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An Overview of Coal Energy Sources and Supply in Thailand

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Abstract

This study introduces the key facts on the current proven reserves, production, sources, and supply of coal. The research provides an overview of the energy situation in Thailand; how the demand for coal and the clean coal activities being undertaken in Thailand. Coal production is currently a large industrial of energy source. In recent years Thailand's economy has grown rapidly, resulting in increased energy demand. This demand is met almost entirely by fossil fuels which provide 90% of the country's supply; gas makes up 70%, coal 20%, and there are some oil-fired plants. The remaining 10% comes mainly from hydroelectricity and other renewables. Several international institutions operating in Southeast Asia play an important role in contributing to the long-term energy strategy in Thailand. However, their work on promoting the use of clean coal technologies is limited in Thailand. The use of coal in Thailand will increase if all the planned new coal-fired power stations are built. Therefore, it is important that information on, and research into, the use of clean coal technologies within Thailand are supported and increased to better inform the wider community

Keywords: *Coal; Energy Sources; Power Generation; Energy Policy.*

1. Introduction and overview

1.1. Coal energy sources in Thailand

Coal, which is primarily used for the generation of electricity. Thailand will look to develop new coal-fired power plants as gas reserves decrease in the country. According to a recent report from the Electricity Generating Authority of Thailand (EGAT), the country will consider clean coal technologies to help reduce carbon dioxide and other greenhouse gas emissions. using imported coal to fuel power plants is the best option for Thailand to provide reliable energy to the grid. Current drilling in the Gulf of Thailand was expected to be productive in a decade, as the gas reserves run dry. This will affect the security of our power supply [12-15]. Using imported liquefied natural gas, which costs double that of natural gas, will push power tariffs to rise. The most appropriate solution is to find other fuels such as coal as a substitute for gas. These fuels should make the power system more sustainable with low tariff rates. In addition to increasing its coal-fired power generation, Thailand hopes to use more renewable energy sources within the next decade [16]. The EGAT report stated the country has a goal to have 25 percent of its energy mix coming from renewable sources within the next 10 years.

Coal was used for power generation for a century [17-22]. Currently, 70% of the electricity used in the world was from coal, and it tended to increase 5-7% annually as the world still had the abundant coal reserve, contrary to oil and natural gas which clearly decreased [23-27]. Thailand lost the chance in using the coal for power generation but let other countries consumed it. Actually, coal was the cheap fuel, leading to the low price of electricity, but people were still concerned about the pollution [28-29]. However, presently there was the clean coal technology that could get rid of pollutant and heavy metal very well, which was different from

Mae Moh Power Plant case 40 years ago when the technology was not modern. EGAT did not use the good technology, scientist, would also protest. Anyway, for the Krabi Power Plant development, EGAT applied the clean technology, so it was the chance for Thailand to have the clean coal power plant enhancing the security of the southern Thailand power system. The example from Japan, in which the Government saw the importance of power. Japan needed to have sufficient power, while social and environmental care was also necessary.

1.2. Energy policy of Thailand

The government anticipated that energy prices would be one of the key concerns due to limited energy resources, environmental issues, global warming and climate change challenges which affect people's quality of life and the country's competitiveness [30-35]. Therefore, the 20-year Energy Efficiency Development Plan 2015-2036 (EEDP) was developed by the Energy Policy and Planning Office, Ministry of Energy (Thailand) to address the issues. The objectives of the EEDP are as follows:

- To establish the energy conservation targets (heat and electricity) in the short term 5 years and long term 20 years where the aim is to reduce energy intensity (EI) by 30 percent in the year 2036 compared with that in the year 2010 for overall country and energy intensive sectors such as industrial, business, and residential.
- To define strategies and guidelines in the energy conservation promotion to achieve the aforementioned targets and to formulate operation plans of the relevant organizations.

In order to formulate the 20-year Energy Efficiency Development Plan 2015-2036, the Ministry of Energy revised the 20-year Energy Efficiency Development Plan 2011-2030 by adjusting the baseline data and assumptions. Therefore, the target of the EEDP 2015-2036 becomes to reduce energy intensity by 30 percent in the year 2036 compared with that in the year 2010 or accounting for 56,142 kilo tons of oil equivalent (ktoe). However, energy savings estimated by an energy intensity reduction during the year 2010-2013 was 4,442 ktoe. Thus, the energy conservation target would be achieved by measures and projects during the year 2015-2036 accounting for 51,700 ktoe where around 15 percent or 7,641 ktoe (89,672 GWh) would be in electricity sectors and around 85 percent or 44,059 ktoe would be in thermal sectors (Table 1).

Moreover, the energy conservation plans of 4 economic sectors; residential, industrial, business, and transportation were revised. Therefore, 6 guidelines were stated to encourage energy conservation as follows:

1) Removing / Revising energy price subsidies to create the market price
2) Introducing tax incentives / to encourage the use of efficient appliances
3) Introducing monetary incentives / grants or soft loan along with energy management consulting to encourage the use of high-efficiency appliances
4) Defining Industrial Factory and Building Energy Code to be under obligations
5) Building public awareness of energy conservation
6) Defining Energy Efficiency Resources Standard (EERS) for power producers and distributors

1.3. Assumptions and frameworks of Thailand power development

The National Energy Policy Council (NEPC) approved assumptions and frameworks to formulate the Thailand Power Development Plan 2015-2036 (PDP2015) (Table 2). In addition, the Alternative Energy Development Plan (AEDP) and the Energy Efficiency Development Plan (EEDP) were also formulated along the timeframe between the year 2015 and 2036. The new Thailand's load forecast was formulated in line with the potential and target of the AEDP and the EEDP, economic growth, changes in economic structure, infrastructure development projects, the performance of the EEDP measures and Very Small Power Producer (VSPP) power purchase plan. The power demand forecast was formulated as the business as usual case (BAU) according to the average forecasted GDP growth during the year 2014-2036.

