# EFFECT OF ENERGY EFFICIENCY POLICY ON AVOIDED INVESTMENT COST FOR ELECTRICITY UTILITIES

**MR. WATSAPON THARANA**
**ID: 55300700530**

**A THESIS SUBMITTED AS A PART OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ENGINEERING IN ENERGY TECHNOLOGY AND MANAGEMENT**

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Mr. Watsapon Tharana
ID: 55300700530

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Thesis Committee

……………………………….…………
( Dr. Athikom Bangviwat ) Advisor

………………………………………..…
( Dr. Boonrod Sajjakulnukit ) Member

…………………………………………….
( Assoc. Prof. Dr. Apichit Therdyothin ) Member

……………………………….………....
( Dr. Milou Beerepoot ) External Examiner

**Thesis Title:** Effect of Energy Efficiency Policy on Avoided Investment Cost for Electricity Utilities

**Student's name, organization and telephone/fax numbers/email**

Mr. Watsapon Tharana
The Joint Graduate School of Energy and Environment (JGSEE)
King Mongkut's University of Technology Thonburi (KMUTT)
126 Pracha Uthit Rd., Bangmod, Tungkru, Bangkok 10140 Thailand
Telephone: 0-87163-1114
Email: T_tonnet@hotmail.com

**Supervisor's name, organization and telephone/fax numbers/email**

Dr. Athikom Bangviwat
The Joint Graduate School of Energy and Environment (JGSEE)
King Mongkut's University of Technology Thonburi (KMUTT)
126 Pracha Uthit Rd., Bangmod, Tungkru, Bangkok 10140 Thailand
Telephone: 0-81867-3828
Email: Athikom.bangviwat@outlook.com

**Topic:** Effect of Energy Efficiency Policy on Avoided Investment Cost for Electricity Utilities
**Name of student:** Mr. Watsapon Tharana **Student ID :** 55300700530
**Name of supervisor:** Dr. Athikom Bangviwat

## ABSTRACT

A continuous increase in energy demand in Thailand affects the future, including energy supply security, energy costs, dependency on energy imports as well as increasing pollution and carbon dioxide ($CO_2$) emission. As a result, the Ministry of Energy announced 20 years Energy Efficiency Development Plan (EEDP) to reduce energy intensity in 2030 by 25% compared to that in 2005. The improvement of energy intensity will result in a reduction of 20% of final energy consumption in 2030. In order to support EEDP, energy efficiency obligation program which is an obligation of the electricity utilities to support their customers to improve their efficiency in electricity usage, is introduced and analyzed in this research. The analysis is focused on the benefits from reducing electricity demand by implemented measure of EERS, which is one measure of EEDP, and its related cost saving from 2016 to 2030. With the target stated in measure of EERS, which is aimed to reduce 1% of electricity demand a year, it is estimated that the reduction in the year 2030 will be 48,612 GWh, which is equivalent to 60% of EEDP target of electricity consumption reduction. The cumulative saving due to the decrease in electricity consumption during 2016 and 2030 can be calculated to be 12,066.37 Million Bath for utilities and cumulative reduction of $CO_2$ emissions by 160,485.36 kilotons

**Keywords:** Energy Efficiency, EEDP, EERS, Saving costs, $CO_2$ emissions, Utilities

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| ACEEE | American Council an Energy-Efficient Economy |
| Btu | British thermal units |
| BFB | Bubbling fluidized bed |
| $CO_2$ | Carbon dioxide |
| CSE | Cost of saved energy |
| CC | Combined Cycle |
| CCS | Carbon capture and storage |
| CT | Combustion Turbine |
| EE | Energy efficiency |
| EIA | U.S. Energy Information Administration |
| EPPO | Energy policy and planning office |
| EERS | Energy Efficiency Resource Standards |
| EED | Energy Efficiency Directive |
| EEDP | Energy Efficiency Development Plan |
| ENCON | Energy Conservation Promotion Fund |
| EGAT | Electricity Generating Authority of Thailand |
| FC | Fixed costs |
| GDP | Gross domestic product |
| GHG | Green house gases |
| GW | Giga watts |
| GWh | Giga watts hour |
| IPP | Independent power producer |
| IGCC | Integrated gasification combined cycle |
| Kg | Kilogram |
| KW | Kilo watt |

## LIST OF ABBREVIATIONS (Cont')

| | |
|---|---|
| KWh | Kilo watt hour |
| MW | Mega watt |
| MWh | Megawatt hour |
| NEEAP | National Energy Efficiency Action Plan |
| $NO_x$ | Nitrogen oxides |
| O&M | Operation and maintenance |
| OECD | Organization for Economic Cooperation and Development |
| PC | Pulverized coal |
| PDP | Power Development Plan |
| SPP | Small power producer |
| $SO_x$ | Sulphur oxides |
| TC | Total cost |
| Toe | Tons of crude oil equivalents |
| VC | Variable cost |
| VSPP | Very small power producer |

# CHAPTER 1

# INTRODUCTION

## 1.1 Rational/Problem statement

Energy is important because humans have to use a lot of it for living and the increase in energy consumption has many problems in the future, for example, environmental problems or problem of the energy crisis. Especially in energy crisis, the data of world energy consumption which is publicized by the U.S. Energy Information Administration (EIA) [1], illustrated that the growth of world energy consumption will be increased rapidly.

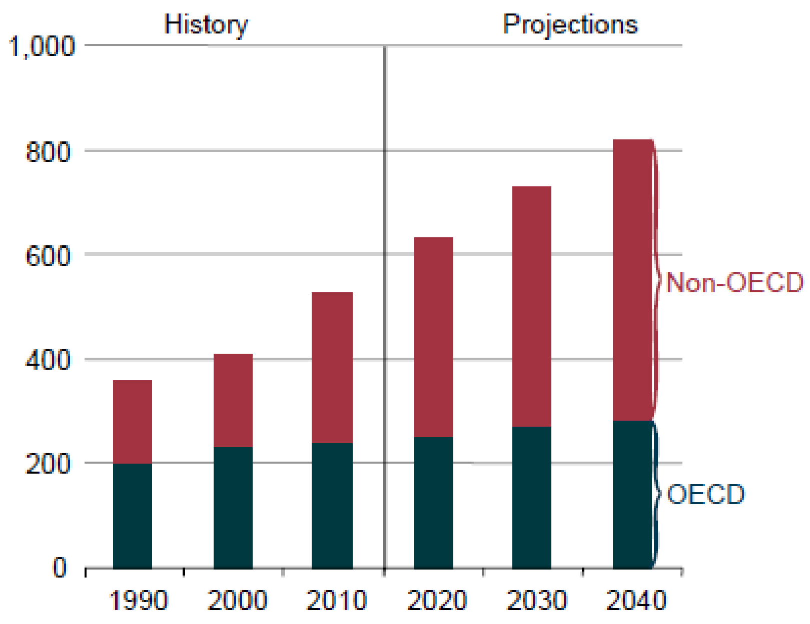


**Figure 1.1** World energy consumption, 1990-2040 (quadrillion Btu) [1].

Figure 1.1 shows that the total energy consumption of the world is projected to increase from about 524 quadrillion British thermal units (Btu) to 630 quadrillion from 2010 to 2020. Moreover, total world energy consumption is projected to increase continuously about 820 quadrillion Btu in 2040, which is equivalent to 56 percent, when it is compared with a consumption in 2010. However, most of the increasing will be occurred by an energy consumption of non-OECD countries (countries outside the organization for economic cooperation and development). When comparing with long term, the energy consumption of OCED countries will increase by 17 percent, but for non-OECD countries, it will increase up to 90 percent.

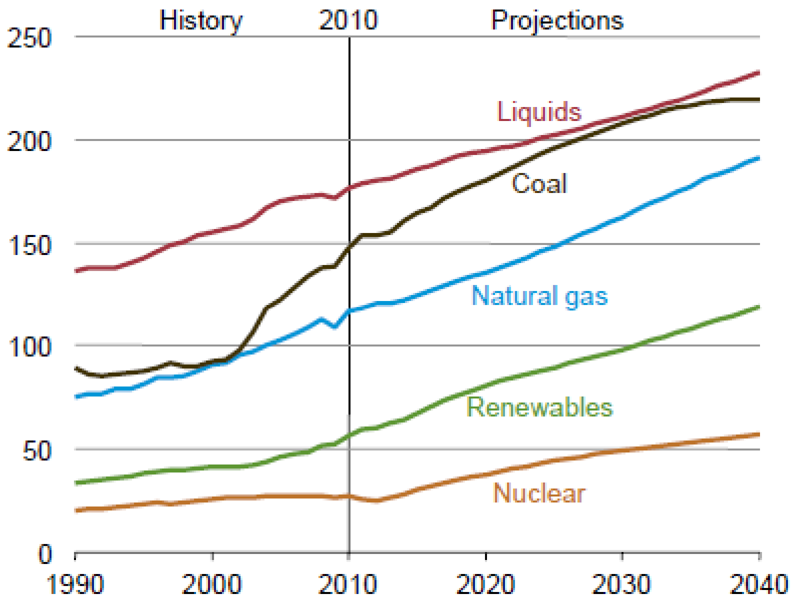


**Figure 1.2** World energy consumption by fuel, 1990-2040 (quadrillion Btu) [1].

Figure 1.2 illustrates world energy consumption by fuel type. Fossil fuel consumption will be increased continuously and it is estimated to increase about 80 percent in each year from 2010 to 2040. Consumption of natural gas is the fastest growing, which is approximated about 1.7 percents a year and Consumption of coal will be increased more than petroleum and other liquid fuel until year of 2030 because after 2030 consumption of coal will be increased by China. However, in the proportions of alternative energy, which are renewable energy and nuclear power, will be the importance of energy sources, this alternative energy is estimated to increase about 2.5 percent a year [1].

According to these data, world energy crisis will certainly occur in the future, for example, lack of energy (energy sources may not be enough for increasing demand), and higher costs of energy. Observing back to the past, nowadays oil prices in Thailand has been increased approximately 5.0 times from the last twenty years cause of increased energy demand, this problem has directly impacted on the people because they have to use oil in normal living, such as, transportation (both of commercial sector and private sector), and industries sector, as a results, this problem has created the difficult living to Thai people from energy expenses. In the same way, the environmental problem will increase as well. This problem also impacts directly on human health. In brief, increasing of energy demand is a world’s problems that every people should be necessarily realized. However, most countries already realized in these energy problems and endeavored to fix or alleviate its. Therefore, the next two topics are about the demonstration of some existed solutions which can alleviate energy problems, first is using of renewable technologies, these renewable technologies have been developed to create new energy sources (supply) which can be used instead of fossil fuel, and second is implementation of policies, most policies has been established to contribute a reduction in energy consumption (demand) of user. These two solutions are a different purpose but actually theses solutions have been implemented as well to alleviate energy problems.

This research focuses on the implemented policies to reduce energy consumption. Therefore this research will be consisted of basic demonstration in renewable technologies, which are expected to promote alternative energy for the readers although the readers already studied in these technologies before.

**1.1.1 Renewable technologies**

This section describes the basic five renewable technologies, solar energy, hydro power, wind power, biomass, and geothermal energy.

**a) Solar energy**

The main source of solar energy is from the sun. This energy is in the form of electromagnetic radiation and travels to the earth in waves of various lengths. Solar energy is a free and inexhaustible energy resource. Nowadays, Human has created the technology to convert solar radiation directly to electricity by photovoltaic cell or solar cell (Figure 1.3). This energy becomes to one of alternative energy that it can alleviate the problems of growing energy demands and environment which are come from using of fossil fuel, when electricity is generated [2].

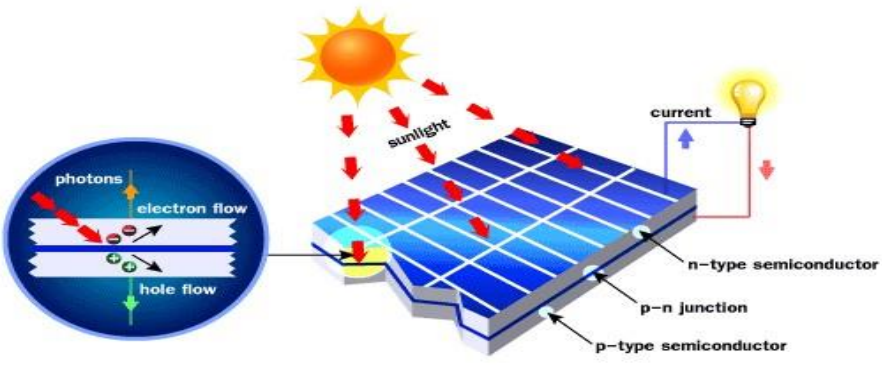


**Figure 1.3** Photovoltaic cells or solar cells [2].

**b) Hydropower**

In the past, mankind converted hydro power into mechanical energy by the use of watermills. The technology was developed until people were able to convert hydro power into electrical energy. By the end of the 19$^{th}$century, the electricity generation from hydro power has been achieved. A dam creates a height difference which is a potential energy called a head between the water before and after the dam (Figure 1.4). Power plants can utilize this potential difference that is derived from falling of water into the turbine. The water flows through a turbine to drive a generator, which can produce electricity [3].

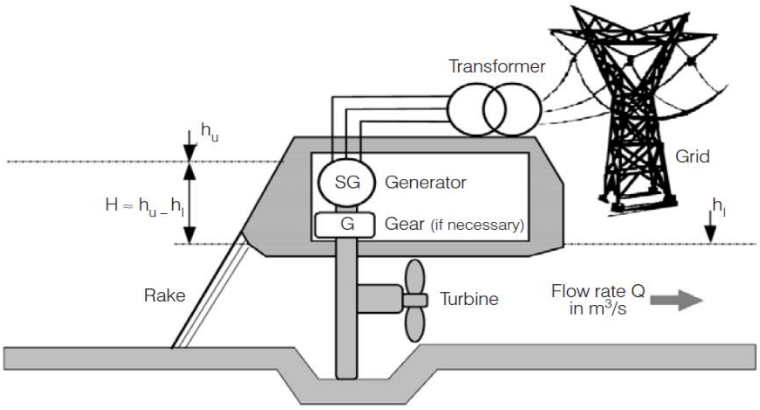


**Figure 1.4** Principle of a hydro-electric power plant [3].

**c) Wind power**

The processes in terms of wind energy or wind power can be described starting from wind, which is the kinetic energy that attacks the wind turbines to drive a generator to convert the kinetic energy of the wind into mechanical power and electrical power, respectively (Figure 1.5). The mechanical power can be used for specific tasks such as grinding grain or pumping water [4].

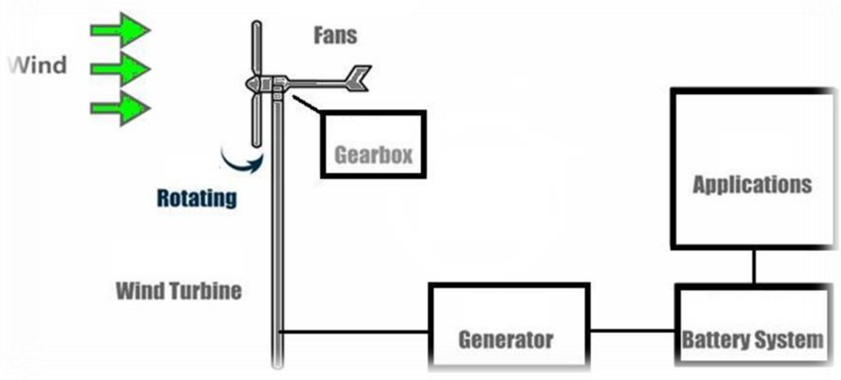


**Figure 1.5** Principle of wind energy [5].

**d) Biomass**

Biomass is an important source of renewable energy with lower content of sulfur and nitrogen than has fossil fuel. When the biomass is combusted, it emits less $NO_x$ and $SO_x$ which less harmful to the environment. Moreover, it is a low cost of energy resource. However, raw biomass has many drawbacks when compared with fossil fuel such as petroleum oil or coal. Firstly, biomass has low energy density or bulky, which makes the handling and transportation of biomass that require large areas. Secondly, the fibrous nature of biomass is cause of the difficulty in size reduction for co-firing with coal in power plant. Furthermore, some biomass has high ash content especially alkaline, which can lead to occur of slag and fouling on the wall of combustion chamber and tube surface in a boiler. Finally, most biomass has high moisture content, which is a result in low heating value [6].

**e) Geothermal energy**

Geothermal energy is a renewable energy source from the heat of the earth. This technology is generated with low carbon emission because geothermal power plants have not the process of burning but this technology can produce steam from a temperature gradient under the earth's surface. In addition to, this technology is equipped with emission-control systems to reduce the exhaust of greenhouse gases, which are occurred by drawn fluids. Thus, geothermal technology has high investment costs, which is about €3.5 million per MW of electricity [7].

**1.1.2 Implementation of policies**

Recently, many policies have been established to reduce energy consumption or to alleviate any energy crisis that may occur in the future. However, this research consists of the detail only policies that have the specific targets to reduce quantity of energy consumption, For example, Energy Efficiency Resource Standards (EERS) in U.S., Energy Efficiency Plan by European Commission, and Especially Energy Efficiency Development Plan (EEDP) in Thailand because this research directly related to EEDP. Accordingly, this research will be included the study in history of energy conservation plans in Thailand before demonstration of EEDP.

**a) Energy Efficiency Resource Standards (EERS)**

Energy Efficiency Resource Standards (EERS) has been implemented by the U.S. government under analysis of the nonprofit organization, which is American Council an Energy-Efficient Economy (ACEEE). The responsibilities of the ACEEE are:

- Analysis in-depth technical and policy.
- Advisor for policy makers and program managers.
- Working with businesses, government officials, public interest groups, and other organizations.
- Establishing workshop, seminar and conference for professionals of energy efficiency.
- Assisting and encouraging traditional and new media to cover energy efficiency policies and technology issues.
- To give a knowledge for businesses via the reports at their websites.

ACEEE's publications consist of many useful articles related to energy efficiency programs that can benefit readers, who would like to study about EE programs.

Energy Efficiency Resource Standards (EERS) has established specific and long-term targets to meet the energy savings. Moreover, EERS can be applied to both of electricity and natural gas utilities with legislation or regulation, theses are designed to suit for state or nation. For example, Table 1.1 shows the saving targets that are depended on states in U.S.

At present, energy efficiency resource standards (EERS) has been implemented in twenty states in the U.S and the targets have been specified as absolute or percentage reductions in energy use relative to business as usual (BAU).

**Table 1.1** Summary of current and pending policies in the U.S [8].

| State | EERS Description | Applies to | Savings Target | Timeframe |
|---|---|---|---|---|
| California | Sets specific energy and demand savings goals. | Investor-owned utilities | Savings goal set for each program year from 2004 to 2013 | 2004-2013 Annual Mwh, MW and therm savings adopted for each of these years. |
| Colorado | Settlement agreement approved by PUC includes specific target utility will make best effort to achieve. | Public Service of Colorado (the major utility in the state) | 320 MW and 800 GWh (40MW and 100 GWh each year) | 2006-2013 |
| Connecticut | Includes energy efficiency at commercial and financial facilities as one eligible source under its Distributed Resources Portfolio Standards | Investor-owned utilities | Savings set for each program year. | |
| | | | 1 | 2007 |
| | | | 2 | 2008 |
| | | | 3 | 2009 |
| | | | 4 | 2010 and thereafter |
| Hawaii | Allow efficiency to qualify as a resource under RPS requirements. | Investor-owned utilities | 20 percents of KWh sales (Overall RPS target EE portion) | 2020 |

**b) Energy Efficiency Directive by the European Commission**

The Energy Efficiency Directive is aimed to reduce the Union's primary energy consumption in 2020 by 20 percent. The EED is forced to legal and measures for Member States have to use more energy efficiency at all of the energy chain. Each Member State has submitted in line with the Directive a National Energy Efficiency Action Plan (NEEAP) together. From the programs plan and an annual report of each member, this research is not mentioned, but it is available in European commission sources [9].

