climate Change (UNFCC), world's energy market price, electricity reserve, and commodity prices to Ukraine and Russia conflict and political situations in some Middle East countries.

Energy Efficiency The energy intensity, on average, has decreased by 0.9% between 1992 and 2012 and by 0.6% in 2013. The Chinese government has focused on reducing energy intensity and aimed at decreasing it by 16% from 2011 to 2015. Meanwhile, the United States government has announced the greenhouse emission reduction goal to 1/3 of the present value within the next 15 years. Exxon Mobil has forecasted that the average rate of energy efficiency for residential consumption will be improved by more than 20% from

2010 to 2040. As for industrial sector, the Organization for Economic Co-operation and Development (OECD) countries' energy intensity will improve by 2% annually until 2040. Transport sector's energy demand for liquid fuel (petroleum and biofuel) by 35 million barrels of oil equivalent per day.

Oil The International Energy Agency (IEA) see that the main driving force for energy sector will be from non-OECD counties as developed countries will face declining energy demand. India and Nigeria will be the top two energy consumers by 2030. McKinsey & Company analyzed that consumption for petrochemical, aviation fuel, and truck fuel oil will be the main driving force for energy sector especially from developing countries. In contrary, growth from the US, EU and Japan as well as petroleum products for light duty vehicles (LDV) will be at slower pace.

Natural Gas The IEA has predicted that the demand for natural gas which is considered a clean fossil fuel will be increasing from 21% of all energy demand in 2012 to 24% in 2040 and sharing second place for most demanded energy with coal. Natural gas will grow at around 1.6% on average per year. The increasing trend is a result of many countries' policies to reduce dependency on coal energy and greenhouse gas. In addition, price incentive also increases the demand in the USA and Middle East significantly. China alone accounts for 1/3 of natural gas demand of the whole non-OECD countries while India's demand is forecasted to jump by four times.

Natural gas production grows at slower pace for every continent except for Europe's being under average. Meanwhile, the US will be facing the increase of unconventional gas production that largely comes from shale gas. International natural gas trade is made through pipeline and marine transport for LNG especially in Asia Pacific. Also, Asia Pacfific tends to be the one that import the most natural gas (replacing Europe) especially China that needs more natural gas to support economic growth and comply with agreement with the US to reduce carbon emission.

Coal The current demand for coal has increased to as much as that of oil. Still, coal demand's growth tends to be at slower pace as the world has become more aware of environmental impact and global warming. The world's demand for coal grew only by 0.4% in 2014 and will continue to increase but at the lower growth rate. Likewise, China's demand will grow at lower rate due to its energy efficiency plan and economy restrucuring by increasingly opting for natural gas and renewable energy. Proven coal reserve is more than one trillion tons and will be enough for consumption for the next 135 years with the current capacity.

Electricity The IEA has forecasted electricity demand to increase, on average, 2.1% per year from 2012 to 2040. World's electricity generation trend is on the rise with coal as the major source. However, on supply side, world's electricity generation trend will grow at lower rate with 1.5% in 2014 down from 2.7% in 2013. Proportion of Coal will be replaced by natural gas, nuclear and renewable energy.

Solar Power Solar power is one of the fastest growing type among renewable energy (biomass, solar, wind, and other biofuels) excluding hydropower. Solar power includes Solar Photovoltaic (Solar PV) and Concentrated Solar Power (CSP) for electricity generation as well as Solar Heat. The cost of PV module is declining which is in par with world's overall grid parity. Both Solar PV's utility-scale and roof-top forms are almost equivalent.

Biomass Energy The current consumption of biomass energy mostly comes from traditional solid biomass including firewood, charcoal, residue from agriculture and animal dung. Traditional solid biomass accounts for 54-60% of overall biomass consumption especially for domestic cooking and heat. Solid biomass is mostly used for electricity and heat while biofuel is mostly used in transport sector. Traditional solid biomass will increasingly shift towards modern solid biomass. The International Renewable Energy Agency (IRENA) forecasted that the world's biomass energy provision will be at around 97-147 exajoules (EJ) per year of which 38-45% comes from agriculture residue and the rest from energy crops.

2. Recommendations for Thailand's Energy Sector Improvement

The government sector should take related risks into consideration when crafting policies that will affect the energy sector. Also, it should create and sustain strong standards to be the base that new regulations and policies can be built upon in the future.

1) Energy Efficiency

The government sector should focus on implementing related regulations and energy consumption standard as well as incentivize and penalize private sectors to act accordingly. Such regulations will have positive impact on the whole Energy Efficiency plan regardless of oil price fluctuation. Thailand had successfully elevated the energy efficiency standard for electronic appliance and enforced the National Energy Policy Council Act. However, there is still a gap for fuel consumption policy which covers only transport but not widely implemented to all the service providers yet.

The support for rail system is one crucial factor that will significantly affect the overall energy efficiency. The potential for improving energy efficiency in transport sector could be further fulfilled especially when transport is the most affected sector by stumbling oil price.

Pricing policy is one of the government's tools to improve energy efficiency as shown by continuously reduced energy subsidy policies. In the future, optimal tax structure should be assigned and more alternatives be offered to solve the problem in the long run.

2) Renewable Energy

There should be continuing support for renewable provision and consumption although the benefit is sometimes lower when the oil price decreases. Still, in the future, renewable energy will bring about positive economic benefits especially for Thailand that relies heavily on energy import. It also hedges the risk of future oil price fluctuations especially when the price spikes.