Table 1. Energy conservation targets classified by economic sector (GWh) [37]

Economic sector	Energy conservation targets				
	2016	2021	2026	2031	2036
Industrial	2,174	9,420	17,497	22,845	31,843
Business	853	5,156	12,687	22,406	36,052
Residential and agricultural	395	1,914	4,877	8,760	13,633
Government	302	1,713	2,960	4,683	7,144
Total	3,724	18,203	38,021	58,694	89,672

Table 2. Estimated energies requirement for the PDP2015 [37]

Energies	Percentage in 2014	Percentage in 2026	Percentage in 2036
Imported hydropower	7	10-15	15-20
Clean coal including lignite	20	20-25	20-25
Renewable energy including hydro	8	10-20	15-20
Natural gas	64	45-50	30-40
Nuclear	-	-	0-5
Diesel/Fuel oil	1	-	-

In addition, population growth, urbanization, and growth rate of electricity customers by economic sectors were also considered [38-42]. Consequently, End-use model and Econometrics model were used for the formulation of the power demand forecast development with the assumptions as follows:

- The power demand forecast models for long-term energy efficiency were used to estimate the power demand of the Provincial Electricity Authority (PEA) distribution system and the Metropolitan Electricity Authority (MEA) distribution system. Assumptions required for the models are growth rates of Residential, Business, Industrial, and Other Customer in the distribution system which changes according to economic and population growth.
- The estimated GDP growth during the year 2014-2036 in which the outcomes from the infrastructure development projects excluding high-speed train projects were included in the estimation. The estimated GDP growth during the year 2014-2036 expected to grow on the average of 3.94 % annually was used in the power demand forecast models.
- The power demand from BTS sky train, MRT train, and 10 mass rapid transit projects in Bangkok were counted in the model except those of the unclear high-speed train projects.
- The target of the EEDP is to reduce the energy intensity of the year 2036 by 30 % from that of the year 2010. Thus, the measures of the EEDP on electricity focus mainly on industrial, building, residential, and government sector

2. Scenario and analyses

Throughout history, coal has been used as an energy resource, primarily burned for the production of electricity and heat, and is also used for industrial purposes, such as refining metals [43-48]. Coal is the largest source of energy for the generation of electricity worldwide, as well as one of the largest worldwide anthropogenic sources of carbon dioxide releases [49-54].

In this study, fuel options for power generation are simulated using a scenario-based approach. The impact of major fuel options, e.g. natural gas, coal and nuclear, on the perspectives of the overall generation cost, demand, and supply was considered [55-61]. For the application of power generation, peak load requirement can be evaluated directly using the product of electricity demand and the assigned load duration curve. The additional capacity for power generation technology can be calculated based on the merit order with the constraint of planning reserve margins [62-63]. The primary resource is a withdrawal by the required feedstock during the transformation process. Moreover, targets of electricity import and export are also allowed for the target planning of power purchasing in the future [64-66]. As a result, total generation cost, demand, and supply can be calculated from the electricity generation process

using each individual technology. The deviation can be presumed by the averaged properties of power production by generation type.

The scenario relies on the target-based future prospect. Ambitious macroeconomic growth causes a rise in electricity demand in the long-run. The needs of diversification on the supply side lead to a lower share of natural gas. The coal options are the considered to be the major alternative fuels in the plan. In this case, the peak power requirement relies on the recent official load forecast. The key assumptions of economic growth and overall energy elasticity for the moderate case and beyond the planning period of 2010 to 2020, it is assumed that the driver of electricity demand remains unchanged from the year 2010.

Capacity expansion of the scenario is referred to in the existing power development plan of which the increase of base-load capacity is mainly from the natural gas combined cycle, coal-fired power plant, expected to be commissioned in 2020.

In this scenario, it is assumed that the coal option becomes favorable to reduce the portion of natural gas utilization in power generation in long-term. Only coal-fired power plants will be installed for the incremental capacity of baseload requirement after the year of 2010. All of the installed capacity and imported capacity during the period remain identical to the scenario.

3. Goal target and the future

3.1. Coal-fired power plant in Thailand

Compared to Indonesia, a nation with approximately 70 coal-fired power plants, Thailand currently has five coal-fired power plants over 300 megawatts and nine smaller plants of around 100 megawatts or less (Table 3, 4). But like Indonesia, the Thai government has approved the new power development plan (PDP2015) to expand the use of coal power with large coal-fired power plants of 7,390 MW combined within the next 21 years. As has already been noted, these coal plants don't just lead to the premature deaths of thousands of Thai people, they also foul the air, water and immediate surroundings, they displace entire communities, destroy some of Thailand's most renowned tourist destinations and contribute to global warming [67-68].

Table 3. Operating coal-fired power plants in Thailand [69]

Power plant name	Capacity, (MW)	Power plant name	Capacity, (MW)
Mae Moh	2,400	Bangkok HSFC plant	50
BLCP	1434	Kaeng Khoi factory	17
Gheco one	700	Ban Pong spi	15
Glow SPP phase 3-5	431	Amphar Sampran	15
Tha Toom	300	Ban Pong ski	15
Muang IRPC	108	Elite kraft factory	10
Wang Sala mill	60	Prachin Buri IPC	10
Ayuthaya mill	57	Prachin Buri UTP	8

Table 4. New coal-fired power plant projects in Thailand [69]

Project name	Status	Sum of capacity, MW
Thap Sakae power station	announced	2,800
Thepa power station	announced	2,000
Krabi new	Planning	800
Mae Moh power station	Pre-permit development	600
Prachin Buri TCP	Pre-permit development	600
Prachin Buri electricity TCP	Planning	20
Grand total		5,020

The mine mouth coal-fired power generation plant in Mae Moh region is the biggest thermal power generation plant in Thailand (Fig. 2), which has used coal-lignite as fuel. It has held the second share of utility power generation about 22.7% of all utility-produced electricity referred from EGAT.