The New Energy Efficiency Directive has been implemented on 4 December 2012, and all 28 countries of EU are cooperated. Under new EED, this was expected to remove barriers that discourage efficiency in the supply side and use of energy and provides for the establishment of indicative national energy efficiency targets for 2020.

**c) History of energy conservation plans in Thailand**

In 1995-1999, Thailand established the energy conservation program, which is called the voluntary program. This program consisted of three main projects to create energy savings, which are renewable energy, and rural industry project, project to support business of energy conservation, and projects of research and development [10].

➢ **Renewable energy and rural industry projects**

This project was created to support using renewable technologies and designed to have less impact in the environment. In detail, this project consists of three main processes, first is distribution of knowledge in renewable technologies, second is increasing of efficiency in renewable technologies or equipment, and third is supporting to use the renewable energy from agricultural residues (bagasse and rice husks) and industrial waste.

Under this project, a total of 1,311 million baht, which was received from the ENCON Fund, was used as a working capital and allocated for providing financial assistance or a subsidy to achieve this project. As a result, a total budget of 598 million baht was used and it was expected that after completion of the life period in equipment or technology used in this project, the savings can be created, following in Table 1.2.

**Table1.2** Benefits of renewable energy and rural industry projects [10].

| Reduction by energy types | Savings | Total of money savings |
|---|---|---|
| Electric energy | 89 million kWh | 2,114 million bath |
| LPG | 109 million kg | |
| Lignite | 616,613 tons | |

➢ **Project to support businesses in energy conservation**

The purpose of this project is the distribution of efficiency technologies. The aim of this project is to increase the demand in efficiency technology from markets and expected to indirectly support for a businesses that related to efficiency technologies, especially in efficiency technologies that are unavailable before.

Under this project, a total budget about 860 million baht, received from the ENCON Fund, was used as the revolving capital and to finance the implementation in this project. As a result, a total budget of 448 million baht was used and was expected to create savings, which are detailed in Table 1.3 below.

**Table 1.3** Benefits from supporting businesses in energy conservation [10].

| Reduction by energy types | Savings | | Total money savings |
|---|---|---|---|
| Electric energy | 209 | million kWh | 583 million bath |
| Diesel | 5 | million liters | |
| Firewood | 203 | tons | |
| LPG | 1 | million kg | |

➢ **Projects of research and development**

This project is to support the research or policies related to energy efficient technologies and including supporting renewable energy used.

As a result, a total budget 610 million bath, allocated to the ECON, was used about 503 million bath to create 55 of the research projects. It was expected that the savings can be created, which are detailed in Table 1.4 after the completion of this project.

**Table 1.4** Benefits of research and development projects [10].

| Reduction by energy types | Savings | Total money savings |
|---|---|---|
| Diesel | 5 million liters | 193 million bath |
| Fuel oil | 305,550 million liters | |
| LPG | 14 million kg | |

For the next period from 2000 to 2004, the voluntary program was extended for energy conservation. A total budget of 29,111.61 million baht was allocated to 3 plans (mandatory plan, voluntary plan, and support plan) and 11 main projects. It was expected to create savings, as shown in table 1.5 [11].

**Table 1.5** Benefit of the voluntary program in 2000–2004 [11].

| | **Mandatory plan** | **Voluntary plan** | **Support plan** | **Total** |
|---|---|---|---|---|
| 1. **Total budget to be used in 3 plans** | 17,021.30 | 6,422.00 | 5,667.31 | 29,110.61 |
| **2. Energy savings** | | | *** | |
| **2.1 Electricity** | | | | |
| - Electricity replacement | | | | |
| Throughout the project life (million unit) | 38,100 | 38,098 | | 76,198 |
| Throughout the project life (million baht) | 95,250 | 39,946 | | 135,196 |
| - Reduction of demand | | | | |
| Megawatt | 626 | 29 | | 655 |
| Investment (million baht) | 36,780 | 1,305 | | 38,085 |
| **2.2 Fuel** | | | | |
| - Fuel replacement | | | | |
| Throughout the project life (million liters) | 5,865 | 788 | | 6,653 |
| Throughout the project life (million baht) | 20,535 | 3,834 | | 24,369 |
| **3.3 Total energy savings** | | | | |
| Throughout the project life (million baht) | 152,565 | 45,085 | | 197,650 |

Continuously from 2005 to 2011, Thailand also established an energy conservation plan. It was expected in 2011 that the increasing of energy efficiency can reduce the energy use, about 10,354 thousand tons of crude oil. This plan was aimed to develop proportion of renewable energy that was increased to 9.2 percent. This plan included the development of people’s knowledge in energy conservation. In the summary of this plan, it is illustrated in Figure 1.6 [12].

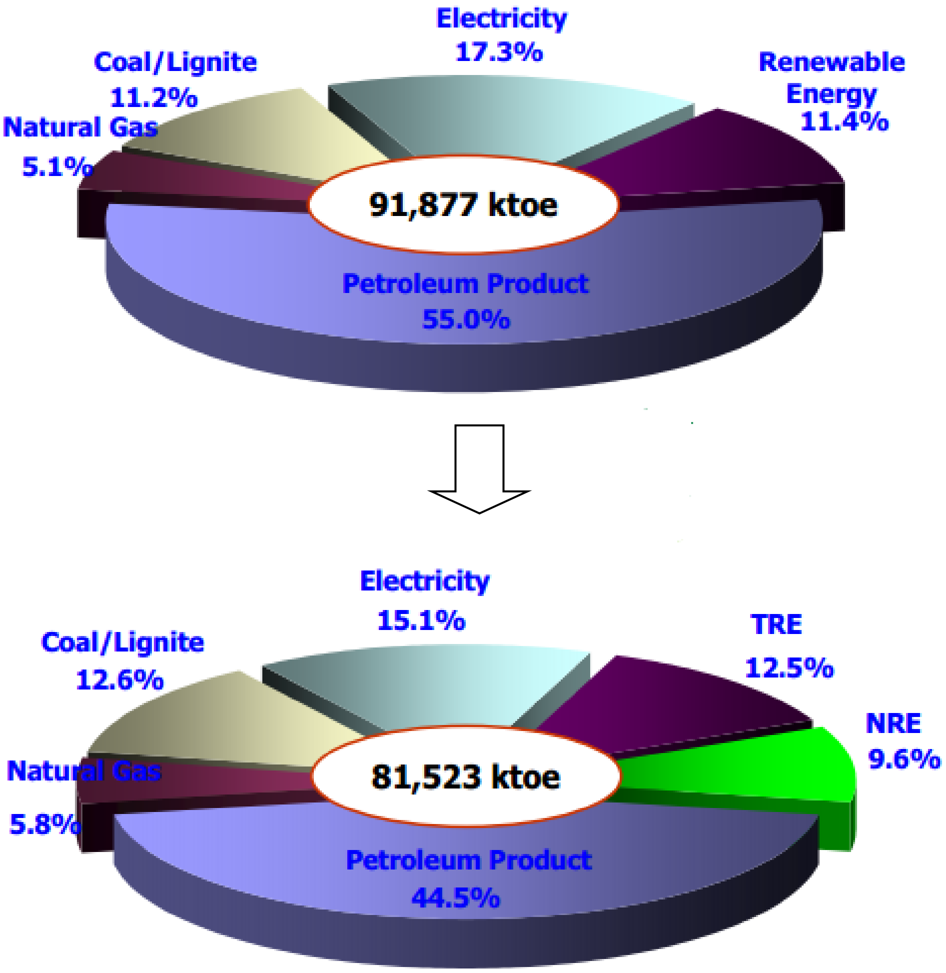


**Figure 1.6** Before (2005) and after (2011) implementation of energy conservation plan.

**e) Energy Efficiency Development Plan (EEDP)**

Energy consumption in Thailand has continuously increased and is approximated to be around 4.4% of the annual average rate in 1990-2010. Recently, the amount of energy consumption is approximated to 2.3 times of the amount consumption in 1990. In the next 20 years (2010 -2030), if there is not have the energy conservation plans or measures of energy efficiency, the energy demand will be projected to increase from 71,000 ktoe to 151,000 ktoe (Figure 1.7), or about 2.1 times of the present amount.

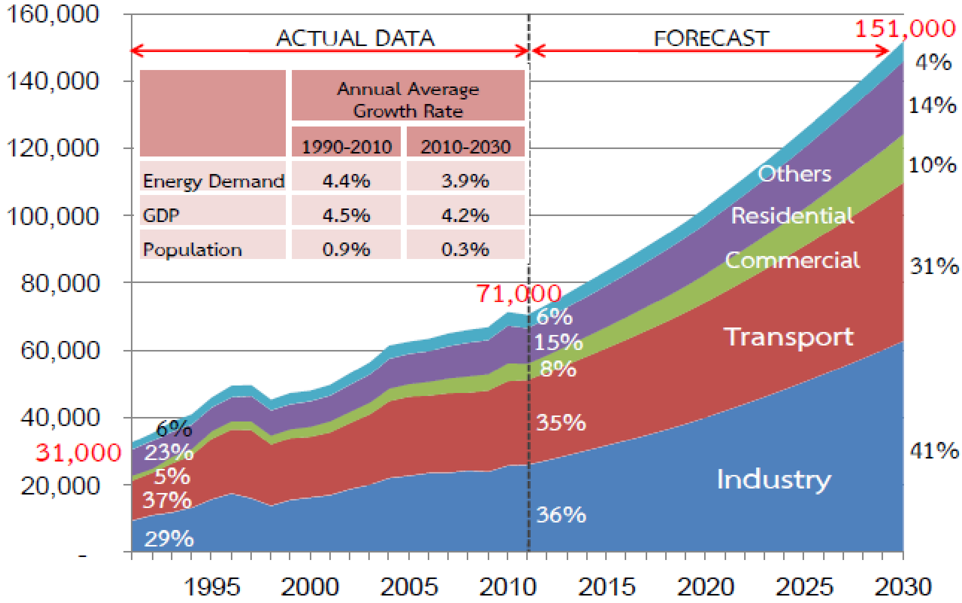


**Figure 1.7** Energy consumption in the past and future demand trend [13].

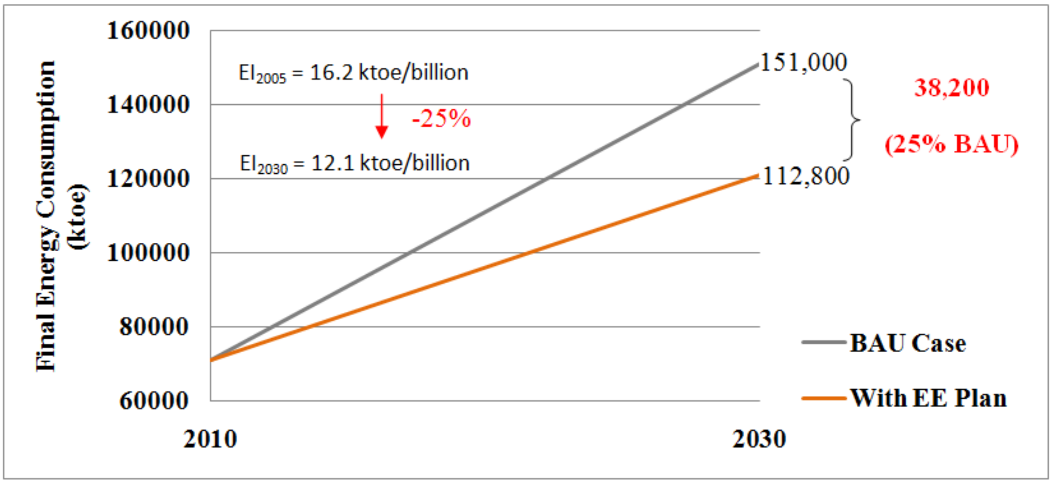


**Figure 1.8** Energy conservation target in 20 years [13].

According to the increase in energy demand, Energy Efficiency Development Plan (EEDP) was established by the Thai government from 2010 to 2030. In the targets, the Energy Efficiency Development Plan (EEDP) is aimed to reduce energy intensity by 25 percents in 2030, when it is compared with 2005. This is approximated to reduce a final energy consumption by 20 percents in 2030 (Figure 1.7), or about 38,200 thousand tons of crude oil equivalent (ktoe). Implemented EEDP has estimated to create about 14,500 ktoe/year of cumulative energy savings, or equivalent to 272 billion baht/year. Moreover, this EEDP can create benefit to environment in reduction of $CO_2$ emission, which has estimated about 49 million tons/year.

## 1.2 Literature Review

### 1.2.1 Study Energy Efficiency programs

This section is detailed about energy efficiency programs for example, basic concept of EE programs, advantage and disadvantage of EE programs, and the assessment of EE programs.

**a) Basic concepts of Energy Efficiency programs**

Energy Efficiency Resource Standards (EERS) is a saving target for utilities through customer energy efficient programs, In the United States has EERS over 30 years but EERS is a relatively new policy for other country. EERS can be successful policy in a variety of market conditions at many countries especially in U.S without government budget. However, there are significant variations in how EERS are designed and implemented, for example, setting target, sectors, cost recovery, and obligation of network or supply companies.

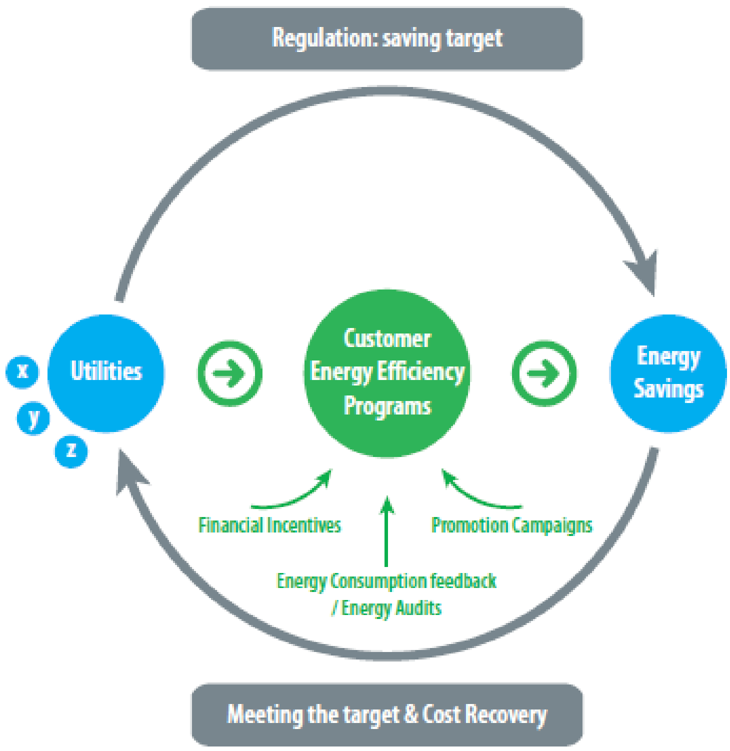


**Figure 1.9** Concepts of energy efficiency resource standards (EERS) [14].

Why Utilities are well suited for implementing EE programs because utilities have relations with customer, and availability of energy consumption data. Utilities can advise infrastructure and expertise in energy efficiency. Moreover, utilities can gain the benefits from implementation of EE programs, which are summarized at table 1.6.

**Table 1.6** Advantages for utilities and customers through EERS [14].

| **Advantages for utilities** | **Utilities provided for customers**<br>**( Advantages for customer )** |
|---|---|
| Reduced needs for additional power plants/avoided difficulties with population acceptance | Financial incentive payments |
| Development of new markets in the field of energy services | Low-interest loans / interest-free loans |
| Avoided or postponed T&D Network upgrades due to peak load reductions | On-bill financing / energy performance contracting |
| Strengthened customer relationship | Free direct installation / equipment replacement |
| Improved reputation | Energy audits / energy saving advice / information campaigns |

**b) Benefits of implementing EERS in the United States**

Based on the results of existing EERS programs of the state, there is strong indication that these programs yield significant benefits to the states and utilities, as well as residential, commercial, and industrial customers [15], including:

- Reduced variable costs for utilities (i.e. lower wholesale power purchase and power production requirements)
- Job creation due to new energy efficiency roles
- Reduced or eliminated need to construct new conventional power plants that emit carbon dioxide
- Lower energy bills for residential, commercial, and industrial customers through reduced energy consumption
- Reduced environmental impacts through lower GHG emissions and reduced pollution.

### 1.2.2 Assessment of Energy Efficiency programs

**a) Ex-ante evaluation of the economy-wide benefits of the Thai EEDP**

This review is about the contents to evaluate the benefits of EEDP (Energy Efficiency Development plan in Thailand) in six indicators [16].

- Energy cost reductions: Economy-wide (national economy perspective) and sector-specific (consumer perspective)
- Reduction of energy import costs
- Reduction of $CO_2$ emissions
- Supporting of energy efficiency investments
- Employment effects
- Effects on governmental budget
- Each indicator has a mathematical model with explanations and results.

**b) Cost Effectiveness**

The cost effectiveness is always used for evaluation of energy efficiency in two indicators. The first is the cost of saved energy, and the second is benefit/cost ratio. Therefore, these two indicators will be demonstrated in meaning and different useful to use for evaluation.

➢ **Cost of saved energy (CSE)**

CSE is Cost of Saved Energy. It is calculated to use for comparing energy efficiency with other energy sources by utilities. The cost may be calculated in various units, such as, $/kWh, $/therm, or $/MWh, and the CSE equation will be showed below.

CSE (in various units) = (T x 10^6) x (Capital Recovery Factor)/ (I x 10^3)

Where: Capital Recovery Factor = [D× (1+D) ^ (M)] ÷ [(1+D) ^ (M)-1]

D = Discount rate

M = Measure life in years

T = Total program cost

I = Incremental savings of electricity (MWh) that year by the energy efficiency program

➢ **Benefit/cost ratio**

Benefit/cost ration can be simply explained that is calculated by a total benefit of the program divided by total costs of the program.

- **The different useful between B/C and CSE**

Program administrators can use the benefit-cost (B/C) ratios to compare with each of programs cost but the values of CSE show only the cost side of its equation. Benefit is important to note that the benefits side of the equation can also vary significantly from state to state. Benefits include avoided energy, capacity, and T&D costs for the UCT, as well as participant and other system-wide, non-energy benefits for the TRC test.

Maggie Molina calculated the levelized utility cost of saved energy (CSE) by collecting a necessary data, such as, annual program costs, energy savings, and measure lifetime. The levelized (CSE) is the best measure to compare energy efficiency with other options of energy source. The calculated value of utility CSE was about 0.028 dollar per kWh for electricity programs and 0.35 dollar per therm for gas programs [17].

In 2004, the ACEEE estimated the cost-effectiveness in both of CSE and benefit/cost rations from nine states in energy efficiency programs. The calculated values of benefit/cost ratios are ranged from 1.0 to 4.3 and the calculated values of utility CSE are ranged from 0.023 to 0.044 dollar per kWh by calculating median value about 0.03 dollar per kWh. In 2009, Katherine Friedrich updated and expanded the assessment to 14 states in energy efficiency programs. Consequently, the utility CSEs are ranged from 0.016 to 0.033 dollar per kWh, or an average 0.025 dollar per kWh and the six natural gas efficiency programs is estimated in this report that have CSE value from 0.27 to 0.55 dollar per therm, or average of 0.37 dollar per therm [18].