Zoning policies which focus on optimizing each area's capacity should be in focus. Likewise, business model development that helps private sector to lessen the risk impact is essential to respond to the fuel price fluctuation. Raw materials used to produce renewable energy should also be managed through long-term contract between energy producers and material suppliers or the support for farmers to have shares in renewable energy business as an incentive for instance.

Financial support based on market competition can help create a mechanism that reduces the level of subsidy needed while maintaining sufficient incentive for investors. With such scheme, investors need to improve their technology knowledge to keep up with the competition pace.

Distributed generation should be promoted so that consumers in various sectors can self-generate electricity for their own consumption with national grid being the reserved source in case the demand exceeds the production. Such method will reduce the dependency on central electricity generators and ameliorate the instability problem especially in the case of buying back a large amount of electricity generated by renewable energy.

Technology research and development should be supported such as solar cell panel, inverter and other components for solar energy generation. Some incentives such as tax policy and other privileges can help local developers to thrive and export later on.

3) Oil

The strategy to allocate sources of oil supply is needed in order to reduce the risk of too-high dependency on the Middle East where geopolitical risks and political instability are high. The oil supply from non-OPEC countries has been growing especially for shale oil. Also, new petroleum source development is emerging in Africa, South America and China. The USA is also considering suspending its prohibition policy of crude oil export in the near future. Many of the Asian countries will be the main target for oil producers who try to gain the market share. Thus, Thailand can leverage from these facts for appropriate strategic plan.

With continuously decreasing prices of crude oil and petroleum products in international market, Thailand can restructure oil price and devise tax policy for fuels that have high impact on the environment without intervening the consumption market. There should be also a continuing collection to oil fund regardless of the falling oil prices. With enough money in oil fund to stabilize oil price, the government can consider to spend the fund on oil reserve for future consumption.

4) Natural Gas

The discovery of natural gas source in the Gulf of Thailand has shaped the former energy plan to focus on natural gas rather than fuel oils for heating purpose in industrial sector and NGV for transport sector. However, current situation has shifted from the past as illustrated by natural reserve that is now significantly lower. Meanwhile,

the increasing natural gas demand brings about higher costs from LNG import. Thus, there should be a revision of energy policies by considering potential and cost of both from natural gas provision and consumption's perspectives.

Thailand should rely less on electricity generated from natural gas by opting for coal and renewable energy to decrease the risk of energy provision and to balance cost and benefit between economic and environmental impacts. Likewise, the subsidy for NGV should be gradually decreased and limiting consumer to specific groups to alleviate the problem of management and readiness of service stations. Meanwhile, natural gas in industrial sector will remain in the competitive price range set by market mechanism.

As transport is one of the most important factors for natural gas, transport infrastructure development especially pipeline network is crucial for increasing efficiency and decreasing the dependency of natural gas. Still, developing natural gas pipeline system requires a large amount of capital and some risks from not making financial profit exists. Therefore, gas pipeline planning is needed to optimize the benefits for power plants, industrial estates, and consumers by focusing on co-benefits that will contribute to the country's economy.

There should be a strategic plan for LNG terminal development to support the future demand growth and to reserve natural gas to stabilize the supply in the long-run. Such strategic plan should consider government to government collaboration and private sector's participation,

growing importance of LNG and its suppliers, the future of Thailand being the center for LNG trade, countries that have lower geopolitical risks and international politics.

5) Coal

Coal should be more in focus along with regulations and enforcement for environmental impact, safety, impact on the local communities and the whole supply chain from producing, importing, and transporting to the process of converting coal into industrial fuel. At the present, although there are some government agencies overseeing coal industry, there is still gap to fill such as local community communication and management. Clean coal technological development should also be taken to consideration as it complies with the goal of greenhouse gas emission reduction agreement in international level.

Coal plant development has faced the resistance from local communities especially for its environmental impact and mismanagement issues. Such issues can be solved from collaboration from all the stakeholders from planning process and bidding auction to overseeing and regulating the operations. Meanwhile, investors should consider appropriate crisis management approach, controlling method and compensation for affected communities and environment. A partnership between government, business sector and community representatives can solve the problems that occur in each area.

The trend of coal fuel consumption is on the rise in order to replace the use of natural gas is advantageous for coal plant especially

for cement industry that has high energy intensity and greenhouse gas emission when producing clinker. At the present, dust from coal plant replaces clinker to save cost and energy consumption significantly. Thus, zoning for coal and cement plants will help increase overall energy efficiency and decrease greenhouse gas emission.

6) Electricity

The need to reduce the dependency from natural gas for electricity generation is one of the main strategies for Thailand's energy plan especially for LNG import that has been on the rise. The falling coal price and the growing renewable energy market makes the goal of increasing renewable energy and reducing natural gas consumption plausible. The objective of stabilizing the cost of energy and controlling the greenhouse gas emission are also in line with Thailand Power Development Plan (PDP2015)

In the long-run, electricity planning should consider altering both technical structure and business model to support the fluid new technology development such as smart grid and renewable energy that will have high impact on Thailand's energy sector. Thus, regulation planning that focuses on allocating the generation process to consumers can reduce the work for central unit and help stabilize the supply in the longer future.

The success of integrating electricity network with neighboring countries within the ASEAN will grant Thailand an opportunity to be the center of electricity trade. However, there are various elements to be

prepared: business and price competition structure, and strong human resource. Proactive diplomatic strategy can also help the process of integrating the energy system to be smoother and more promptly.

The conflict between local people, business and government sectors on electricity generation plant has been the main obstacle for ameliorating Thailand's electricity system. The key solution to the problem is to build trust, confidence, and mutual benefits between the three parties. Forming a business under a partnership system with local people being stakeholders can be the most sustainable solution among others.

Thailand Energy Outlook 2016

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