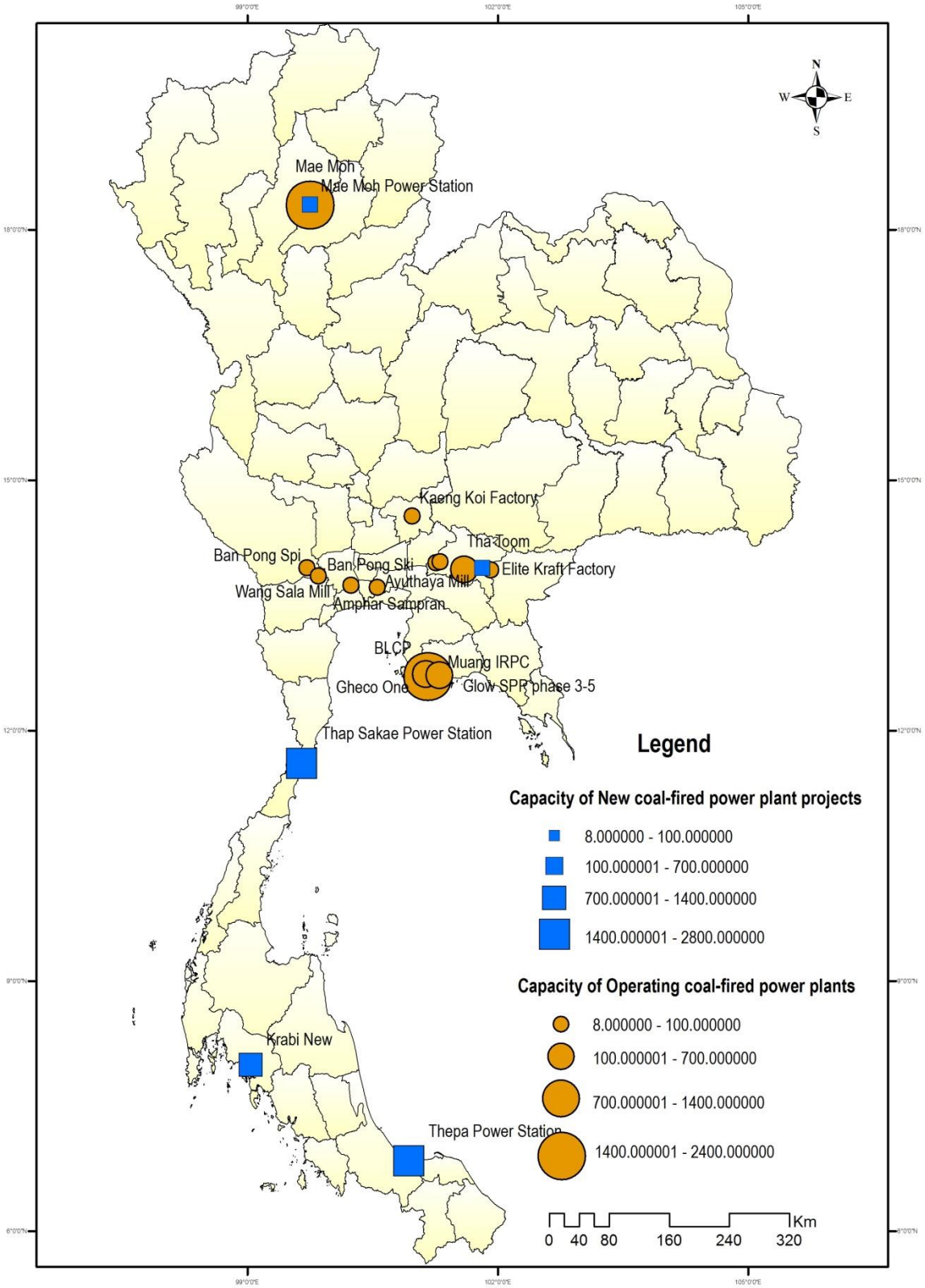

Figure 1. The coal-fired power plant in Thailand with a capacity of operating coal-fired power plants

In the year 2000, the gross electricity production by type of fuels used is approximately from natural gas, lignite, fuel oil, hydro, diesel oil and others about 52.5%, 22.7%, 16.8%, 7.8%, 0.2% and 0.0026%, respectively. Due to the lignite fuel in Mae Moh region contains a high amount of sulphur about 3% therefore, in some year, the number of health complaints have increased during the cool season when high concentrations of SO_2 has been emitted [70-74]. EGAT responded to this problem by gradually installing the flue gas desulphurization systems (FGD) (Fig. 3) in the power generation unit. Sulphur dioxide has been controlled by FGD and produced satisfactory results. On the other hand, Life cycle thinking point of view, it is important to study and understand about the environmental impacts of the power generation plant after installation of FGD in the whole life cycle (from cradle to grave) [75-78]. Moreover, when EGAT installed and operate the FGD, it has also required high investment budget, operation cost, maintenance cost and other cost. Therefore, the externality analysis of SO_2 ought to be investigated for the whole life span of the FGD. This paper discussed about Life Cycle Assessment (LCA) and externality study, in which focus on Mae Moh lignite-fired power generation plant with the generated capacity of 2,625 MW and generated electricity 15,547.56 GWh.