### 1.2.3 Related literature of energy efficiency programs

**a) Calculating the nation's annual energy efficiency investments**

John A. "Skip" Laitner illustrated the benefit of energy efficiency investment in economics by estimations of savings and paybacks for each investment (Table 1.7) [19].

**Table 1.7** Savings and payback periods (Years) in energy efficiency investment.

| # | Recommendation | Cost | Savings | Payback |
|---|---|---|---|---|
| 297 | Eliminate Leaks in Inert Gas and Compressed Air Lines/Valves | $608,399 | $2,273,872 | 0.3 |
| 288 | Utilize Higher Efficiency Lamps and/or Ballasts | $7,829,240 | $3,362,338 | 2.3 |
| 180 | Reduce the Pressure of Compressed Air to the Minimum Required | $189,701 | $1,184,348 | 0.2 |
| 173 | Install Occupancy Sensors | $1,168,758 | $739,002 | 1.6 |
| 158 | Use More Efficient Light Source | $22,436,738 | $4,448,634 | 5.0 |
| 108 | Install Compressor Air Intakes in Coolest Locations | $177,869 | $363,707 | 0.5 |
| 88 | Use Multiple Speed AFD Motors for Pump, Blower, Compressor Loads | $2,286,257 | $1,636,760 | 1.4 |
| 74 | Insulate Bare Equipment | $555,689 | $663,401 | 0.8 |
| 66 | Utilize Energy-Efficient Belts and Other Improved Mechanisms | $59,289 | $149,492 | 0.4 |
| 63 | Reduce Compressed Air for Cooling, Agitating Liquids, Moving Product, Drying | $161,412 | $331,810 | 0.5 |
| 1917 | All Other Recommendations | $97,641,128 | $59,080,725 | 1.7 |
| 3412 | Total Combined Recommendations | $133,114,480 | $74,234,089 | 1.8 |
| n/a | Average Per Recommendation | $39,014 | $21,757 | 1.8 |

Source: Integrated Assessment Centers Database, Rutgers University (2012)

**b) Financial analysis of incentive mechanisms to promote energy efficiency: case study of a prototypical southwest utility**

Peter Cappers analyzed in three of energy efficiency portfolios with difference of energy savings targets (Table 1.8) and costs to determine impacts of utility, customers, and society by assuming that 11 year average measure lifetime for all EE portfolios, and costs of significant and aggressive EE portfolios have higher costs than moderate EE due to more expensive measures and higher customer incentives. In the results, each EE portfolios analysis is illustrated on Table 1.9 [20].

**Table 1.8** Three energy efficiency portfolios [20].

| | | | Lifetime Impacts | | | | |
|---|---|---|---|---|---|---|---|
| Energy Efficiency Portfolio | Target % Reduction in Incr. Retail Sales | Ramp-Up Period (Years) | Peak Period Savings (GWh) | Off-Peak Period Savings ( GWh) | Peak Demand Savings (Max MW) | Program Admin. Costs (¢/Lifetime kWh) | Total Resource Costs (¢/Lifetime kWh) |
| Moderate | 0.5%/Year | 2 | 10,452 | 4,479 | 226 | 1.6 | 2.6 |
| Significant | 1.0%/Year | 3 | 19,433 | 8,328 | 421 | 1.8 | 3.0 |
| Aggressive | 2.0%/Year | 5 | 34,314 | 14,706 | 743 | 2.7 | 4.0 |

**Table 1.9** The results of analysis by three energy efficiency portfolios [20].

| Energy Efficiency Portfolio | Total Resource Benefits ($B) | Total Resource Costs ($B) | Net Resource Benefits ($B) | Benefit Cost Ratio | Customer Bill Savings ($B) | Achieved After-Tax ROE |
|---|---|---|---|---|---|---|
| None | N/A | N/A | N/A | N/A | N/A | 10.43% |
| Moderate | $0.67 | $0.26 | $0.41 | 2.6 | $1.10 | 10.39% |
| Significant | $1.22 | $0.55 | $0.67 | 2.2 | $1.69 | 10.36% |
| Aggressive | $2.06 | $1.20 | $0.86 | 1.7 | $2.37 | 10.32% |

**c) Meeting aggressive new state goals for utility-sector energy efficiency: examining key factors associated with high savings**

Martin Kushler examines the key factors to meet high energy savings for increasing savings targets through EERS programs. Main of this report, they show the top-performing states (14 stares) in terms of utility-sector energy efficiency programs (Table 1.10) and identify significant factor that effected on high level of energy savings (Table 1.11). Moreover, this report also has suggestion for each of states to meet their high energy savings target [21].

**Table 1.10** Expert rankings of states on electric utility-sector energy efficiency [21].

| State | Median Rank by Expert Panelist | Number of Times State Was Selected by Expert Panelist as One of Top Ten Leading EE States |
|---|---|---|
| California | 1 | 9 |
| Massachusetts | 3 | 9 |
| Connecticut | 3 | 7 |
| Vermont | 4 | 9 |
| Wisconsin | 6 | 8 |
| New York | 6 | 8 |
| Oregon | 7 | 9 |
| Minnesota | 7 | 6 |
| New Jersey | 9 | 7 |
| Washington | 9 | 6 |
| Texas | 11 | 5 |
| Iowa | 11 | 3 |
| Rhode Island | 13 | 2 |
| Nevada | 14 | 1 |

**Table 1.11** Expert ratings of key energy efficiency factors [21].

| Factor | Importance Up Until Now (Mean Rating of Raters) | Number of Raters Giving Highest Rating Level to This Variable | Likely Importance In Achieving Future Higher Goals (Mean Rating of Raters) | Number of Raters Giving Highest Rating Level to This Variable |
|---|---|---|---|---|
| The relative size of the EE program budget | 8.8 | Five | 9.4 | Four |
| Having a strong state legislative requirement for EE | 8.3 | Three | 9.4 | Six |
| Having a regulatory commission very supportive of EE | 8.0 | Three | 8.5 | Four |
| Having EE programs that are higher quality than typical industry practice | 7.1 | One | 8.0 | Three |
| Having utility shareholder incentives for EE results | 6.8 | One | 8.3 | Three |
| The personal commitment of utility top management | 6.8 | Four | 8.9 | Five |
| Increased experience and capability due to history of prior EE programs | 6.4 | One | 7.7 | One |
| How high the price of electricity (gas) is | 5.6 | None | 6.8 | None |
| Having decoupling in place | 5.4 | One | 7.8 | Three |
| Who administers the EE programs (utility vs. non utility) | 5.1 | None | 5.1 | None |
| Existing state building codes/ efficiency standards, which affect "baseline" conditions | 4.9 | None | 5.9 | None |
| Particular characteristics of state/service territory (e.g., demographics, economy, climate) | 4.5 | None | 5.3 | None |
| Whether a state is "restructured" or not | 4.4 | One | 4.4 | One |
| Having some penalty for poor utility EE performance | 4.0 | None | 5.0 | None |
| Diminished remaining potential due to history of prior EE programs | 3.8 | None | 4.1 | None |
| The perceived cost of carbon emissions | 3.4 | None | 7.9 | None |

**e) What is important when modeling the economic impact of energy efficiency standards**

Matt Croucher examines the necessary factors which are needed to include when examining an economic impact for energy efficiency standards. In addition to, they also have a discussion of some factors may be incorrectly estimated in the economic impact literature and they also demonstrated beneficial details of energy efficiency measures in economic from several literatures. For Example, implementation of energy efficiency measures can increase cumulative savings therefore it is possible that implementation of energy efficiency measures can reduce the capital costs of generation by reducing need to invest in additional power plants [22].

## 1.3 Research Objective

From the increasing energy intensity in Thailand that has more effect to the future, such as, energy supply security, increasing of energy costs, dependency on energy imports as well as increasing of pollution and carbon dioxide ($CO_2$) emissions .Therefore, the Thai government established the 20-year Energy Efficiency Development Plan (EEDP) to reduce energy intensity with the overall aim of 25% in 2030, as compared to 2010.

In order to support this plan, the topic of Effect of Energy Efficiency Policy on Avoided Investment Cost for Electricity Utilities focus on reducing the electricity demand of end users, which can be significant to utility in economic aspects, so that the economics could be implemented to descript the benefits to utilities from reducing electricity demand of end users. In order for utilities to realize the importance and support of this EEDP due to the most common of business model is a consideration with revenue. This means that a reduction in electricity demand would be less revenue from utilities aspect in energy sales. As a consequence, utilities may not necessarily realize the electricity saving as a benefit.

For understanding, energy efficiency resource standard (EERS) is one measure in an energy efficiency development plan (EEDP). EERS is obligated directly with utilities to reduce electricity demand of their customer but if mention to EEDP which consisted of variety measures to reduce energy consumption. According to, this research is designed with an objective are:

1. To determine the economic benefits for utilities received by implemented measures of EERS in EEDP.
2. To estimate the reduction of $CO_2$ emissions received by implemented measures of EERS in EEDP.

Moreover, this research includes the review of financial mechanisms in investment of energy efficiency in ASAIN which can be expected to be knowledge for readers.

## 1.4 Scope and Approach

This research consists of details to study energy efficiency programs in most countries that implement EE programs for more understanding, for example, Energy Efficiency Recourse standards (EERS) in U.S., Energy Efficiency Obligations in Europe and especially Energy Efficiency Development Plan (EEDP) in Thailand, which is directly related to this research. However, the study of EEDP that is a plan for reducing of all energy intensity but this research will be focused only reducing of electricity demand from this plan.

Secondly, this research is designed to analyze in the economic aspects so that when electricity demands can be reduced by end-users under EEDP, and then how to affect utilities by analysis in cost savings. In addition to, this research is included the analysis in environment that is the reduction of $CO_2$ emission and then this research will be summarized the benefits of EEDP to show utilities in two aspect, economics (cost savings), and environment ($CO_2$ emission). Under Assumption, Energy efficiency development plan (EEDP) is aimed to reduce 1% of electricity demand a year from recently.

Lastly, this research also includes the reviews of financial mechanisms to support energy efficiency investment, which can be expected to improve energy efficiency. In review, it consists of financial mechanisms in investment of energy efficiency which was found in ASAIN, including advantages and disadvantages in each type of mechanisms.

# CHAPTER 2

# THEORIES

This chapter consists of theories related to this research in four main topics, the first is to examine the reducing electricity use under EE programs, the second is cost of production, the third is reserve standard of power, and the last is capital cost of power plants. These will be demonstrated in this chapter.

## 2.1 To examine the reduction of electricity use under EE programs

Timothy J. Brennan examines the optimality of Energy Efficiency Resource Standards (EERS) programs that reduce electricity use.

Assume:

- Q be the quantity of electricity demand.
- B(Q) be the benefit of consumers received by using electricity.
- MC(Q) be the marginal cost of electricity generation.
- V(Q) be the value of electricity (B(Q) – C(Q)). For allow V(Q) to change from outside factors, changing from V(Q) to V(Q, θ), where θ is a parameter that are depended on exogenous changes in the cost and benefit functions.
- E(Q) be the external harm associated with electricity generation. To simplify, E(Q) is assumed that it is independent of θ, which is an affected parameter to V.

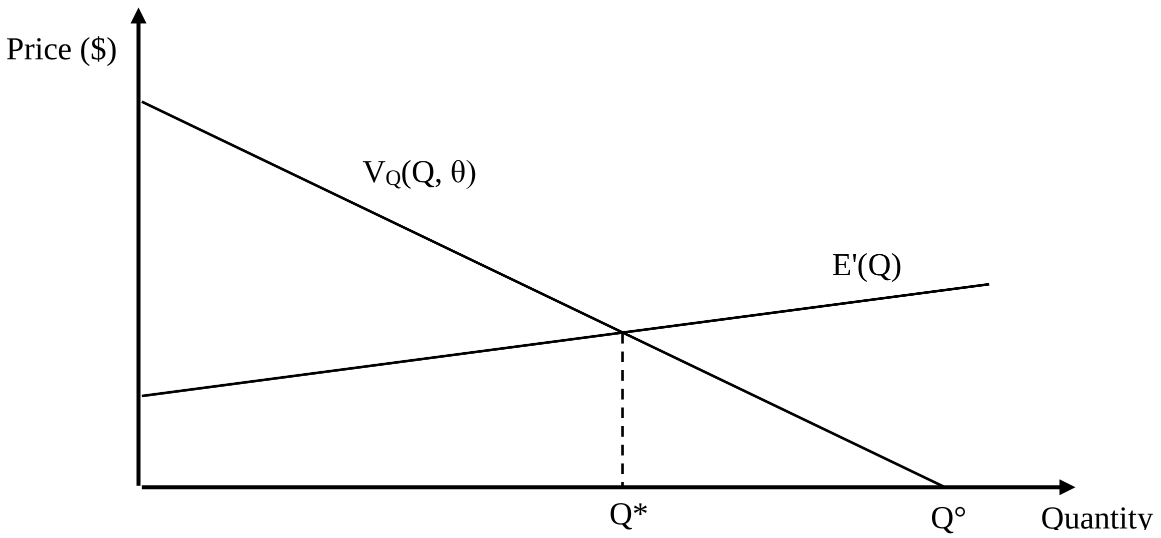


**Figure 2.1** Business-as-usual and optimal electricity use [23].

Figure 2.1, electricity will be used up to the point at $V_Q(Q, \theta) = 0$, assume Q° be the value of Q where this holds. If external harms are taken into account. The net economic is maximized at level of electricity use where $V_Q(Q, \theta) - E'(Q)) = 0$, assume Q* be the level of electricity where this holds. The optimal reduction in electricity use is Q° – Q*, this difference will depend on θ. When assuming no market failures associated with a significant lack of competition or asymmetric information.

When implementing EERS, the savings of electricity will be calculated by the difference in electricity quantity between absence of policy and presence of policy, or equals to $Q_{BAU} - Q_{EERS}$. However, savings quantity of electricity depended on EERS goals. Timothy J. Brennan also illustrated EERS to meet savings in two characteristics, fixed-quantity EERS (Figure 2.2), Fixed-Percentage EERS (Figure 2.3), and at marginal external harm (E'(Q)) is constant.

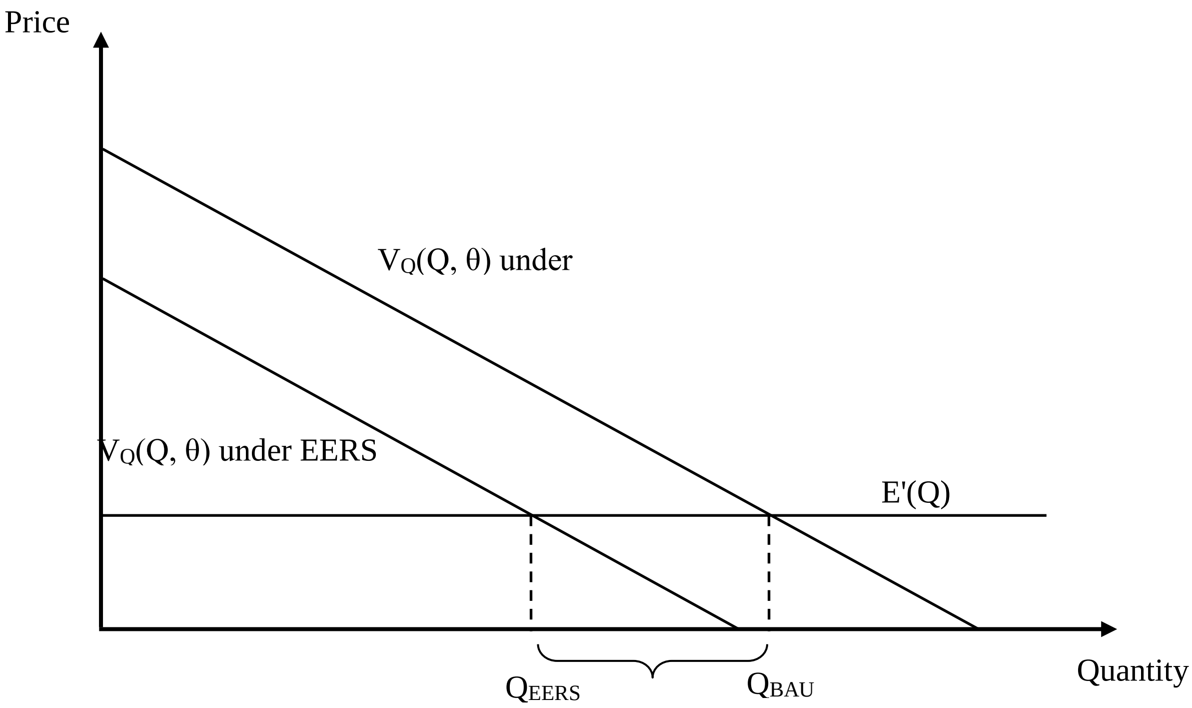


**Figure 2.2** Potential optimality of a fixed-quantity EERS [23].

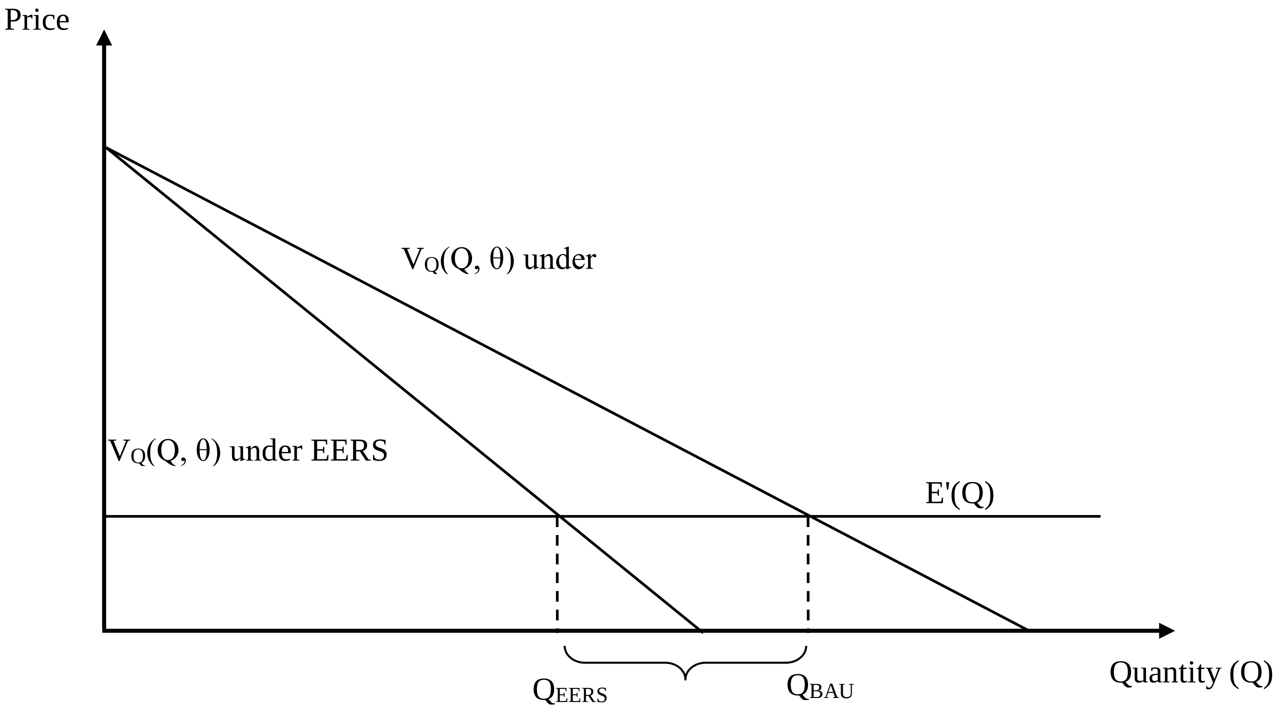


**Figure 2.3** Potential optimality of a fixed-percentage EERS [23].

## 2.2 Costs of production

Generating electricity of power plants, has high costs to produce electricity but most costs are fixed cost. Thus, this topic will be demonstrated the components of production cost, Total cost (TC), Fixed cost (FC), Variable cost (VC), and marginal cost.

**Table 2.1** Fixed, Variable, and Total cost.

| Quantity q | Fixed cost FC ($) | Variable cost VC ($) | Total cost TC ($) |
|---|---|---|---|
| 0 | 60 | 0 | 60 |
| 1 | 60 | 30 | 90 |
| 2 | 60 | 55 | 115 |
| 3 | 60 | 75 | 135 |
| 4 | 60 | 105 | 165 |
| 5 | 60 | 155 | 215 |
| 6 | 60 | 225 | 285 |

When considering with company that produces a quantity of product (denoted q) by using inputs of capital, labors, and materials, the company's accountants have the task of calculating the total dollar costs incurred to produce product level q.

**a) Total costs**

Table 2.1 shows the total costs (TC) for each different level of product q. it indicates that TC goes up as q goes up. This makes sense because it takes more labor and other inputs to produce more of good; extra factors involve an extra money cost. It cost $115 in all to produce 2 units, $130 to produce 3 units, and so forth.

**b) Fixed costs**

Fixed costs are expense that must be paid even of the company produces zero products, such as, cost from factory rent or payment for salaries. They are fixed because they do not change if product changes. For example, a law company might have an office lease which runs for 10 years and remains an obligation even if the company shrinks to half its previous size. Because FC is the amount that must be paid regardless of the level of product, it remains constant at $55.

**c) Variable costs**

Variable costs do vary as the quantity of product changes. Examples include materials required to produce product, such as, steel to produce automobiles, production workers to staff the assembly lines, power to operate factories, and so on. In a supermarket, checkout clerks' hours worked to match the number of shoppers coming though the store. By definition, VC begins at zero when q is zero. VC is the part of TC that grows with product; indeed, the jump in TC between any two outputs is the same as the jump in VC.

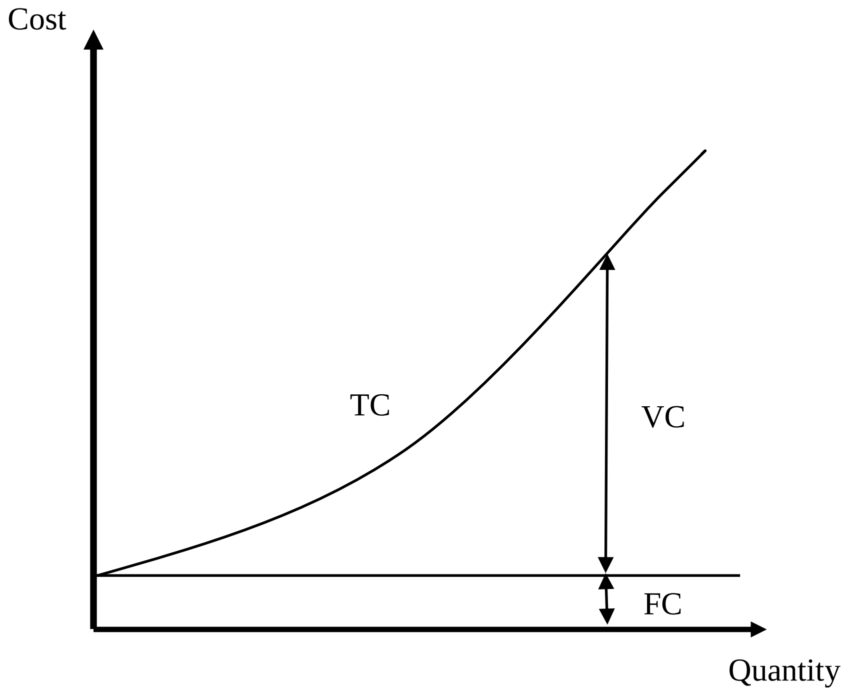


**Figure 2.4** Total costs, Fixed Costs, and Variable costs.

Total costs show the lowest total dollar expense that needed to produce in each of product level (q). So, TC will be increased, when q rises. Fixed costs show the total dollar expense that is still paid although no product is produced. So, fixed costs are not depended on quantity of product.

**d) Marginal costs**

Marginal costs (MC) are the extra or additional cost of producing 1 extra unit of product. Assuming, a company is producing 1000 compact discs for a total cost of $10,000. If the total cost of the TC of the subsequent quantity. Thus the MC of the first product is $30 (= $90 - $60); the marginal cost of the second unit is $25 (= $115 - $90); and so on.

Instead of getting MC from the TC column, we could get the MC figures by subtracting each VC number in column 3 of Table 2.1 from the VC in the row below it. Variable cost always grows exactly like total cost. The only difference being that VC must (by definition) start out from 0 rather than from the constant FC level (Check that $30 - $0 = $85 -$55, and $55 - $30 = $110 - $85, and so on).

**Table 2.2** Calculation of marginal costs.

| (1)<br>Quantity<br>q | (2)<br>Total costs<br>TC<br>($) | (3)<br>Marginal costs<br>MC<br>($) |
|---|---|---|
| 0 | 55 | |
| | | 30 |
| 1 | 85 | |
| | | 25 |
| 2 | 110 | |
| | | 20 |
| 3 | 130 | |
| | | ----- |
| 4 | 160 | |
| | | 50 |
| 5 | 210 | |

## 2.3 Reserve standard of power

- Standby reserve is reserved power which has been identified at 15 percent of peak demand, following world standards. For example, if the forecast of peak demand is equal to 33,000 MW, the reserved power must be installed up to 5,000 MW. Due to generating of power must be considered in many factors, such as, over demand forecast, lifetime of power plant, and risk of fuels [24].
- Spinning reserve is the reserve capacity of a power plant that can be immediately activated, when the system lacks power. The world standard is identified at 800 MW to 1600 MW, or the least of capacity is more than capacity of the largest power plant. This spinning reserve is used for supporting, if the uncontrollable of lacked power will be occurred or preventing blackout, blackout is a condition of lacked power in large area [24].

## 2.4 Capital cost of power plants

The capital costs of power plants are differently estimated in each country. This research must be analyzed in cost savings to utilities, the capital costs of power plants that will be used for estimation. Mainly, it is received from estimation of EIA which are shown in Table 2.3.

**Table 2.3** Updated estimates of power plant capital and operating costs [25].

| | Plant Characteristics | | Plant Costs (2012$) | | |
|---|---|---|---|---|---|
| | **Nominal Capacity (MW)** | **Heat Rate (Btu/kWh)** | **Overnight Capital Cost ($/kW)** | **Fixed O&M Cost ($/kW-yr)** | **Variable O&M Cost ($/MWh)** |
| **Coal** | | | | | |
| Single Unit Advanced PC | 650 | 8,800 | $3,246 | $37.80 | $4.47 |
| Dual Unit Advanced PC | 1,300 | 8,800 | $2,934 | $31.18 | $4.47 |
| Single Unit Advanced PC with CCS | 650 | 12,000 | $5,227 | $80.53 | $9.51 |
| Dual Unit Advanced PC with CCS | 1,300 | 12,000 | $4,724 | $66.43 | $9.51 |
| Single Unit IGCC | 600 | 8,700 | $4,400 | $62.25 | $7.22 |
| Dual Unit IGCC | 1,200 | 8,700 | $3,784 | $51.39 | $7.22 |
| Single Unit IGCC with CCS | 520 | 10,700 | $6,599 | $72.83 | $8.45 |
| **Natural Gas** | | | | | |
| Conventional CC | 620 | 7,050 | $917 | $13.17 | $3.60 |
| Advanced CC | 400 | 6,430 | $1,023 | $15.37 | $3.27 |
| Advanced CC with CCS | 340 | 7,525 | $2,095 | $31.79 | $6.78 |
| Conventional CT | 85 | 10,850 | $973 | $7.34 | $15.45 |
| Advanced CT | 210 | 9,750 | $676 | $7.04 | $10.37 |
| Fuel Cells | 10 | 9,500 | $7,108 | $0.00 | $43.00 |
| **Uranium** | | | | | |
| Dual Unit Nuclear | 2,234 | N/A | $5,530 | $93.28 | $2.14 |
| **Biomass** | | | | | |
| Biomass CC | 20 | 12,350 | $8,180 | $356.07 | $17.49 |
| Biomass BFB | 50 | 13,500 | $4,114 | $105.63 | $5.26 |
| **Wind** | | | | | |
| Onshore Wind | 100 | N/A | $2,213 | $39.55 | $0.00 |
| Offshore Wind | 400 | N/A | $6,230 | $74.00 | $0.00 |
| **Solar** | | | | | |
| Solar Thermal | 100 | N/A | $5,067 | $67.26 | $0.00 |
| Photovoltaic | 20 | N/A | $4,183 | $27.75 | $0.00 |
| Photovoltaic | 150 | N/A | $3,873 | $24.69 | $0.00 |
| **Geothermal** | | | | | |
| Geothermal – Dual Flash | 50 | N/A | $6,243 | $132.00 | $0.00 |
| Geothermal – Binary | 50 | N/A | $4,362 | $100.00 | $0.00 |
| **Municipal Solid Waste** | | | | | |
| Municipal Solid Waste | 50 | 18,000 | $8,312 | $392.82 | $8.75 |
| **Hydroelectric** | | | | | |
| Conventional Hydroelectric | 500 | N/A | $2,936 | $14.13 | $0.00 |
| Pumped Storage | 250 | N/A | $5,288 | $18.00 | $0.00 |

# CHAPTER 3

# METHODOLOGY

The main methodology in this research is an analysis of economic aspects to support Energy Efficiency Development Plan (EEDP) for utilities. Moreover, this chapter includes the review of financial mechanisms of energy efficiency investment in industries that can be expected to be knowledge for the readers.

## 3.1 Economic aspect

According to Chapter 1, Energy Efficiency Development Plan (EEDP) is aimed to reduce all final energy consumption. However, this research is designed to focus only the benefits from reducing of electricity consumption. In order to support this plan, this research is designed to find the benefits in economic aspect which can be received by measures of EERS from EEDP. Accordingly, utilities of Thailand will be directly related to this analysis.

This analysis will show that utilities can receive the benefits from supporting their customers to reduce their electricity demand and the benefits will be shown in cost savings. Thus, this topic is conducted to analyze a cost saving to utilities by EERS.

### 3.1.1 Necessary Data

The necessary data in this analysis are received by power development plans in Thailand [26]. The two main data, which are the projection of generation capacity from 2012 to 2030 and project electricity demand from 2011 to 2030. These two data are shown in Appendix A.

#### a) Data Adjustment

However, projected capacity in Appendix A is shown in units of capacity (MW), but this research analyzes in units of energy (GWh). Therefore, this research has the calculation to change from capacity unit (MW) to energy unit (GWh), following on Equation 3.1. As a consequence, the value of projected generation capacity in the energy unit (GWh) will be shown in Table 3.1.

$$\mathrm{E\ (GWh)} = \frac{\mathrm{C(MW)} * 24 * 365}{1000} * \mathrm{L} \quad \text{------------------- (3.1)}$$

When:

E = Electricity in unit of energy (GWh)

C = Electricity in unit of capacity (MW)

L = Load factors

For example: In year of 2012 $\frac{34{,}265 \times 24 \times 365}{1000} \times \frac{75.84}{100} = 227{,}642.41$

**Table 3.1** Projected capacity, converted to units of energy (GWh).

| Year | Units of capacity (MW) | Load factor (%) | Units of energy (GWh) |
|---|---|---|---|
| 2012 | 34,265 | 75.84 | 227,642.41 |
| 2013 | 36,491 | 76.24 | 243,709.67 |
| 2014 | 39,542 | 75.98 | 263,185.54 |
| 2015 | 43,157 | 75.80 | 286,565.93 |
| 2016 | 45,530 | 75.59 | 301,485.27 |
| 2017 | 47,240 | 75.37 | 311,897.94 |
| 2018 | 48,329 | 75.16 | 318,198.91 |
| 2019 | 51,386 | 75.24 | 338,686.36 |
| 2020 | 50,389 | 75.29 | 332,335.81 |
| 2021 | 52,912 | 75.34 | 349,207.77 |
| 2022 | 56,135 | 75.39 | 370,724.75 |
| 2023 | 56,732 | 75.43 | 374,866.22 |
| 2024 | 59,509 | 75.48 | 393,476.36 |
| 2025 | 60,477 | 75.51 | 400,035.76 |
| 2026 | 64,007 | 75.57 | 423,721.99 |
| 2027 | 64,979 | 75.61 | 430,384.25 |
| 2028 | 67,012 | 75.65 | 444,084.50 |
| 2029 | 69,358 | 75.72 | 460,056.61 |
| 2030 | 70,686 | 75.75 | 469,051.09 |

As a result, projected electricity demands and projections of generation capacity in units of energy (GWh) are plotted in Figure 3.1 and Figure 3.2 respectively. In this analysis, projected electricity demand will be called BAU to simplify understanding.

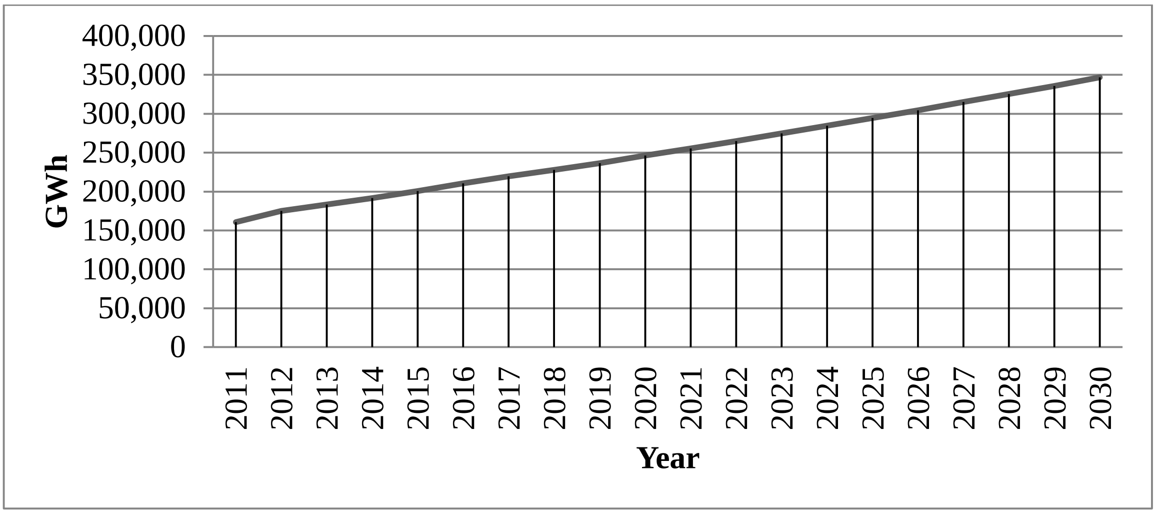


**Figure 3.1** Projected electricity demand (BAU) [26].

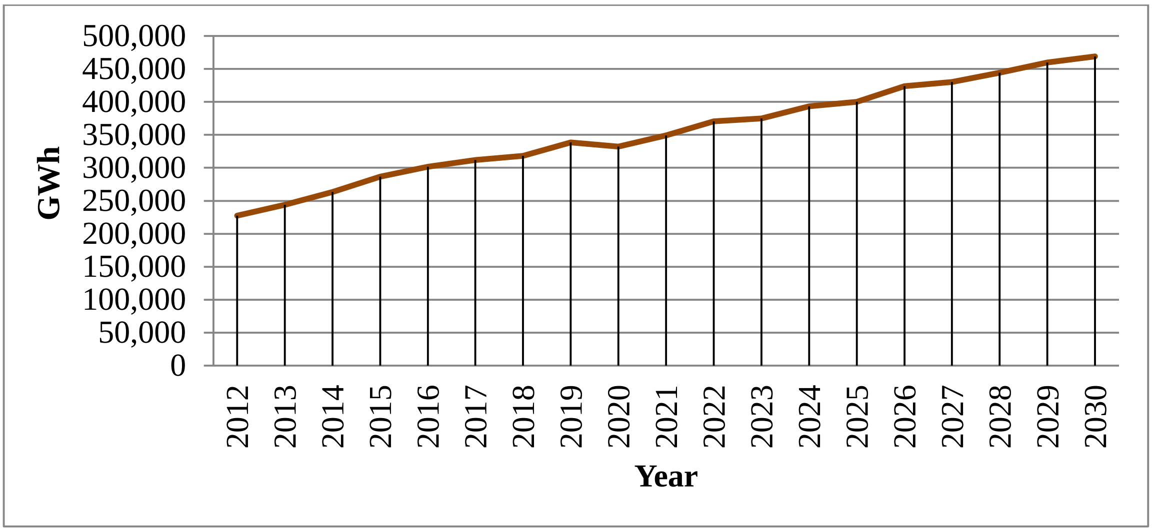


**Figure 3.2** Projection of generation, converted to units of energy (GWh).

### 3.1.2 Projected electricity demand under EERS target

**a) Setting target of EERS**

An electricity target, Energy Efficiency Development plan, was aimed to reduce 81,116 GWh of electricity demand in 2030 (Table 3.2 and Figure 3.3) by all measures. However, this research analyzes under the assumption that the measures of EERS, is aimed to reduce 1% of electricity demand a year, started from 2016, this target is received by studying of energy efficiency programs.

**Table 3.2** Share of energy savings by economic sector in 2030 [13].

| Economic sector | Technical Potential in 2030 | | | Specified Target in 2030 | | |
|---|---|---|---|---|---|---|
| | Electricity (GWh) | Heat (Ktoe) | Total (Ktoe) | Electricity (GWh) | Heat (Ktoe) | Total (Ktoe) |
| Industry | 42,146 | 13,758 | 17,349 | 39,112 | 12,767 | 16,100 |
| Transportation | - | 22,528 | 22,528 | - | 16,800 | 16,800 |
| Large commercial building | 27,416 | 405 | 2,741 | 23,007 | 340 | 2,300 |
| Small commercial building & residential | 23,219 | 1,693 | 3,671 | 18,972 | 1,383 | 3,000 |
| Total | 104,182 | 38,548 | 47,426 | 81,116 | 31,288 | 38,200 |

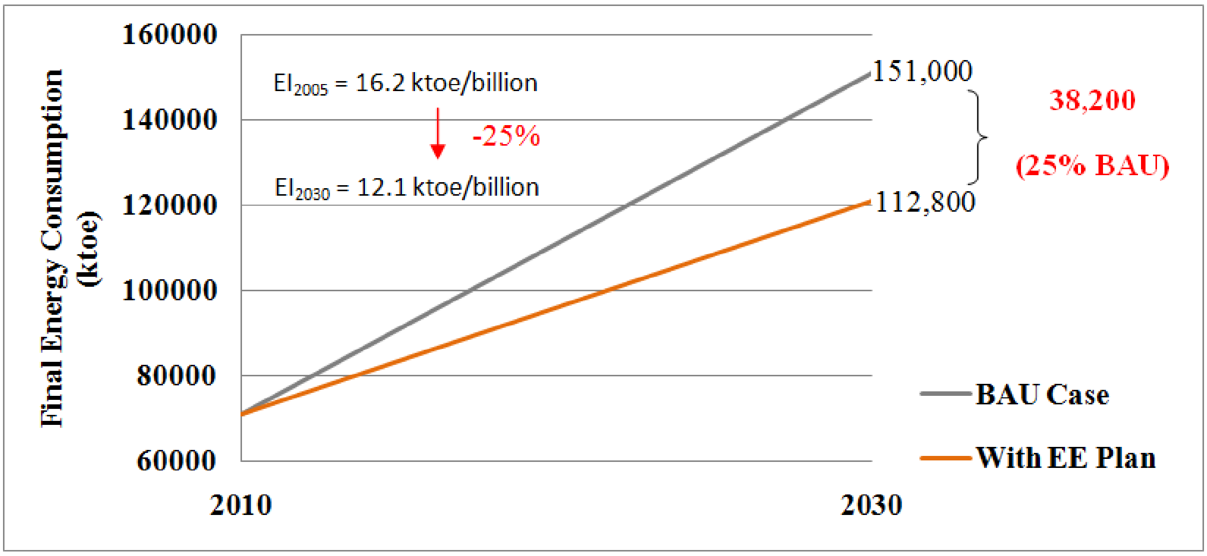


**Figure 3.3** Energy conservation target in 20 years [13].

**b) Finding growth rate of electricity demand**

Before projection of electricity demand under EERS target, the growth rate is necessary to use for projecting electricity demand. Accordingly, the growth rate is calculated by using the data of projected electricity demand at Appendix A. The values of the growth rate year are shown in Table 3.3.