Figure 2. Top 3 largest coal-fired power plant in Thailand

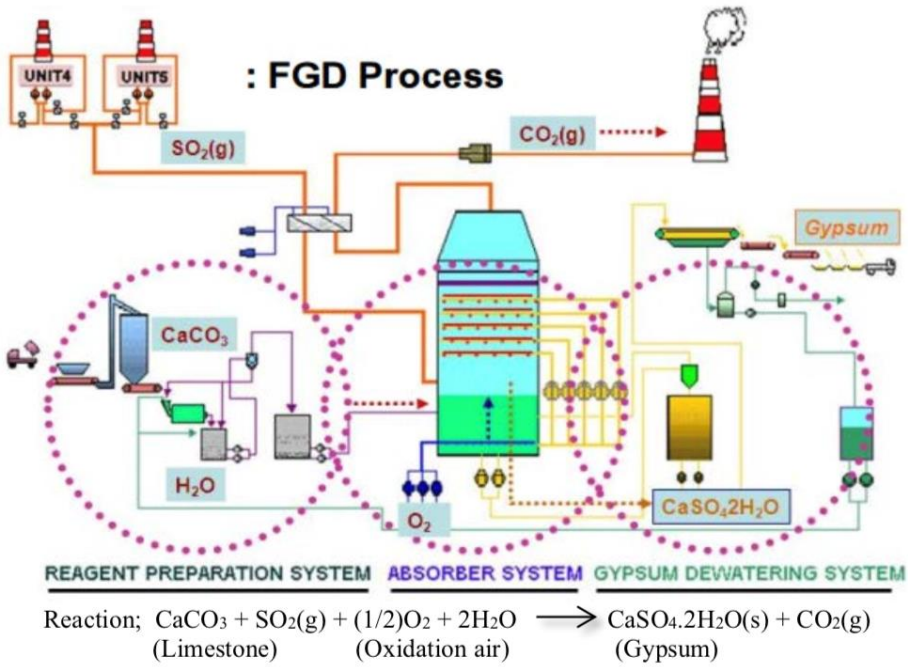

Figure 3. The flue gas desulphurization systems (FGD) in the power generation unit of Mae Moh

The 2 x 700 MW power plant of BLCP (Fig. 2), that can produce approximately 10,000 gigawatt hours (GWh), is designed to achieve the maximum efficiency consistent with reliability and cost factors [79-80], thereby, gaining the greatest possible economic utilization of the imported coal [81-88].

The raw material for BLCP power plant will be bituminous coal imported from Australia and Indonesia. The coal will be transported by ships to the berth located at the southwest of the project by coal unloaders. It will be transported and separated into 3 piles at the coal yard. The total storage capacity will be 662,000 tons in which are sufficient for 60-days continuous electricity generation. From the coal yard, the coal will be transported via conveyors to bunkers and coal pulverizers where it will be ground to a suitable size for putting into boiler furnace in suspension in transport air. Combustion of coal provides heat which is transferred to demineralized water in the tubes surrounding the furnace [89-92]. Boiling water and steam will be separated in the boiler drum located at the top of the boiler.

BLCP Power Station controls the percentage of sulfur content on per shipment basis within the range of 0.27-0.70%, and the average limit of 0.45% on per year basis. Based upon the plant design and the technical calculation, it is estimated that the Station can outperform all key parameters or limits as stipulated by the EIAs as follows.

- Dust at 43 mg/m^3 against the regulatory limit of 120 mg/m^3. Simply put, it is 64% better than the standard.
- Oxide of sulfur (SO_2) at 262 ppm. against the regulatory limit of 320 ppm. It is 18% better than the standard. (However, the annual average is at 124 ppm., or 61% better than the standard).
- Oxide of nitrogen (NO_x) at 241 ppm against the regulatory limit of 350 ppm. It is 31% better than the standard.

GHECO-One plant is designed and will be operated in line with international standards (Fig. 2), using high-quality coal and state of the art and environmentally friendly technology including NOx, SO_2 and Dust emission reduction facilities and Supercritical Pulverized Coal Boiler Technology with high efficiency reducing consumption of fuel and all emissions (Fig. 4). The project has been granted the Environment Impact Assessment (EIA) approval and Environmental

Health Impact Assessment (EHIA) approval by the Office of Natural Resources and Environmental Policy and Planning (ONEP). GHECO-One Co. Ltd (GHECO-One) is proceeding with construction activity of its coal-fired power station even though it is waiting for the opinion of the Council of State regarding which state agencies can grant permission for construction. To solve the issue GHECO-One sought authorization from the Industrial Estate Authority of Thailand (IEAT) or the National Energy Regulator agencies. The plant is located in Map Ta Put industrial zone in Thailand.

GHECO-One is the owner of the project, which will have a 660 megawatts (MW) generation capacity. GHECO-One is a joint venture company formed by Hemaraj Land and Development Public Company Limited and the Glow Group that own 35% and 65% of it respectively. GHECO-One has already signed the power-purchase deal with EGAT for the supply of electricity.

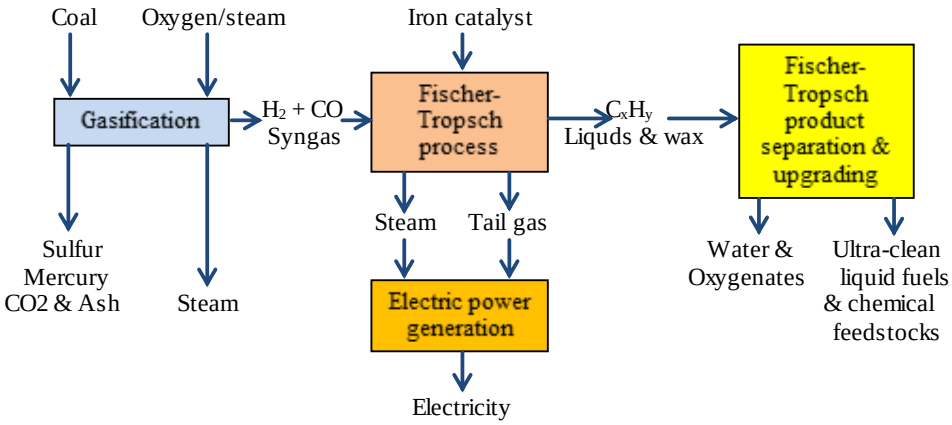

Figure. 4. Producing liquid fuels from coal – two approaches

Coal unloading facility as a precautious measure, the station will engage an independent party to perform and check the quality of every shipment of imported bituminous coal. The objective is to ensure full compliance, particularly to the sulfur content limit, at the early stage of the electricity generation process [93-95]. During the unloading, water spray equipment is also installed at the unloaded hopper in order to prevent dust dispersal.