In Table 3.3, the values of growth rate per year are not stable. To simplify the projection of electricity demand under EERS target, average growth rate is estimated to use instead. Consequently, the value of average growth rate from 2015 to 2030 is equal to 3.71 percent.

For example, the calculation of the growth rate from 2014 to 2015:

$$\frac{210{,}619 - 200{,}726}{200{,}726} \times 100 = 4.93$$

**Table 3.3** Growth rate of electricity demand from 2015 to 2030.

| Year | Electricity Demand (GWh) | Growth Rate (%) |
|---|---|---|
| 2015<br>2016 | 200,726<br>210,619 | 4.93 |
| 2016<br>2017 | 210,619<br>219,616 | 4.27 |
| 2017<br>2018 | 219,616<br>227,760 | 3.71 |
| 2018<br>2019 | 227,760<br>236,408 | 3.80 |
| 2019<br>2020 | 236,408<br>246,164 | 4.13 |
| 2020<br>2021 | 246,164<br>255,591 | 3.83 |
| 2021<br>2022 | 255,591<br>265,039 | 3.70 |
| 2022<br>2023 | 265,039<br>274,672 | 3.63 |
| 2023<br>2024 | 274,672<br>284,640 | 3.63 |
| 2024<br>2025 | 284,640<br>294,508 | 3.47 |
| 2025<br>2026 | 294,508<br>304,548 | 3.41 |
| 2026<br>2027 | 304,548<br>314,925 | 3.41 |
| 2027<br>2028 | 314,925<br>325,470 | 3.35 |
| 2028<br>2029 | 325,470<br>335,787 | 3.17 |
| 2029<br>2030 | 335,787<br>346,767 | 3.27 |
| **Average growth rate is 3.71 percent** | | |

**c) Projected electricity demand under EERS target from 2016 to 2030**

Electricity demand under EERS target will be projected. Thus, the calculations and estimated value of electricity demand from 2016 to 2030 are shown in Table 3.4.To project electricity demand under EERS target from 2016 to 2030, which follow Equation 3.2.

$$E_i = (E_{i-1} \times 1.0371) \times 0.99 \qquad \text{------------ (3.2)}$$

Where: $E_i$ = Electricity demand under EERS target at year of i

In Table 3.4, this table shows projection of electricity demand under EERS by started target from 2016. Therefore, electricity demand at 2015 is necessary to project a demand at 2016. The value of electricity demand at 2015 is from the data of projected electricity demand in Appendix A. It is equal to 200,726.00 GWh. The value of 1.0371 is an average growth rate which is from previous estimation and the value of 0.99 is a reduced target of EERS.

Equation 3.2 explains that electricity demand will increase at 3.71% per year by average growth rate. It will be reduced 1% per year by EERS target of electricity demand from 2016 to 2030.

**Table 3.4** Projection of electricity demand under EERS target.

| **i** | **($E_{i-1}$ * 1.0371)*0.99** | **Electricity demand under EERS** |
|---|---|---|
| 2015 | - | 200,726.00 |
| 2016 | ( 200,726.00 * 1.0371 ) * 0.99 | 206,091.21 |
| 2017 | ( 206,091.21 * 1.0371 ) * 0.99 | 211,599.82 |
| 2018 | ( 211,599.82 * 1.0371 ) * 0.99 | 217,255.67 |
| 2019 | ( 217,255.67 * 1.0371 ) * 0.99 | 223,062.70 |
| 2020 | ( 223,062.70 * 1.0371) * 0.99 | 229,024.94 |
| 2021 | ( 229,024.94 * 1.0371 ) * 0.99 | 235,146.55 |
| 2022 | ( 235,146.55 * 1.0371 ) * 0.99 | 241,431.78 |
| 2023 | ( 241,431.78 * 1.0371 ) * 0.99 | 247,885.01 |
| 2024 | ( 247,885.01 * 1.0371 ) * 0.99 | 254,510.73 |
| 2025 | ( 254,510.73 * 1.0371 ) * 0.99 | 261,313.54 |
| 2026 | ( 261,313.54 * 1.0371 ) * 0.99 | 268,298.19 |
| 2027 | ( 268,298.19 * 1.0371 ) * 0.99 | 275,469.54 |
| 2028 | ( 275,469.54 * 1.0371 ) * 0.99 | 282,832.56 |
| 2029 | ( 282,832.56 * 1.0371 ) * 0.99 | 290,392.39 |
| 2030 | ( 290,392.39 * 1.0371 ) * 0.99 | 298,154.29 |

As a result, the projected electricity demand under EERS target is plotted at Figure 3.4.

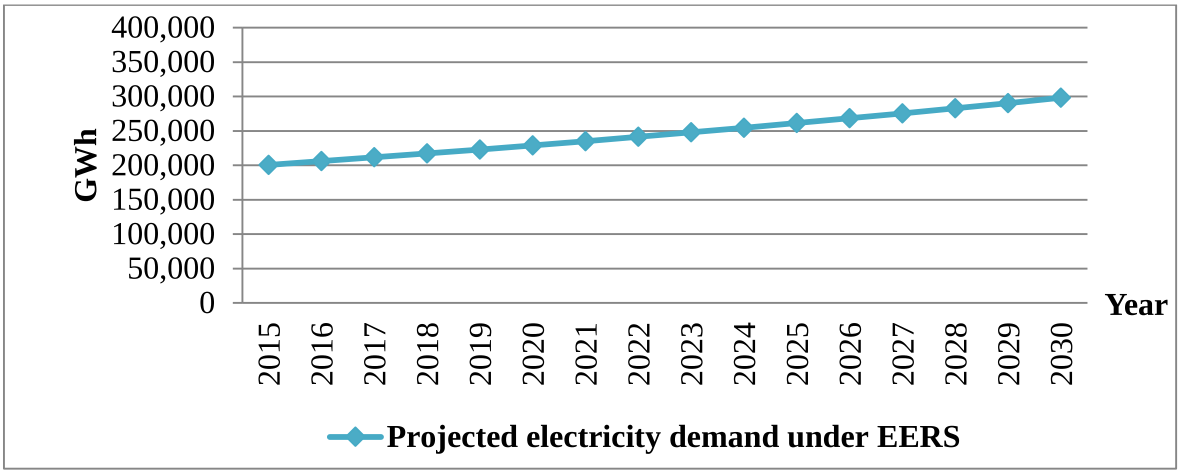


**Figure 3.4** Projected electricity demand under EERS.

### 3.1.3 Analysis of cost savings

Figure 3.5 indicates that the projected capacity is still higher than the electricity demand under EERS from 2015 to 2030. It means that the projected capacity is over necessary to an electricity demand under EERS. Therefore, this research is designed to analyze that if some investment of additional capacity can be postponed to optimize with electricity demand under EERS, how much of cost savings can be created.

Moreover, this research also finds the reduction of $CO_2$ emissions from reducing electricity demand by EERS. These analyses are presented in Chapter 4, which is an analyzed result.

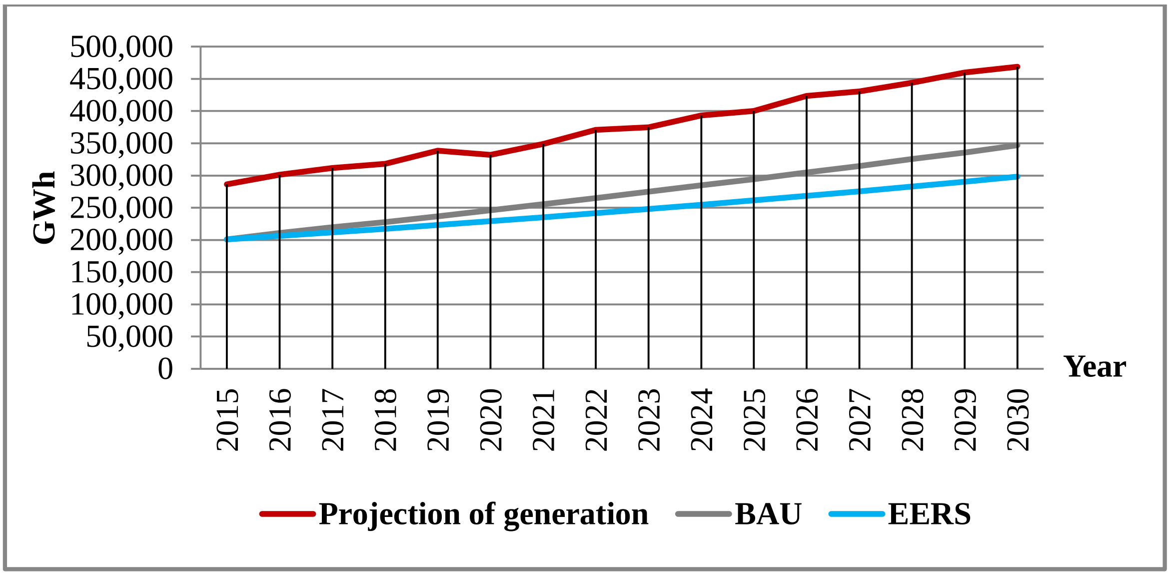


**Figure 3.5** Comparing with projection of generation, BAU, and EERS.

## 3.2 Financial mechanisms

In figure 3.6, this research already showed in chapter 1. It indicates that most of the energy consumption in the future will come from rapid industrialization. As results, the environmental problem will be raised from this energy consumption trend, for example, greenhouse gas (GHG) emissions, $CO_2$ emissions.

Consequently, this research includes the review of financial mechanisms to support energy efficiency investments especially in industry. The major source of this review was extracted from a paper of financial mechanisms for improving energy efficiency in industry in Asia [27].

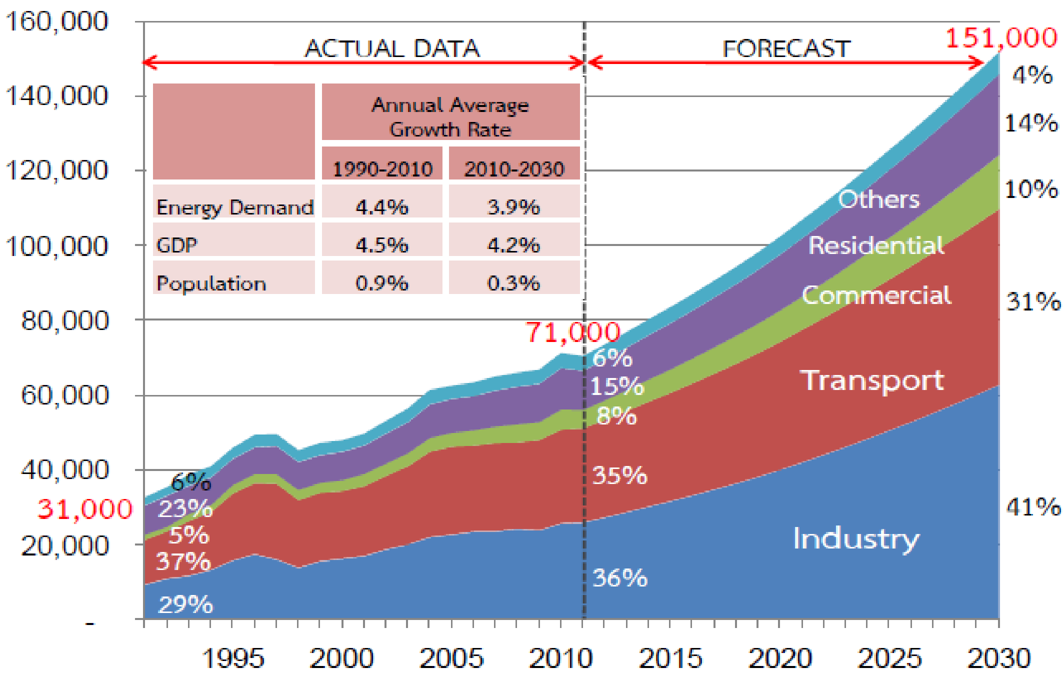


**Figure 3.6** Energy consumption in the past and future demand trends [13].

Accordingly, the next part will demonstrate to types of financial mechanisms, which impact the investment of energy efficiency projects for industrial entrepreneurs.

### 3.2.1 The review of types of financial mechanisms

This part demonstrates the meaning of each financial mechanism, as shown in Table 3.5.

**Table 3.5** Types of financial mechanisms [27].

| | |
|---|---|
| **Tax policy** | - Tax incentives |
| **Subsidies** | - Subsidies |
| **Lending programs** | - Bank loans |
| | - Soft loans / revolving funds |
| | - Guarantee funds |
| | - Energy efficiency "Bank windows" |
| **ESCOs** | |

**a) Tax incentive**s

The reduction in taxes by government can be incentive to support business in investment of energy efficiency. Therefore, tax incentives can be used to create or increase energy efficiency projects.

- **Accelerated depreciation**

These tax incentives can make more attractive to business in investment of energy efficiency. The rapid depreciation is effected to reduce taxable income of business, when it is compared with the normal depreciation at the same life time of purchased equipment. Therefore, under accelerated depreciation is to reduce cost of energy efficiency investment for business.

- **Tax deductions**

This tax incentive is a deduction of investment cost in energy efficiency technologies from the business's annual profits. For example, if businesses have to pay 20 percent for income taxes, businesses will be received a saving by the deduction in investment cost of energy efficient equipment or technologies that would be 20 percent of its cost.

- **Tax credits**

Under this tax incentive is to allow businesses for reduction in total tax liabilities that is reduced from some or all of investment costs in energy efficiency. Tax credits can create more savings to business than tax deductions and accelerated depreciation because it directly give a reduction in the amount of taxes but tax deductions and accelerated depreciation is to only reduce the amount of taxable profit by a percentage of the cost of the investment.

- **Tax reductions**

Tax reduction is an incentive to import energy efficiency equipment. This incentive can be significant for developing countries, when the technology sources of energy efficiency in domestic are limited and the standard duties of imported equipment are high to import. Therefore, tax reduction can help business to succeed these barriers.

**Table 3.6** Pros and Cons of implemented tax incentives.

| **Pros** | **Cons** |
|---|---|
| I) Tax incentives are directly linked to investment. Therefore, tax incentives are more effective than a reduction in energy taxes, such as fuel or power use, when the targets are improving in investment of energy efficiency in equipment or technologies.<br><br>II) Tax incentives are preferable to subsidies because they are easier to implement. | I) Tax incentives would be more complicated for implementation and are related to the cost of purchasing equipment, Therefore, tax incentives are not the most effective way to improve energy efficiency or reduce energy.<br><br>II) The problem of free rider can be occurred when using tax incentives. Some companies may try to benefit from a tax reduction in energy efficiency investment that they try to make every case to create a reduction in tax.<br><br>III) Tax incentives required a lot of expense from public funds.<br><br>III) Contractors may raise the cost of energy efficiency equipment to help business for increase tax credits because tax credits related directly to cost of purchasing. |

**b) Subsidies**

Normally, tax incentives are a part of subsidies or are indirect subsidies to businesses (in the form of lost government revenue) that can receive the tax benefit. So, the variety ways of direct subsidies to improve in energy efficiency investment of business can be separated in three major forms, first is a fixed payment for an eligible investment, second is a percentage of the total investment, and third is an amount linked to the amount saved in energy or energy costs.

**Table 3.7** Pros and Cons of implemented subsidies.

| Pros | Cons |
|---|---|
| I) Direct subsidies are appropriate to developing countries more than developed countries because developing countries have a higher investment risk. Therefore, direct subsidies can be more effective to stimulate investments of energy efficiency than indirect subsidies (tax incentives) in developing countries.<br><br>II) When the projects of energy efficiency have not attention by banks because it is too small.<br><br>III) When the projects of energy efficiency are considered by commercial banks to be more risky.<br><br>IV) Subsidies can create a profit to energy efficiency projects in the countries, where real costs of energy will not be reflected from subsidy, when energy prices are subsidized.<br><br>V) When the targets are SMEs that they have barriers to obtain loan in energy efficiency projects. | I) The problem of free riders can be occurred but it can be minimized or restricted by defining qualify for subsidy, such as, types of investment.<br><br>II) When the target audiences are lacking knowledge, the subsidy cannot be an effective. Therefore, Outreach programs are necessary to maximize the effectiveness.<br><br>III) Subsidy programs have costs to operate. Thus, governments must subsidize payments high enough to induce an investment. |

**c) Lending Programs**

Businesses need to receive outside funds to cover their investments in energy efficiency projects. Normally, businesses use bank financing but it has several barriers to use. For example, they lack understanding in the value of energy efficiency projects. They favor investments which are aimed to increase the production of a business and they think that energy efficiency projects are high risk in investment, theses problems are a part of lacking knowledge in the benefit of energy efficiency. According to these barriers, the next section will be demonstrated about the methods to approach the bank loan for energy efficiency projects which are soft loans, guarantee funds, and energy efficiency "bank windows".

- **Soft loans and revolving funds**

Soft loans use public funds to offer loans for energy efficiency investment at lower interest rates, compared with market rate. Mechanism of soft loan is a subsidy for the costs of a bank loan to borrowers in investment of energy efficiency projects. Soft loan programs are less broadly to use, it is suitable to encourage investments in energy efficiency that have high financial cost. Soft loans are often associated with revolving funds, the new projects of energy efficiency can be received a subsidy by repaid loan funds.

**Table 3.8** Pros and Cons of implemented revolving funds.

| Pros | Cons |
|---|---|
| I) Involving the commercial banking industry uses existing financial institutions and expertise and keeps governments out of the banking business.<br><br>II) Establishing the fund solves the problem of lack of bank interest in making energy efficiency loans by providing dedicated public funds. Involving banks in fund administration introduces them to energy efficiency lending and familiarizes them with these types of projects.<br><br>III) Lower than market interest rates make energy efficiency investments more attractive to potential loan applicants. | I) The availability of collateral.<br><br>II) The ability of applicants to develop adequate proposals.<br><br>III) Accessibility for companies such as SMEs, which often face greater difficulties in obtaining bank financing due to their weaker financial positions, lack of credit history, and/or inability to supply adequate collateral. |

- **Guarantee Funds**

The principle of guarantee funds that the public or donor funding insist to guarantee the loan recipient for a risk of repayment and the loan recipient have to pay an annual fee to the guarantor, typically, it is about 1 to 3 percents of total outstanding balance of the loan for receiving a guarantee. Consequently, this mechanism can alleviate the barriers from bank loan for investment of energy efficiency projects. Therefore, guarantee funds may be used, where the banks require support to alleviate risk of loan in energy efficiency project.