All coal will be carefully unloaded and transported to the direction of the plant or the coal stockyard, by belt conveyor with wind protection sheet in order to prevent diffusion, spreading of dust, and falling of objects [96-97]. Water from spraying will be pumped back for treatment first before being recycled for future usage in order to save operating cost. As a result, water will be wisely used and conserved without the need for drainage into the sea. The station is also required to monitor and to check the quality of seawater around the unloading port on a regular basis.

All power station is also required to keep and maintain coal stockyards at the appropriate volume to ensure continuity of electricity generation without interruption caused by shortage during the normal and abnormal time [98]. The coal stockyard is designed to consist of three piles; the first two piles will be actively used for generating electricity and the last pile to be pressed and covered by grasses, for the purpose of back up during the fuel shortage or emergency. Water spray system is also installed with technical flexibility for constant adjustment to match with the wind speed. The 6-meter high wind protection wall is also constructed along the length of the stockyard in order to avoid dust dispersal or heat combustion [99-100].

3.2. Coal market policy

Thailand has no explicit policy on coal production or imports, and no government department is tasked with overseeing coal imports specifically [101-103]. Coal mining and transport regulations, however, are in place. As Thailand has very limited domestic coal resources, the planned increase in coal-fired generation will necessitate an increase in coal imports. Given

the fairly liquid global market for coal, this is unlikely to raise any supply concerns. There are, however, environmental concerns associated with coal, in particular the climate change impacts of emissions. As the agreement signed at COP21 in Paris in December 2015 requires future climate change targets to be more stringent than current targets, any coal generation developed in Thailand will have to coexist with increasingly ambitious climate goals. Any new coal generation should be high efficiency, low-emissions (HELE), which, in addition to emitting significantly less CO_2 emissions than subcritical units, could also potentially be retrofitted to include Carbon Capture and Storage (CCS) at some later stage.

3.3. Coal-fired generation

Coal-fired generation accounts for 19.9% of total power production in Thailand. In 2014, demand for coal amounted to 25.6 million tons of coal equivalent (Mtce), and was evenly split between industrial and power generation uses. Thailand expects demand for coal to increase at an average annual rate of 1.8% per year, reaching 36.1 Mtce by 2036. While increasing industrial demand accounts for some of this growth, the majority is due to increases in coal used for power generation.

Thailand is in the process of replacing old and inefficient coal-fired generation units, such as the Khrabi power plant. This is being heavily opposed by the Thai public and non-governmental organizations, which fear detrimental health and environmental impacts from coal-fired generation [104-105]. PDP2015 calls for additional replacements and new coal-fired generation in Thailand up to 2036. In the face of domestic opposition, the government of Thailand and EGAT are building coal-fired generation units outside Thailand and importing the electricity generated via IPPs and PPAs. The first such plant is the mine-mouth Hongsa power station in Xaignabouri, Lao PDR, with another planned in Myanmar. Hongsa is being developed by Ratchaburi Electricity Generating Holding, Banpu Power and Lao Holding State Enterprise (LHSE), and will export 1,473 MW of power to Thailand with EGAT as the purchaser. A similar project is underway in Myanmar, where PTT Energy and Ratchaburi Electricity Generating Holding plan to invest in a 600 MW coal-fired power plant in Kyaing Tong, of which about 500 MW would be exported to Thailand.

The most common approach for studying the health impacts of coal-fired power plants is the "impact pathway" approach, which follows air pollution from emissions from the studied sources, to the dispersion and chemical transformation of emissions, to resulting pollution levels in different locations, to population exposure, resulting increase in health impacts, and finally to the total health impacts on the population-level [106-07]. The impact pathway approach with information sources used in the study.

The national emission standards applied to each power plant were identified and were used to calculate air pollutant emissions as a first approximation. Indonesia's state power company, PLN, has designed their power plants for 4,300 kcal coal with 0.35% sulfur, so emission rates for plants for which Plant reports compliance fuel as the SO_2 control method were calculated on this basis. Non-PLN plants without SO_2 controls were assumed to burn average Indonesian coal with 0.6% sulfur.

4. Electricity transmission and distribution

Electric power distribution is the final stage in the delivery of electric power; it carries electricity from the transmission system to individual consumers. Distribution substations connect to the transmission system and lower the transmission voltage to medium voltage with the use of transformers [108]. Distribution transformers lower the voltage to the utilization voltage of household appliances and typically feed several customers through secondary distribution lines at this voltage. Commercial and residential customers are connected to the secondary distribution lines through service drops. Customers demanding a much larger amount of power may be connected directly to the primary distribution level.

Once the power is generated, it is delivered over national and regional transmission systems to cooperative-owned substations. A number of partners are involved in this process and

a portion of what is collected in your monthly bill is returned to these partners for their role in service delivery. Transmission systems, like distribution systems, are comprised of poles, wires and other equipment that are vulnerable to environmental elements and failure due to age, technical or mechanical issues [109]. When transmission-related outages occur, the operative is dependent on the transmission provider for both information and restoration. Transmission-related outages tend to be larger and more widespread than distribution system outages (Fig. 4).

This is our piece of the delivery pie. Transmission providers deliver power to our substations. The power for ultimate delivery over our distribution system to individual homes or business [110]. A portion of your monthly payment, specifically the service charge and distribution kWh charge, are used to cover the many expenses of daily operation of your cooperative, including the cost of providing and maintaining our distribution system (Fig. 4).