- **Energy Efficiency “Bank Windows”**

Energy Efficiency “Bank Windows” are programs developed to more understand in energy efficiency projects of bank itself. Typically, they develop their staff by training to be a specialist to evaluate and understand risks of energy efficiency project for the customers loans. As a result, these programs can reduce transactions costs for both customer and banks, make offering loans less risky for the banks, and help facilitate financing.

**d) ESCO**

Energy Services Company (ESCO) Performance Contracts are innovative financing to the customer or business that they will provide a design for the implementation of energy efficiency projects with a financing and the guarantee of performance. The guarantee of performance is a guarantee to the customer for a savings outcome of energy efficiency projects.

This section will describe ESCOs and the types of performance contracts generally available. How do ESCOs work? ESCO provide contract to improve energy savings from energy efficiency projects to the customers and the fee level will depend on the amount of savings outcome created by improvement of ESCO. It is the linkage of performance and payment that defines performance contracting. In a case of performance contracting, the ESCO will perform an energy efficiency audit to a customer and then they design an energy efficiency projects based on their audit. The ESCO will then secure financing for the project. The financing typically will be based on the outcome of energy cost savings which are expected by implementing the recommended changes. However, if the changes cannot create savings, the customer does not pay the ESCO.

### 3.2.2 Example of implemented financial mechanism in ASIA

This part is an example of an implemented financial mechanism to support the investment of energy efficiency projects in ASIA. In detail, this research is related to energy efficiency in Thailand. Therefore, this part is emphasized to demonstrate only the unavailable financial mechanisms in Thailand by other ASIA countries and available financial mechanisms in ASIA are shown in Table 3.9. However, this part will be demonstrated of available financial mechanism in Thailand as well.

**Table 3.9** Available financial mechanisms in ASIA [27].

| Country | Mechanism | | | | | |
|---|---|---|---|---|---|---|
| | Tax incentives | Subsidies | Lending programs | | | ESCOs |
| | | | Loan Funds | Guarantee Funds | Bank Windows | |
| Thailand | | | | | | |
| India | | | | | | |
| China | | | | | | |
| Philippines | | | | | | |
| Sri Lanka | | | | | | |
| Vietnam | | | | | | |
| Mongolia | | | | | | |
| Bangladesh | | | | | | |
| Indonesia | | | | | | |

**a) Available financial mechanisms in Thailand**

➢ **Tax Incentives**

The three examples of tax incentives established by Thai government that can encourage investment in energy efficiency. These will be demonstrated below.

- In 2005, the Thai government established a pilot program which is tax incentives to both building and factory owners. This program can provide a tax deduction for 100 percent of savings which can be generated by an energy efficiency investment, up to a cap of 2 million baht or about 50,000 us dollars. Business must be report their savings or conservation results in document and the DEDE organization is responsible to inspect and approved its. At the last, business can receive a tax refund by evidence of taxes paid, and the amount of refund base on their savings document.
- Cost-Based Tax Incentives Program. Businesses can receive a 25 percent of a tax deduction for the investment of energy efficiency projects. The first budget is about 50 million baht and can be spread to business over 5 years.

- Import duty exemption, which is offered by the organization of BOI to exempt import duties for the investment of energy efficiency equipment. For example, high efficiency machines, renewable energy equipment, solar PV manufacturing.

➢ **Energy Efficiency Revolving Fund**

In 2002, Energy Efficiency Revolving Fund was established in Thailand. The funds were allocated by ENCON fund. How the Fund Works, DEDE is responsible to manage the fund and work with the six banks, each bank is responsible to process loan application. The credit line of loan is received from the ENCON fund about 100 to 400 million baht at no interest to provide loan for energy efficiency projects to business. The loans under this program have interest rate below a market about 4 percent but each bank is free to set an interest rate for competitive. In practice, the lowest interest rate was identified to 2.7 percent and the projects example in energy conservation of ENCON are, to improve efficiency of combustion in fossil fuels which can prevent energy loss, recycle waste, improve electricity efficiency.

Moreover, loan funds can be covered to purchase and install equipment, cover design and supervision fees, construct works necessary for the installation and operation of equipment, and transportation costs, including duties and value added tax (VAT).

➢ **ESCOs**

Thailand has a small, but it growing ESCO sector. Thailand has 4 to 5 full service of ESCOs (i.e., companies that do comprehensive audits and recommend improvements). There also are a number of “supplier ESCOs” that offer performance guarantees for equipment that they manufacture and install. As noted in the discussion of the Revolving Fund above, financing continues to be a major barrier for ESCOs providing performance contracts.

**b) Unavailable financial mechanisms in other ASIA countries**

➢ **Subsidies**

- In the demand side management program of Sri Lanka, the company of Ceylon electricity provided subsidized prices for compact fluorescent lamps and interest’ free loans to purchase of the lamps.
- Vietnam Demand Side Management and Energy Efficiency Project cooperate with the Ministry of Industry to implement a Commercial Energy Efficiency Pilot Program - established programs to promote energy efficiency project by supporting from The World Bank/GEF. These programs have objective to stimulate energy efficiency

investment of business. Under these programs, amount of 210 enterprises received subsidy for 25 to 40 percents of the cost of energy efficiency projects. The programs focused initially on commercial building.

➢ **Guarantee Funds**

- Sri Lanka also has established guarantee funds to alleviate barriers for loan financing and to help reduce the costs from borrowing. This program is a part of the energy conservation fund in Sri Lanka by expected funding to support about 3.85 million dollars in energy efficiency investments. This program will provide guarantees up to 75 percents of the total loan that is approved by a participating bank. Recipients or borrowers are charged an annual premium equal to 0.5 percent of the outstanding loan balance at below market rate.
- In 2006, Mongolia established a green credit guarantee fund (GCGF). This fund provided guarantees for energy efficiency projects or improvements. The purpose is to help address primary barriers for financing of energy efficiency projects, inadequate collateral. Moreover, the fund was allocated at rates below market and this program provided guarantees up to 80 percent by the total loan. However, participants may have at most two projects receiving guarantees per time. Guarantees for one project may not exceed 10 percent by total of capital fund.
- China allocated the fund by cooperation of national investment and guaranty company Ltd, which is called I&G. they are the important role to give guarantees for energy efficiency project or improvement at national level in China.

➢ **Energy Efficiency Loan "Windows"**

- India participants in UNEP-World Bank. India's efforts were focused on increasing the banks capability to loan for energy efficiency projects and on development of Bank Energy Efficiency Loan Windows, including promoting ESCOs (Energy Service Company). This program was designed to develop and help the banks to increase investment in energy efficiency projects especially in SMEs. This program has lower interest rates than market rates, assistance with the costs of audits or detailed project reports, and waiving of loan processing fees.

## 3.3 Structure of methodology

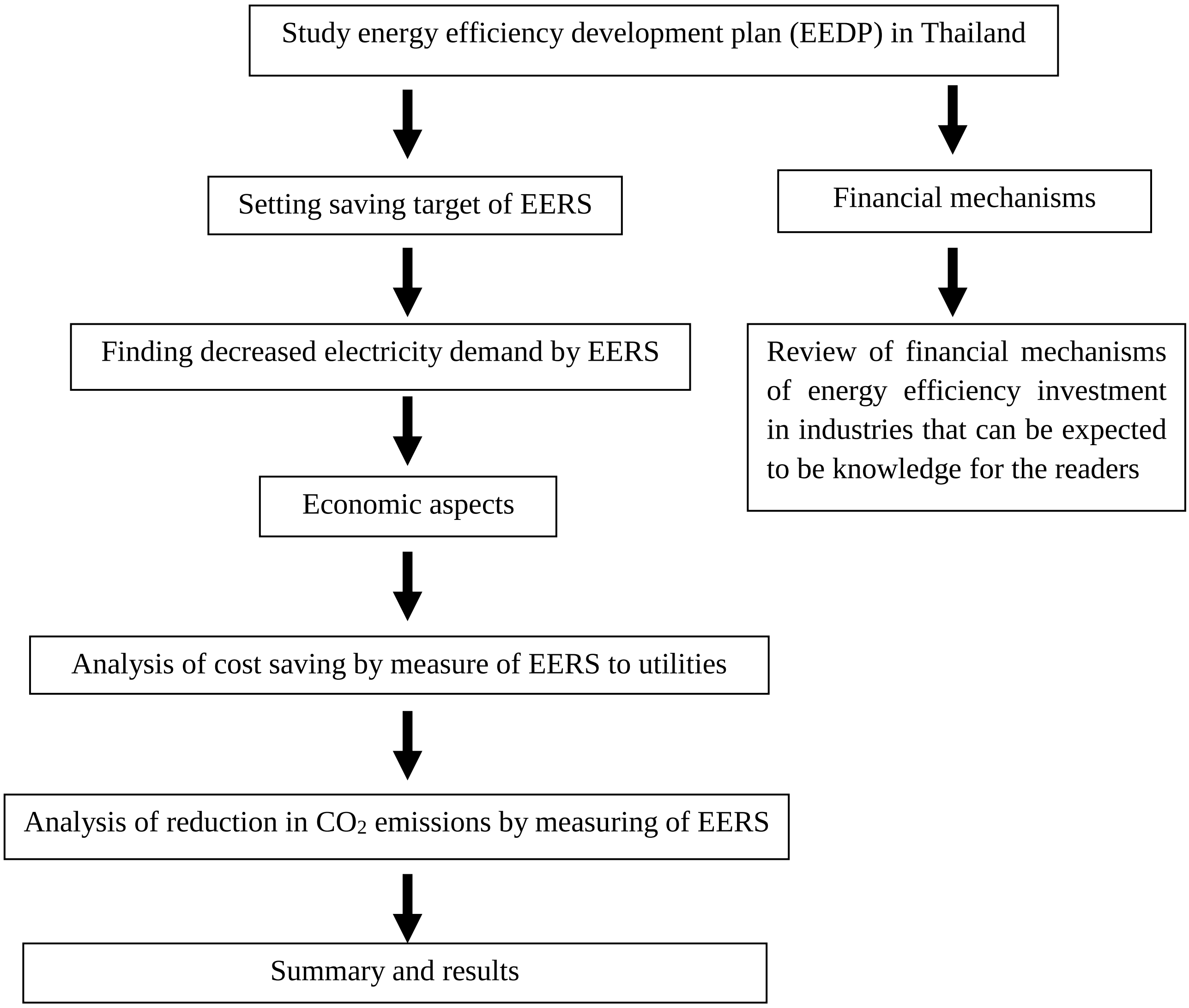


**Figure 3.7** Structure of methodology.

CHAPTER 4

# ANALYZED RESULTS

This chapter consists of two main topics. The first topic is an analysis of the reduction of $CO_2$ emissions, and the second topic is an analysis of cost savings, which can be received by the measure of EERS from an energy efficiency development plan (EEDP).

## 4.1 Analysis of reduction of $CO_2$ emissions by measure of EERS

This topic is an analysis of how much of cumulative $CO_2$ emissions can be reduced from 2015 to 2030.

### 4.1.1 Calculation of decreased electricity demand by measure of EERS

In Figure 4.1, the decreased electricity demands by measure of EERS from 2015 to 2030 can be calculated by the difference of electricity demand between BAU and EERS. The results of a calculation are shown in Table 4.1.

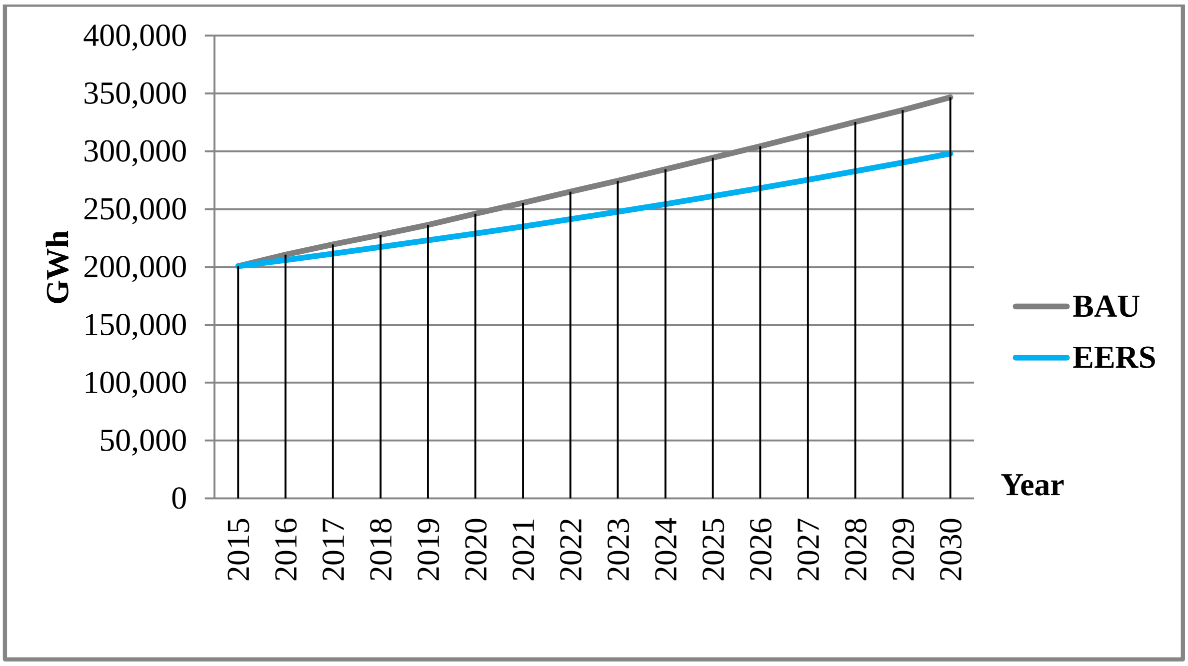


**Figure 4.1** Compared electricity demand between BAU and EERS.

**Table 4.1** Decreased electricity demand a year by measure of EERS.

| Year | BAU | EERS | The decreased electricity demand |
|---|---|---|---|
| 2015 | 200,726 | 200,726.00 | 0.00 |
| 2016 | 210,619 | 206,091.21 | 4,527.79 |
| 2017 | 219,616 | 211,599.82 | 8,016.18 |
| 2018 | 227,760 | 217,255.67 | 10,504.33 |
| 2019 | 236,408 | 223,062.70 | 13,345.30 |
| 2020 | 246,164 | 229,024.94 | 17,139.06 |
| 2021 | 255,591 | 235,146.55 | 20,444.45 |
| 2022 | 265,039 | 241,431.78 | 23,607.22 |
| 2023 | 274,672 | 247,885.01 | 26,786.99 |
| 2024 | 284,640 | 254,510.73 | 30,129.27 |
| 2025 | 294,508 | 261,313.54 | 33,194.46 |
| 2026 | 304,548 | 268,298.19 | 36,249.81 |
| 2027 | 314,925 | 275,469.54 | 39,455.46 |
| 2028 | 325,470 | 282,832.56 | 42,637.44 |
| 2029 | 335,787 | 290,392.39 | 45,394.61 |
| 2030 | 346,767 | 298,154.29 | 48,612.71 |

Consequently, the reduction of $CO_2$ emissions can occur by decreasing of these electricity demands and can be estimated the quantity of $CO_2$ by emission factor, which is presented in the next section.

### 4.1.2 Emission factor of $CO_2$

The emission factors of $CO_2$ in each type of power plan are shown in Table 4.2. These data are received from the review of Study and estimation of carbon intensity from electricity generation in Thailand, and Emission Inventory of Electricity Generation in Thailand [28]. It will be useful for highly accurate estimation of $CO_2$ emission, if the proportion of electricity generation by fuel types can be found.

**Table 4.2** Emission factors of $CO_2$ in each type of generation [28].

| Power Plant | Fuel | Emission Factor $KgCO_2$/MWh |
|---|---|---|
| Thermal (steam Turbine) | Coal (Lignite) | 1080.00 |
| | Fuel Oil | 765.16 |
| | Co-firing Fuel oil/Natural gas | 591.85 |
| Gas Turbine | Natural | 822.22 |
| | Diesel | 779.00 |
| Combined Cycle | Natural | 451.64 |
| Co-generation | Natural | 485.00 |

However, in previous analyses could not identify a proportion of decreased electricity generation and identified only a quantity of decreased electricity demand. Therefore, the annual average of $CO_2$ emissions will be used instead to estimate for decreased $CO_2$ quantity and these values are available in PDP [26]. Moreover, an anal average of $CO_2$ emission can be observed that its value will be decreased in every year because in the future generation technologies of electricity in Thailand will be developed to be high efficiency to generate and reduce GHG emission, in addition to, the use proportion of renewable technologies will be aimed to increase instead of fossil fuel.

Accordingly, the annual average of $CO_2$ emissions and a calculation of $CO_2$ emissions are shown in Table 4.3.

**Table 4.3** Results of reducing $CO_2$ emission by measure of EERS.

| **Year** | **Annual Amounts ($kgCO_2/MWh$)** | **Decreased electricity demand (GWh)** | **$CO_2$ emission (kilotons)** |
|---|---|---|---|
| 2015 | 448.00 | 0.00 | 0.00 |
| 2016 | 430.00 | 4,527.79 | 1,946.95 |
| 2017 | 429.00 | 8,016.18 | 3,438.94 |
| 2018 | 413.00 | 10,504.33 | 4,338.29 |
| 2019 | 416.00 | 13,345.30 | 5,551.64 |
| 2020 | 412.00 | 17,139.06 | 7,061.29 |
| 2021 | 407.00 | 20,444.45 | 8,320.89 |
| 2022 | 410.00 | 23,607.22 | 9,678.96 |
| 2023 | 413.00 | 26,786.99 | 11,063.03 |
| 2024 | 406.00 | 30,129.27 | 12,232.48 |
| 2025 | 407.00 | 33,194.46 | 13,510.15 |
| 2026 | 403.00 | 36,249.81 | 14,608.67 |
| 2027 | 391.00 | 39,455.46 | 15,427.08 |
| 2028 | 395.00 | 42,637.44 | 16,841.79 |
| 2029 | 391.00 | 45,394.61 | 17,749.29 |
| 2030 | 385.00 | 48,612.71 | 18,715.89 |
| | | **Cumulative** | 160,485.36 |

As a result, the cumulative $CO_2$ emissions can be reduced by about 160,485.36 kilotons from 2016 to 2030 by measure of EERS.

## 4.2 Analysis of cost savings from EERS

This part will show that if electricity demand is reduced, followed on EERS target, how much of cost savings will be created and the cost saving can be created by postponing of additional capacity from projected capacity in PDP (appendix A). Postponing of additional capacity can be occurred to optimize with electricity demand under EERS.

### 4.2.1 Changing unit of electricity demand under EERS

Electricity demand under EERS will be converted from energy units (GWh) to capacity units (MW) for comparing with projected capacity, following on Equation 3.1, which was already demonstrated. Consequently, the values in capacity unit (MW) of electricity demand under EERS are calculated and showed in the Table 4.4 below.