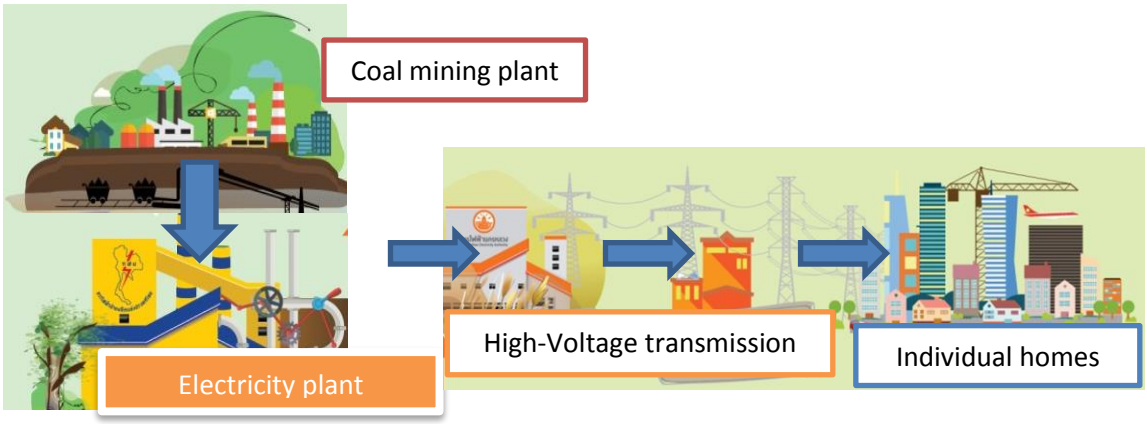

Figure 5. Coal and electricity transmission and distribution of Thailand

EGAT is the country's system operator, managing and controlling, via the National Control Center and five regional control centers, the dispatch of power generation both from both EGAT's own power plants and from private power plants to meet the country's demand in the most efficient, reliable, and environmentally-responsible way. It also owns and operates the national transmission network which includes transmission lines and substations of various high voltage levels which covers all parts of the country (Fig. 5).

5. Energy efficiency demand and power demand forecast

As an economy situated within ASEAN, the relative performance of Thailand compared to its neighbors is an important consideration with respect to the nature of domestic demand. Competition from countries such as Myanmar – which is relatively less developed but which is undergoing reforms that may increase economic development in the near term – may force Thailand to move up the economic value chain. If so, this could change the nature of electricity demand within the country, potentially reducing or even breaking the link between economic growth and growth in electricity consumption. Indeed, it is possible that the economy of Bangkok may have already experienced such a decoupling. Certain parts of Thailand, however, remain relatively underdeveloped. It is therefore possible that a decline in demand growth in some parts of Thailand could be offset by an increase in demand growth elsewhere (Fig. 6).

The Thai government should therefore be commended for taking a strong and approach to energy efficiency. Energy efficiency combines all the guiding principles of PDP2015, and is a key component of improving Thailand's electricity security. The EEP is ambitious and comprehensive and, implemented as planned, will decrease Thailand's energy intensity and increase demand for energy-efficient products and services. Achieving the reduction targets outlined by the EEP would avoid the equivalent of 16 new coal plants, and decrease greenhouse gas and other environmentally destructive emissions. A number of factors continue to constrain the implementation of energy efficiency markets in Thailand. A lack of coordination between

government agencies could have an impact on the effectiveness of policies and programmes, as could a lack of energy efficiency finance, particularly for small and medium-sized enterprises [102-104].

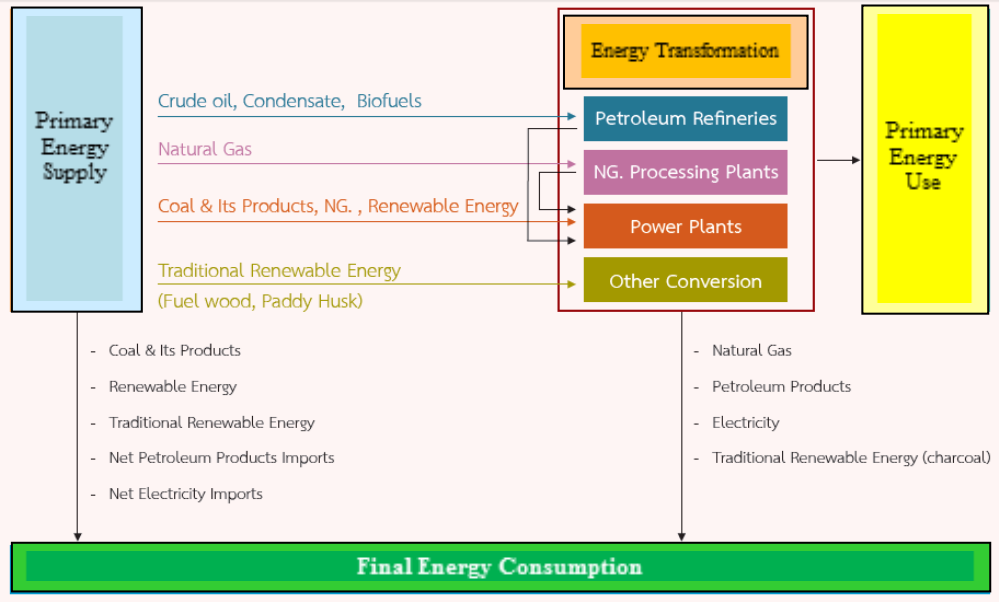

Figure 6. Flow diagram of energy supply and consumption in Thailand

Energy providers have taken an active role in demand-side energy efficiency, sustaining and expanding this role requires a system that would make reducing energy demand, and capturing the other benefits of energy efficiency, a viable business opportunity. Barriers to energy efficiency include a lack of manpower, lack of awareness on the part of the public, the relative expense of more efficient technologies, the length of payback periods and the opportunity cost of installing energy-efficient equipment versus avoiding associated downtime. Experts within Thailand have expressed concern that the easiest energy efficiency measures have already been exploited, and that it is becoming more difficult to find projects with a high enough internal rate of return to justify the investment. This is partly because the economics of energy efficiency program is undermined by Thailand's relatively low electricity tariffs. The country's tariff structure already differentiates between peak and off-peak periods. As a further step, Thailand could move to provide more granular real-time pricing in particular to large consumers, who may be in a better position to react to real-time price changes than smaller consumers. Thailand should also work to ensure that tariffs are truly cost-reflective.