**Table 4.4** Electricity demand under EERS in unit of capacity (MW).

| Year | Unit of energy (GWh) | Load factor (%) | Unit of capacity (MW) |
|---|---|---|---|
| 2016 | 206,091.21 | 75.59 | 31,123.68 |
| 2017 | 211,599.82 | 75.37 | 32,048.87 |
| 2018 | 217,255.67 | 75.16 | 32,997.44 |
| 2019 | 223,062.70 | 75.24 | 33,843.41 |
| 2020 | 229,024.94 | 75.29 | 34,724.93 |
| 2021 | 235,146.55 | 75.34 | 35,629.43 |
| 2022 | 241,431.78 | 75.39 | 36,557.51 |
| 2023 | 247,885.01 | 75.43 | 37,514.75 |
| 2024 | 254,510.73 | 75.48 | 38,491.97 |
| 2025 | 261,313.54 | 75.51 | 39,505.12 |
| 2026 | 268,298.19 | 75.57 | 40,528.84 |
| 2027 | 275,469.54 | 75.61 | 41,590.13 |
| 2028 | 282,832.56 | 75.65 | 42,679.21 |
| 2029 | 290,392.39 | 75.72 | 43,779.47 |
| 2030 | 298,154.29 | 75.75 | 44,931.85 |

### 4.2.2 Adding 15% for theoretical reserves to electricity demand under EERS

To avoid lacking power, the electricity demand under EERS a year will be increased up to 15% from 2016 to 2030. This value of 15 is received from the theory of reserved power, this was explained at theories chapter. Thus, this topic shows value of multiplying electricity demand under EERS with 1.15 in Table 4.5 and Figure 4.2.

**Table 4.5** Added 15% of electricity demand under EERS.

| Year | Electricity demand under EEDP | Added 15% of electricity demand under EERS |
|---|---|---|
| 2016 | 31,123.68 | 35,792.24 |
| 2017 | 32,048.87 | 36,856.20 |
| 2018 | 32,997.44 | 37,947.06 |
| 2019 | 33,843.41 | 38,919.92 |
| 2020 | 34,724.93 | 39,933.67 |
| 2021 | 35,629.43 | 40,973.85 |
| 2022 | 36,557.51 | 42,041.13 |
| 2023 | 37,514.75 | 43,141.96 |
| 2024 | 38,491.97 | 44,265.76 |
| 2025 | 39,505.12 | 45,430.88 |
| 2026 | 40,528.84 | 46,608.17 |
| 2027 | 41,590.13 | 47,828.64 |
| 2028 | 42,679.21 | 49,081.09 |
| 2029 | 43,779.47 | 50,346.39 |
| 2030 | 44,931.85 | 51,671.63 |

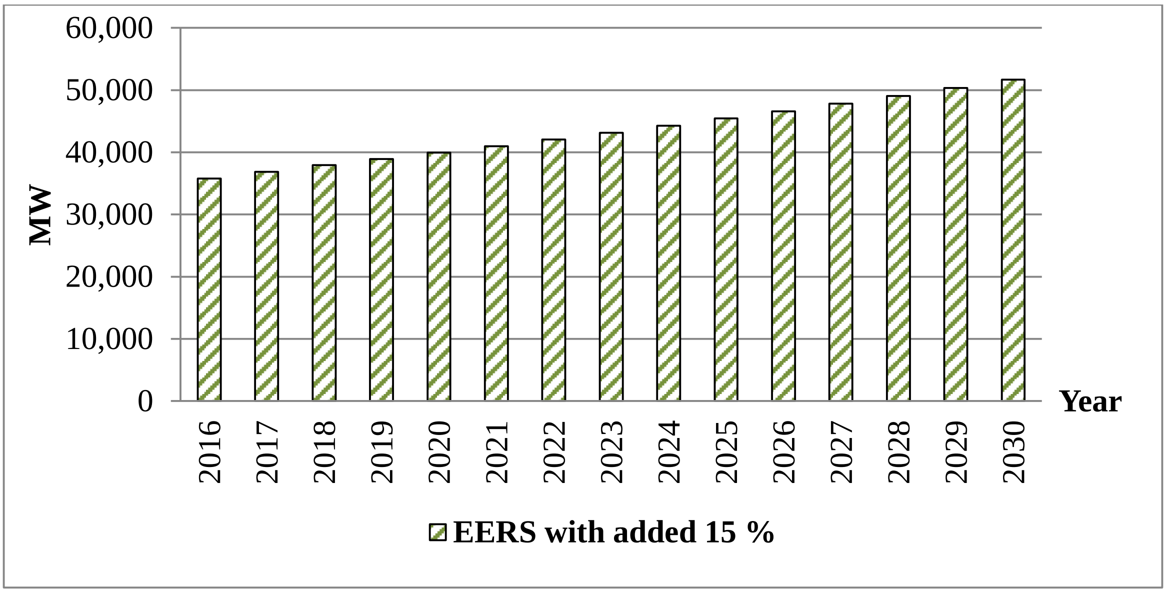


**Figure 4.2** Projected electricity demands under EERS with added 15 %.

**4.2.3 Comparing between projected capacity and electricity demands under EERS with added 15%**

The projected capacity and electricity demand under EERS are compared as shown Figure 4.3. The projected capacity is still higher than electricity demand under EERS in every year from 2016 to 2030. It indicated that it has some excess capacity or unnecessary of additional capacity. So, this unnecessary of additional capacity can be postponed to optimize with electricity demand under EERS. For example, projected capacity at 2016 may be supported electricity demand under EERS until 2025 by unnecessary installation of additional capacity from 2017 to 2025 (Figure 4.3).

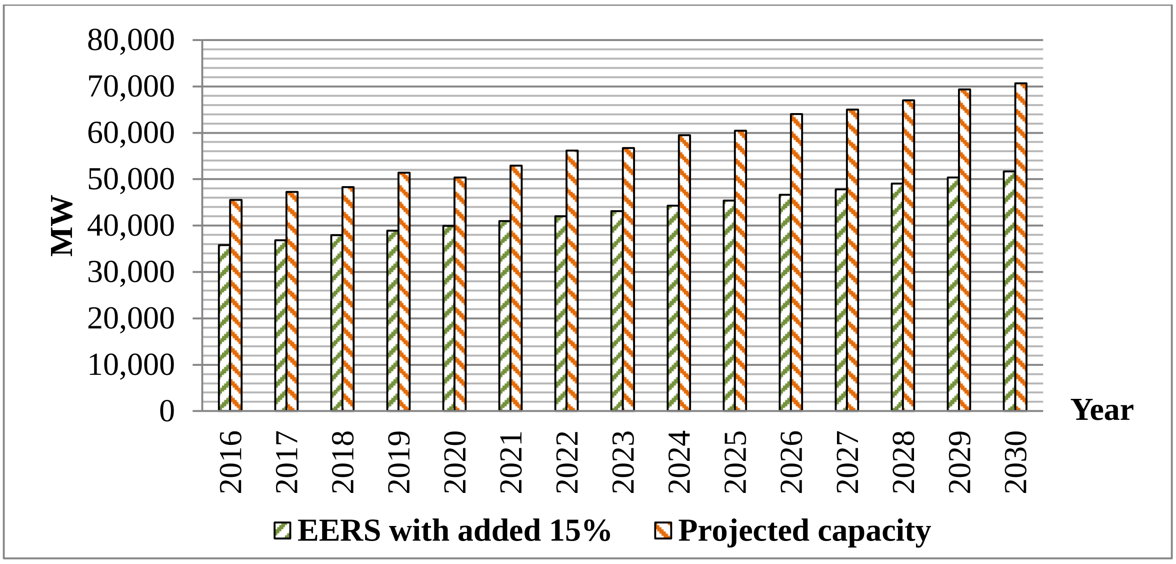


**Figure 4.3** Projected capacity compared with electricity demand under EERS.

However, this example is still wrong because actual power plans have retirement from lifetime of itself. So, the analysis must be included the retired capacity.

According to the projected capacity at 2016, it will be decreased by retired capacity and cannot support the electricity demand under EERS until 2025 absolutely.

Therefore, an analysis is to find how many years of projected capacity in PDP can be postponed to optimize the electricity demand under EERS, including a calculation of retired capacity, and the last results will be estimated in cost savings, which are received from additional capacity that can be postponed. So, the next topic is to find retired capacity.

### 4.2.4 Finding a retired capacity

Retired capacity will be calculated from the total capacity minus the projected capacity for that year. These calculations are shown in Appendix B. For example, a projected capacity at 2013 is equal to 36,491 MW and it will be added by 2,226 MW, followed on PDP at 2014. Thus, if it has not a retired capacity at 2014, a total capacity at 2014 will be equal to 40,594 MW but projected capacity from PDP (appendix A) at 2014 is equal to 39,542 MW. So, retired capacity is calculated by 40,594 MW minus to 39,542

MW and a result is 1,052 MW at 2014. Accordingly, the value of retired capacity from 2012 to 2030 is showed at table 4.6.

**Table 4.6** Value of retired capacity from 2012 to 2030.

| Year | Retired capacity (MW) |
|---|---|
| 2012 | 0.00 |
| 2013 | 0.00 |
| 2014 | 1,052.10 |
| 2015 | 1,176.10 |
| 2016 | 748.10 |
| 2017 | 495.10 |
| 2018 | 1,281.00 |
| 2019 | 184.00 |
| 2020 | 1,529.00 |
| 2021 | 200.00 |
| 2022 | 150.10 |
| 2023 | 2,864.10 |
| 2024 | 679.10 |
| 2025 | 2,378.00 |
| 2026 | 4.00 |
| 2027 | 2,624.10 |
| 2028 | 1,392.00 |
| 2029 | 270.00 |
| 2030 | 417.00 |

### 4.2.5 Analysis of postponed capacity

The first analysis is to find how many years of projected capacity at 2016 can support electricity demand under EERS. Figure 4.4 shows that projected capacity at 2016 will decrease every year by retired capacity and can support electricity demand under EERS until 2021 because existed capacity at 2022 is lower than electricity demand under EERS (Existed capacity is calculated from projected capacity minus to retied capacity in that year).

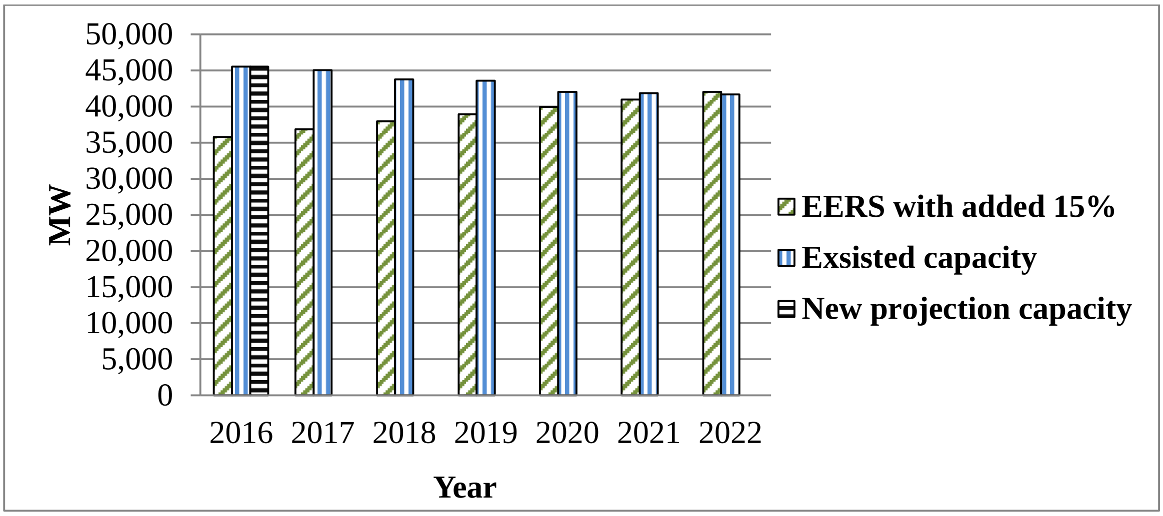


**Figure 4.4** Analysis of postponed capacity from 2016 to 2022.

Consequently, the additional capacity must be installed in 2022 (Figure 4.5) and the additional capacity in 2022 will be postponed from PDP at year of 2017. In the same meaning, the projected capacity from PDP (Appendix A) at year of 2017 can be postponed to year of 2022 to optimize with electricity demand under EERS.

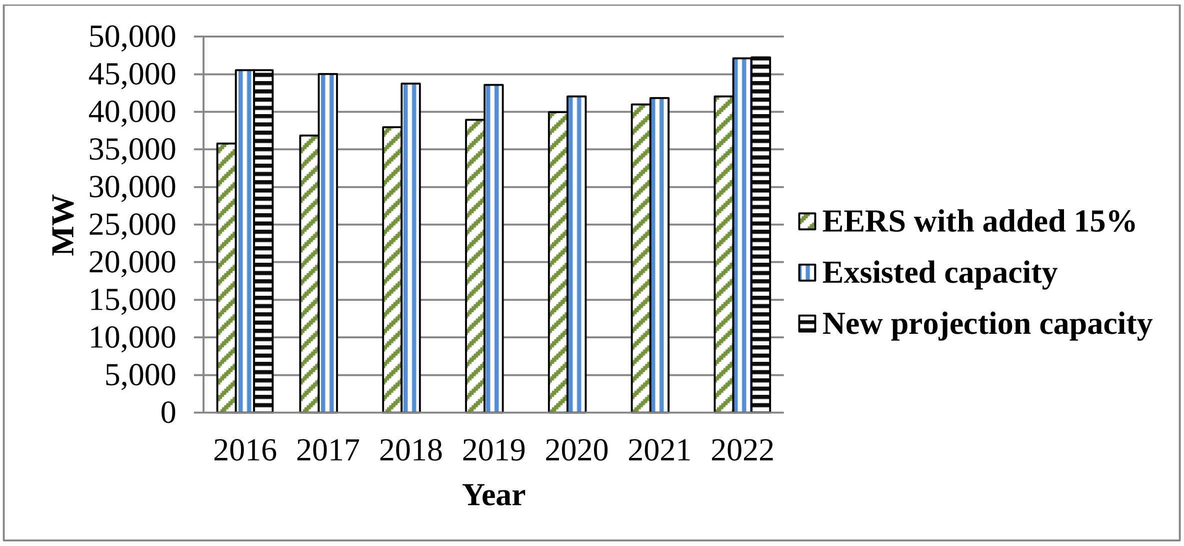


**Figure 4.5** Continuous analysis of postponed capacity from 2016 to 2022.

Accordingly, the second analysis is to continuously find out how many years of projected capacity in 2022, which was postponed from 2017, can support electricity demand under EERS in the next year.

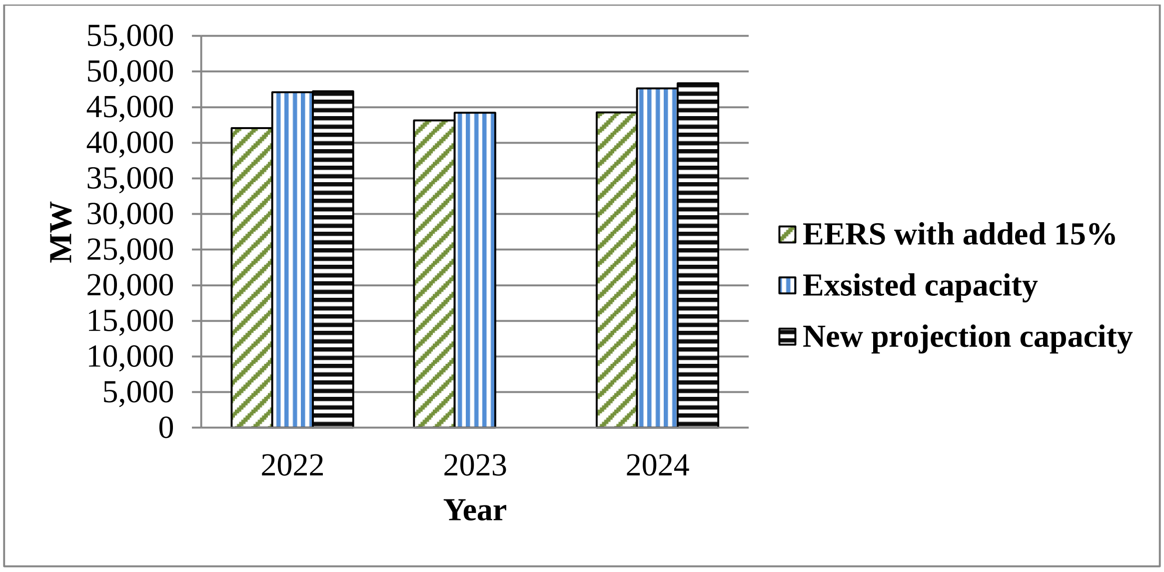


**Figure 4.6** Analysis of postponed capacity from 2022 to 2024.

Figure 4.6 indicates that the projected capacity at 2022 can support electricity demand under EERS until 2023. Therefore, the additional capacity must be installed at 2024. In the same concept, the additional capacity at 2024 is postponed from PDP at year of 2018, or the projected capacity at 2018 is postponed to 2024.

According to these analyses, the analysis will be finished until year of 2030. All results are shown in Figure 4.7 and the postponed capacity is summarized and presented in Table 4.7.