Finally, with regard to demand forecasts, certain parties outside government are concerned that current projections overestimate long-term growth rates. If actual demand growth is lower than projections suggest, this could have a profound impact on the relevance of the PDP.

World production and consumption of coal declined in 2015, by 4% and 1.8%, respectively. Production fell for the first time since 1998, with large declines in the Asia Pacific (-2.9%) and North America (-10.3%). China remained by far the world's largest producer even though output fell by 2%. Coal consumption declined in all regions except South & Central America and the Asia Pacific [105-108]. The US and China accounted for all of the net declines in global consumption.

World primary energy consumption grew by a below-average 1.0% in 2015, the slowest rate of growth since 1998. Growth was below average in all regions except Europe & Eurasia. All fuels except oil and nuclear power grew at below-average rates. Oil remained the world's dominant fuel and gained global market share for the first time since 1999, while coal's market

share fell to the lowest level since 2005. Renewables in power generation accounted for a record 2.8% of global primary energy consumption [109-110].

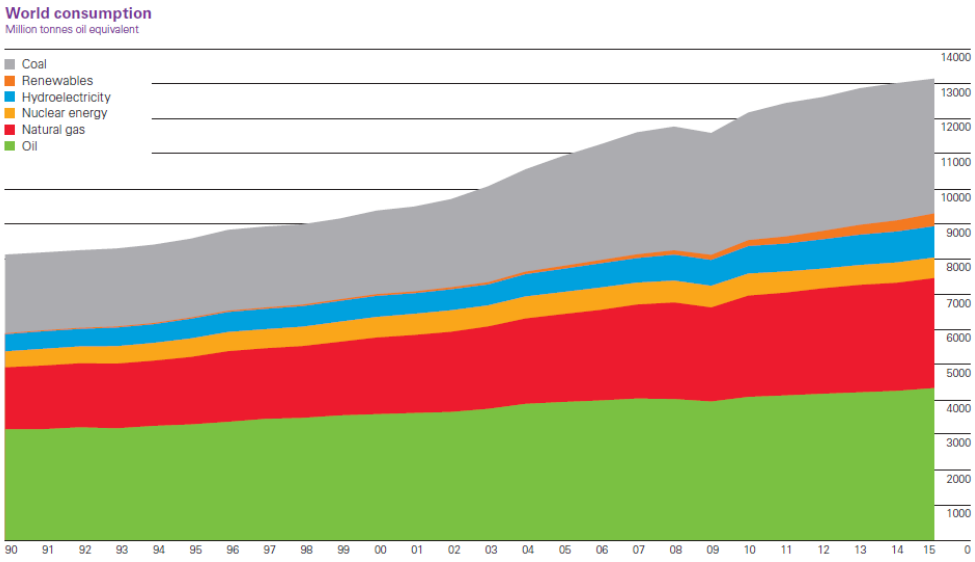

Figure 7. World consumptions of energy [3]

Coal reserves are available in almost every country. The biggest reserves are in the Asia & Oceania region [3, 111-114].

In projecting the energy demand during 2010-2020, consideration is also given to key energy policy issues of the government, for example, the energy efficiency improvement, the promotion of new & renewable energy development, the assumption that after 2011 there would be more imports of electricity from neighboring countries and that the major fuels used by new Independent Power Producers (IPPs) would be natural gas at a share of 70% and coal at a share of 30% [4-5, 115].

The overall growth in primary energy demand in Thailand is projected to be at an average rate of 4.3% during the forecast period, with oil still accounting for the largest share up to the year 2010. Then, natural gas demand would surpass oil demand from the year 2010 onwards. The demand of lignite/coal would grow, but its share in the energy mix would be rather stable and would slightly increase to 15% by the year 2020, with an average growth rate of 6% during the forecast period [Fig. 8].

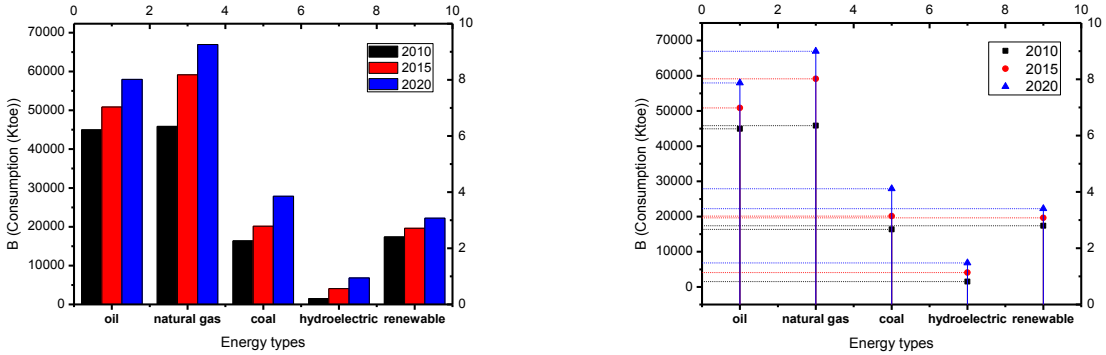

Figure 8. Projection of the share of primary energy demand during 2010-2020

The cumulative average growth rate of the overall final energy demand during the forecast period is projected to be 4.5%. The growth rate of natural gas demand during the forecast period would be the largest, i.e. 13.7%, followed by that of electricity at 5.8% and lignite/coal

at 5.6%. Oil consumption would grow but its cumulative average growth rate would be only 2.8% [Fig. 9].

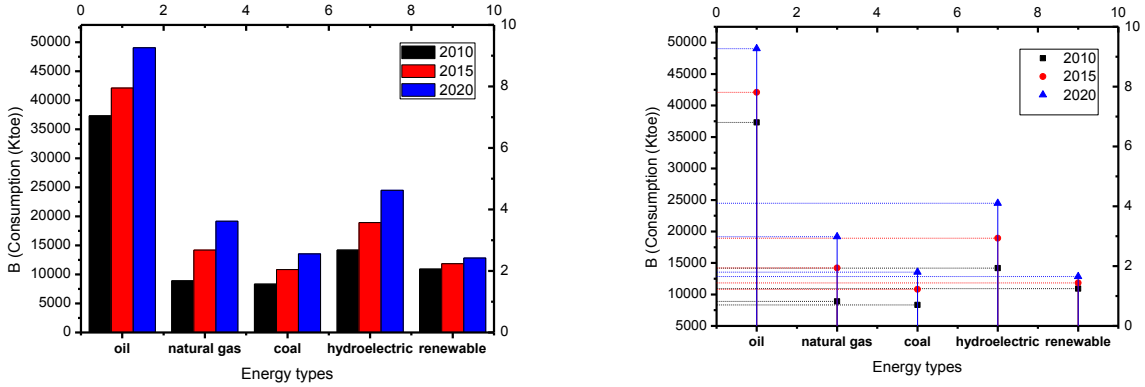

Figure 9. Projection of the share of final energy demand during 2010-2020

Using lignite & coal as fuel for power generation is a means to diversify fuel types to increase the power system security with the minimum generating cost and to stabilize the power tariffs. However, the share of coal used in power generation is now still below 20%. In the future, coal will play a greater role in the power generation in Thailand. With the full steam operation of 1,400-MW BLCP coal-fired power plant this year, a demand of 3.5 million tons of imported coal is expected for the plant. The government will encourage EGAT and new IPPs to use imported coal for power generation to be supplied to the grid after 2011. Also, the use of clean coal technology will be required to enhance the operating efficiency while reducing the environmental impact.

Given the forecast on energy demand and supply of Thailand, as mentioned earlier, together with the policy on the fuel mix of the government, it is expected that the use of coal & lignite for power generation will gradually increase in the near future. Especially for imported coal for use by IPPs, its share is projected to increase apparently from 7% in 2010 to 12% in 2020.

Table. 5 as shown the forecasting on primary energy demand and coal demand outlook according to Consumption and Compound Annual Growth Rate in Thailand. The forecasting on final energy demand and coal demand outlook according to Consumption and Compound Annual Growth Rate in Thailand, the data shown in table 6.

Table. 5. Forecast on primary energy demand

Energy types	Consumption (Ktoe)			Compound Annual Growth Rate [CAGR (%)]		
	2010	2015	2020	2010	2015	2020
Oil	44,954	50,846	57,967	2.6	2.5	2.7
Natural gas	45,852	59,145	66,955	10.1	5.2	2.5
Coal	16,355	20,141	27,881	7.1	4.3	6.7
Hydroelectric	1,510	4,061	6,835	-1.5	21.9	11.0
Renewable	17,371	19,620	22,223	1.8	2.5	2.5
Total	126,405	153,813	181,860	5.4	4.1	3.4

Table. 6. Forecast on final energy demand

Energy types	Consumption (Ktoe)			Compound Annual Growth Rate [CAGR (%)]		
	2010	2015	2020	2010	2015	2020
Oil	37,311	42,099	49,038	2.8	2.4	3.1
Natural gas	8,905	14,204	19,169	26.9	9.8	6.2
Coal	8,333	10,817	13,532	6.9	5.4	4.6
Hydroelectric	14,186	18,930	24,474	6.3	5.9	5.3
Renewable	10,917	11,832	12,838	1.6	1.6	1.6
Total	79,652	97,882	119,051	5.2	4.2	4.0

In the industrial sector, the government targets to replace 5% of oil consumption by natural gas which can be produced domestically. The gas district cooling and cogeneration will be promoted in large industries and buildings and in the industrial estates. The use of renewable energy, especially biomass, is being promoted for heat generation [116-118]. Several measures are introduced, such as, the establishment of the minimum efficiency of the combined heat and power system, measures on biomass management in industrial factories, a tax incentive for industries using biomass fuel, and legal measures on wastewater treatment and waste disposal [119-120]. Coal will be another fuel option in this sector. Imported coal of which the quality is better than domestically produced lignite has been widely used in various industries in Thailand. At present, the government has promoted greater use of clean coal technology to reduce the environmental impact resulting from the use of coal.

6. Conclusions

Thailand's renewable energy framework is supply-side oriented. Policy measures have been designed to focus on incentivizing the increase in supply. The demand for increased renewable energy generation in Thailand has been limited to a small circle of investors. In this case, the role of consumers of electricity is merely as the bearers of costs of renewable energy investment. Hence continuous support for renewable in Thailand should include initiatives to call for more strategic planning, better regulatory support, better governance, and better public communication.

Thailand electricity generating development focuses on sustainability, the efficiency of supply and demand-side management, and public participation, with the aim to save the energy resources and reduce the effects on the environment that are accepted by the whole world as the most suitable way for the good life quality of global populations.

Thailand's renewable energy framework still needs improvement for the following:

- Planning and strategy; the lack of strategic integration in Thailand's energy policies and measures serve as an impediment to renewable energy growth in Thailand overall. In particular, major policies that affect the renewable power industry are not unified, including Thailand's long-term power procurement plan.
- Policy and regulatory framework; though Thailand has made advances in putting in place an attractive feed-in tariff measure. Unforeseen problems that arose during the implementation process included the problem of speculation. Ad hoc and non-transparent responses to these caused delays in the application process for adder support and led to public criticism of poor governance.
- Financing options; financial support does exist from both the private and public sector, both domestically and from international financiers. In order for the market to expand in a continuous and sustainable manner, there is a need for an increase in capacity building in private and public financial institutions to evaluate risks and opportunities in renewable energy.

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