**Table 4.7** Summary and results of postponed capacity.

| Year | Postponing from | New projection capacity | Retired capacity | Existed capacity | EERS with added 15% |
|---|---|---|---|---|---|
| 2016 | | 45,530.00 | 748.10 | 45530.00 | 35,465.07 |
| 2017 | | | 495.10 | 45034.90 | 36,550.99 |
| 2018 | | | 1,281.00 | 43753.90 | 37,665.47 |
| 2019 | | | 184.00 | 43569.90 | 38,664.64 |
| 2020 | | | 1,529.00 | 42040.90 | 39,706.17 |
| 2021 | | | 200.00 | 41840.90 | 40,775.78 |
| 2022 | Year of 2017 | 47,240.00 | 150.10 | 47089.90 | 41,874.21 |
| 2023 | | | 2,864.10 | 44225.80 | 43,007.96 |
| 2024 | Year of 2018 | 48,329.00 | 679.10 | 47649.90 | 44,166.56 |
| 2025 | Year of 2019 | 51,386.00 | 2,378.00 | 49008.00 | 45,368.41 |
| 2026 | | | 4.00 | 49004.00 | 46,584.47 |
| 2027 | Year of 2021 | 52,912.00 | 2,624.10 | 50287.90 | 47,845.81 |
| 2028 | Year of 2022 | 56,135.00 | 1,392.00 | 54743.00 | 49,141.31 |
| 2029 | | | 270.00 | 54473.00 | 50,451.91 |
| 2030 | | | 417.00 | 54056.00 | 51,824.86 |

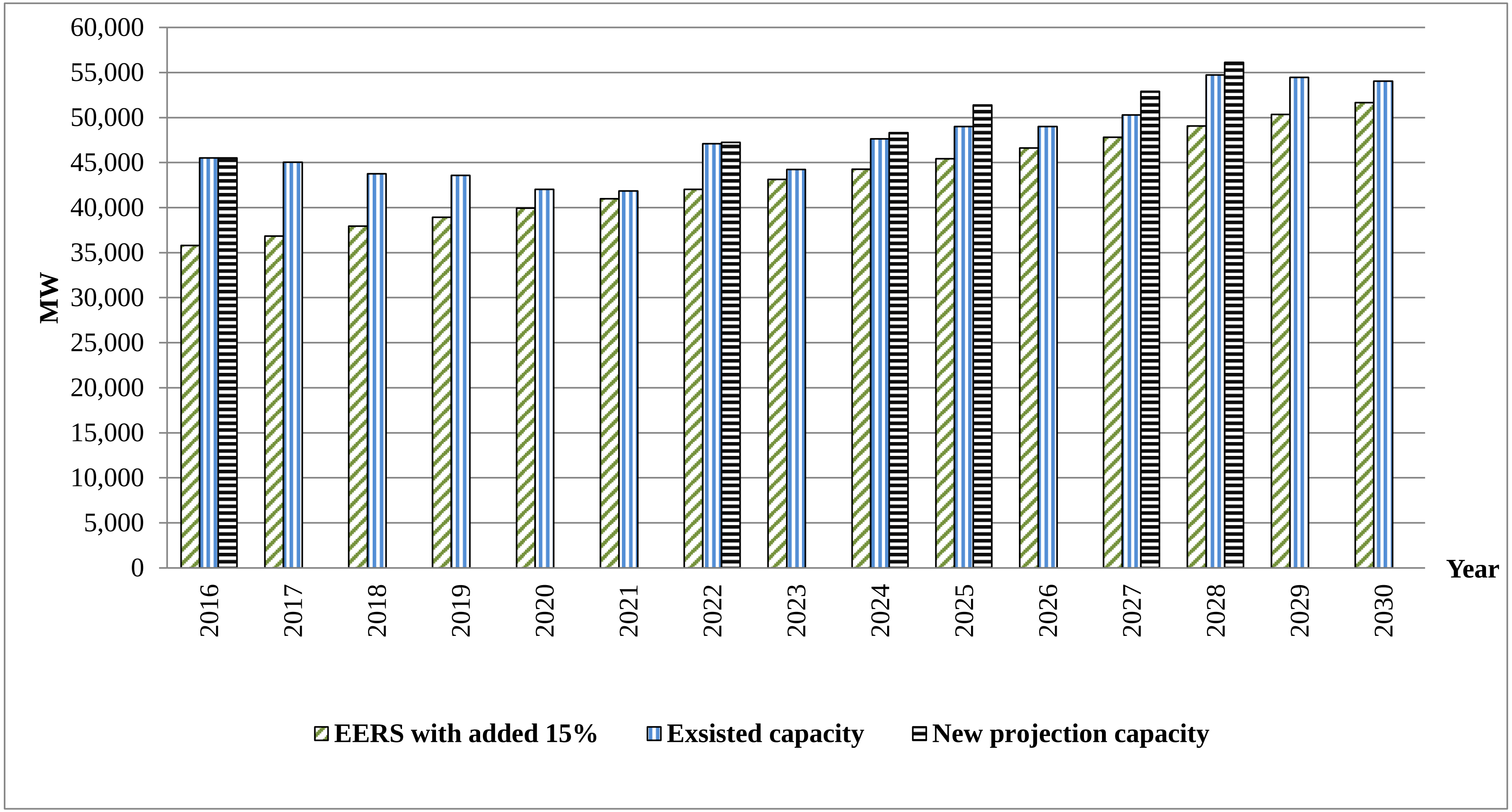


**Figure 4.7** Summary and results of postponed capacity.

### 4.2.6 Analysis of capacity savings and cost savings

**a) Analysis of capacity savings**

In Figure 4.8 capacity saving is calculated from the maximum of the projected capacity from PDP minus to the maximum capacity of the new projection. Consequently, the capacity saving will be equal to the deference between projected capacity at 2030 and new projection capacity at 2028 (Table 4.8). The result is 14,551.00 MW. So, the capacity is 56,135.00 MW, which can support electricity demand under EERS until year of 2030.

**Table 4.8** New projection capacity compared with projected capacity from PDP

| Year | New projection capacity (MW) | Projected capacity (MW) |
|---|---|---|
| 2016 | 45,530.00 | 39,542.00 |
| 2017 | | 43,157.00 |
| 2018 | | 45,530.00 |
| 2019 | | 47,240.00 |
| 2020 | | 48,329.00 |
| 2021 | | 51,386.00 |
| 2022 | 47,240.00 | 50,389.00 |
| 2023 | | 52,912.00 |
| 2024 | 48,329.00 | 56,135.00 |
| 2025 | 51,386.00 | 56,732.00 |
| 2026 | | 59,509.00 |
| 2027 | 52,912.00 | 60,477.00 |
| 2028 | 56,135.00 | 64,007.00 |
| 2029 | | 64,979.00 |
| 2030 | | 67,012.00 |
| 2031 | | 69,358.00 |
| 2032 | | 70,686.00 |

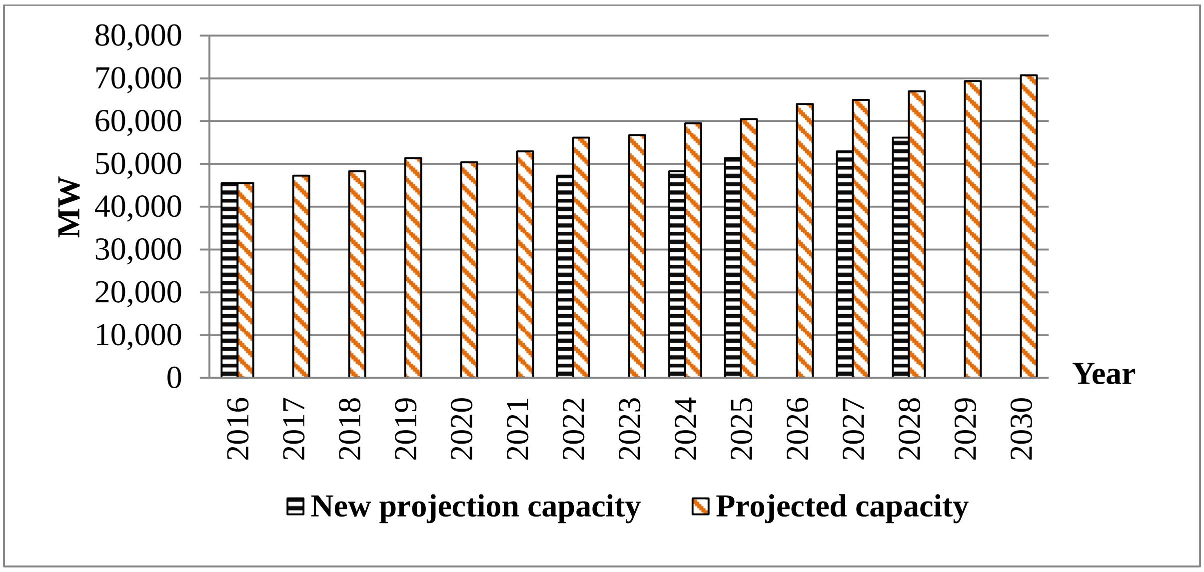


**Figure 4.8** New projection capacity compared with projected capacity from PDP.

**b) Analysis of cost savings**

Firstly, an analysis is done to find out how much additional capacity in five years, 2017, 2018, 2019, 2021, and 2022. These years are related with postponing additional capacity that is shown in the previous analysis (Table 4.7). Therefore, Table 4.9, which is calculated from Appendix B, shows the total of additional capacity and proportions of additional capacity in four fuel type, natural gas, coal, renewable energy and hydro power.

**Table 4.9** Total additional capacity in five years that is postponed.

| Year | Total additional capacity (MW) | Natural gas (MW) | Coal (MW) | Renewable energy (MW) | Hydro (MW) |
|---|---|---|---|---|---|
| 2017 | 2,205.10 | 900.00 | 270.00 | 1,015.10 | 20.00 |
| 2018 | 2,370.00 | 721.00 | - | 966.00 | 638.00 |
| 2019 | 3,241.00 | 725.00 | 800.00 | 493.00 | 1,223.00 |
| 2021 | 2,723.00 | 1,981.00 | - | 740.00 | 2.00 |
| 2022 | 3,373.10 | 1,985.00 | 800.00 | 587.10 | 1.00 |

Secondly, this analysis is to find out how many years of postponing. These are shown in Table 4.10 below.

**Table 4.10** Number of postponed years.

| From/To | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2017 | 5 years | | | | | 2,205.1 MW | | | | | | | | |
| 2018 | | 6 years | | | | | | 2,370 MW | | | | | | |
| 2019 | | | 6 years | | | | | | 3,241 MW | | | | | |
| 2021 | | | | | 6 years | | | | | | 2,723 MW | | | |
| 2022 | | | | | | 6 years | | | | | | 3,373.1 MW | | |

Lastly, cost savings will be estimated by postponing the investment of additional capacity. Thus, a cost saving is a saving from interest rate in investment, and in this analysis is assumed at 8% a year. For example, the additional capacity in 2017 of natural gas was postponed to the next five years. So, it can be created a cost saving about 327.60 million dollars, followed on this simple equation at 4.1 below.

Cost savings = added capacity * capital cost * interest rate * years ---------------- (4.1)

**Table 4.11** The results of cost savings received by measure of EERS.

| Year | Type of fuel | Additional capacity (MW) | Capital cost (M.dollars/MW) | Interest rate | Number of postponed years | Cost saving (M.dollars) |
|---|---|---|---|---|---|---|
| 2017 | Natural Gas | 900.00 | [A]0.91 | 8% | 5 years | 327.60 |
| | Coal | 405.00 | [B]3.47 | | | 562.14 |
| | Renewable energy | 1,015.10 | 2.00 | | | 828.08 |
| | Hydro | 20.00 | [A]2.93 | | | 23.44 |
| | Total saving | | | | | 1,741.26 |
| 2018 | Natural Gas | 721.00 | 0.91 | 8% | 6 years | 314.93 |
| | Coal | 0.00 | 1.50 | | | 0.00 |
| | Renewable energy | 966.00 | 2.00 | | | 927.36 |
| | Hydro | 638.00 | 2.93 | | | 897.28 |
| | Total saving | | | | | 2,139.58 |
| 2019 | Natural Gas | 725.00 | 0.91 | 8% | 6 years | 316.68 |
| | Coal | 800.00 | 1.50 | | | 1,332.48 |
| | Renewable energy | 493.00 | 2.00 | | | 473.28 |
| | Hydro | 1,223.00 | 2.93 | | | 1,720.03 |
| | Total saving | | | | | 3,842.47 |

Source: A. U.S. Energy Information Administration (EIA). Updated estimates of power plant capital and operating costs.
B. Julianne M. Klara, Supercritical Pulverized Bituminous Coal Plant, National Energy Technology Laboratory.

**Table 4.11** The results of cost savings received by measure of EERS (Cont').

| Year | Type of fuel | Additional capacity (MW) | Capital cost (M.dollars/MW) | Interest rate | Number of postponed years | Cost saving (M.dollars) |
|---|---|---|---|---|---|---|
| 2021 | Natural Gas | 1,981.00 | 0.91 | 8% | 6 years | 865.30 |
| | Coal | 0.00 | 1.50 | | | 0.00 |
| | Renewable energy | 740.00 | 2.00 | | | 710.40 |
| | Hydro | 2.00 | 2.93 | | | 2.81 |
| | Total saving | | | | | 1,578.51 |
| 2022 | Natural Gas | 1,985.00 | 0.91 | 8% | 6 years | 867.05 |
| | Coal | 800.00 | 1.50 | | | 576.00 |
| | Renewable energy | 587.10 | 2.00 | | | 563.62 |
| | Hydro | 1 | 2.93 | | | 1.41 |
| | Total saving | | | | | 2,764.55 |

As a result, the total of cost savings can be created about 12,066.37 million U.S dollars from postponing of investment.

# CHAPTER 5

# CONCLUSION AND RECOMMENDATIONS

## 5.1 Conclusion

From the Energy Efficiency Development Plan (EEDP), this was established in 2010 by the Thai government. In detail, the Energy Efficiency Development Plan (EEDP) is formulated with a target to reduce energy intensity by 25% in 2030, compared with 2005, or equivalent to reduction of final energy consumption by 20% in 2030, or about 38,200 thousand tons of crude oil equivalents (ktoe).

In order to support this plan, the topic of Effect of Energy Efficiency Policy on Avoided Investment Cost for Electricity Utilities is designed to focus on reducing electricity demand of end users (not all of final energy consumption) by implementing measures of EERS in EEDP, So that EERS can be significant to utility in economic aspect, Such that the economics could be demonstrated a benefits to utilities from reducing electricity demand of end users.

Accordingly, the purpose of this research is to find the benefits by implementing the measure of EERS in EEDP so that utilities will be realize the importance of EERS and then they should cooperation in this measure and support this measure as effectively as possible. Therefore, the main objectives of this research consists of two topics, the first is to determine the benefits of utilities in economics aspect received by implementing measure of EERS in EEDP. Moreover, the reducing of electricity demand is not only benefits to utilities but it can be benefit to environment in reduction of $CO_2$ emissions; therefore, the second objective is to estimate reduction of $CO_2$ emissions received by implemented measure of EERS in EEDP.

Moreover, this research also included the review of financial mechanisms, such as, tax incentives, subsidies, bank loan, soft loans or revolving funds, guarantee funds, energy efficiency “Bank windows”, and ESCOs. Theses financial mechanisms are related to energy efficiency investment in industries, So that this review is expected to give knowledge to readers or policymakers for improving energy efficiency.

### 5.1.1 Benefits of implemented measure of EERS to utilities and the environment

From an analysis in this research, this research is analyzed under the assumption that EERS is aimed to reduce 1 percent of electricity demand a year. As a consequence, it has been shown that the reduction in the year 2030 will be 48,612 GWh, which is equivalent to 60% of EEDP target in reduction of electricity consumption.

**a) Cost savings to utilities by implementing measure of EERS**

The cost savings to utilities are received by postponing investments, when the investment of additional power plants can be postponed, the cost savings will occur from the interest rate in investment, and the assumption of 8 percent in interest rate was used in this analysis.

In summary, when reducing 1 percent of electricity demand a year by implementing a measure of EERS, the projected capacity from PDP can be postponed for the investment of additional power plants to be optimized with projected electricity demands under measure of EERS. The postponing in this analysis is a sequence, followed each year, and the results are shown Table 5.1 below.

**Table 5.1** Postponing of additional power plants.

| From/To | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2017 | 5 years | | | | | 2,205.1 MW | | | | | | | | |
| 2018 | | 6 years | | | | | | 2,370 MW | | | | | | |
| 2019 | | | 6 years | | | | | | 3,241 MW | | | | | |
| 2021 | | | | | 6 years | | | | | | 2,723 MW | | | |
| 2022 | | | | | | 6 years | | | | | | 3,373.1 MW | | |

Under this postponing in investment, the cumulative savings due to the decrease in electricity consumption during 2016 and 2030 can be calculated to be 12,066.37 Million Bath for the utilities. It can be expected for the utilities that the implementation measure of EERS in EEDP will be given importance.

**b) Reduction of $CO_2$ emissions to the environment**

Carbon dioxide ($CO_2$) is the primary greenhouse gas, which is emitted by human activities. The main human activity is a combustion process from fossil fuels (coal, natural gas, and oil) that emits a lot of $CO_2$. These are used for energy and transportation. However, generating electricity is a significant source that uses a lot of fossil fuel. The combustion of fossil fuels to generate electricity is the largest single source of $CO_2$ emissions in the nation. As results, the problems of global warming will be occurred from generating electricity.

Moreover, type of fossil fuel has different amounts of $CO_2$ emissions to generate electricity, for example, burning coal will produce more $CO_2$ than oil or natural gas, and these is depended on emission factors of $CO_2$ in each type of generation. The reduction of $CO_2$ emissions can be achieved in many ways, such as improving efficiency of equipment or technology, and increasing proportion of renewable energy, etc. another way is a policy to reduce of the energy consumption.

This research also showed that the reduction of $CO_2$ emissions can be achieved by reducing electricity demand though EEDP in Thailand. The reduction of $CO_2$ will be occurred from lesser generating electricity, when electricity demand is aimed to reduce. In summary, the cumulative reduction of $CO_2$ emissions can be created to 160,485.36 kilotons in this analysis from 2016 to 2030 and these are beneficial to environmental aspect.

However, actually an analysis of $CO_2$ emissions should be designed to use the emission factor of $CO_2$ which are separated by each type of generation [26] for higher accuracy but this analysis cannot separate a decreased electricity generation by each type, Therefore, this analysis is designed to use the annual average of emission factor of $CO_2$ from power development plan in Thailand instead.

## 5.2 Recommendation

This research has also illustrated that the decrease in electricity demand under the Energy Efficiency Development Plan (EEDP) is beneficial to utilities as the investment of additional power plants can be postponed.

The energy efficiency obligation program does not only result in generation cost savings to utilities but also increases energy security in the future, including reduction of $CO_2$ emissions. Therefore, utilities should provide support to their customers to improve their energy efficiency, and reduce their electricity demand.

However, this research is designed to assume that EERS is aimed at reducing 1% of electricity demand, or reduction at 2030 about 48,612 GWh, but an actual specific target of EEDP is equal to 81,116 GWh. Therefore, if electricity demand can be reduced, following the EEDP targets, it can create more benefits to both utilities and environment.

**5.2.1 Measure of EERS to achieve reduction in electricity consumption by utilities**

There are a variety measures to improve energy efficiency that can create a reduction in energy consumption. For example, a financial mechanism, which was demonstrated in Chapter 3, is a one measure to be an incentive for improving in energy efficient technologies to customers or end users and as a results energy consumption can be reduced by this higher efficient technologies. However, when electricity consumption is mainly focused in reduction, the standard measures will be direct efficiency to reduce electricity consumption.

Mentioned to EERS in the United States, EERS was applied to electricity utilities that the government enforced energy efficiency resource standard (EERS) with a legislation or regulation to public utilities that they have to be a responsibility to reduce electricity demand of their customer and the target was be set appropriately, depended on state or nation. This measure is effectively to reduce electricity demand in U.S.

Why utilities are suited for this program because they have relations with customer, they also have availability of energy consumption data, and they can advice infrastructure and expertise in energy efficiency to a customer.

Accordingly, the Thai government should enforce this measure by the cooperation of related sectors to determine the minimum standards of energy savings, such as in a certain percentage of the average of the total generation or sales with the approach for energy saving verification, which should include the rate of penalties for failure to success in a targets and the incentive rate for achievement greater than the targets. Moreover, the government should focus on industry consumption in the first priority due to the electricity consumption in industry sector is highest, when it is compared with other sectors, as already illustrated in Table 3.2.

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**Appendix A:**

Data from Thailand Power Development Plan 2012-2030 (PDP2010)

# Projected capacity by power plant types from 2012 to 2030

| Plant Types | | | Unit | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Renewable Energy** | | - EGAT | MW | 3,459 | 3,477 | 3,483 | 3,552 | 3,557 | 4,082 | 4,105 | 4,159 | 4,165 | 4,168 | 4,169 | 4,182 | 4,185 | 4,188 | 4,190 | 4,252 | 4,270 | 4,284 | 4,325 |
| | | | % | 10.1 | 9.5 | 8.8 | 8.2 | 7.8 | 8.6 | 8.5 | 8.1 | 8.3 | 7.9 | 7.4 | 7.4 | 7 | 6.9 | 6.6 | 6.5 | 6.4 | 6.2 | 6.1 |
| | | - SPP | MW | 966 | 1,215 | 1,634 | 2,003 | 2,638 | 2,791 | 2,791 | 2,851 | 2,888 | 2,888 | 2,888 | 2,888 | 2,838 | 2,782 | 2,777 | 2,770 | 2,667 | 2,667 | 2,647 |
| | | | % | 2.8 | 3.3 | 4.1 | 4.6 | 5.8 | 5.9 | 5.8 | 5.6 | 5.7 | 5.5 | 5.1 | 5.1 | 4.8 | 4.6 | 4.3 | 4.3 | 4 | 3.9 | 3.8 |
| | | - VSPP | MW | 759 | 1,531 | 1,712 | 1,795 | 1,875 | 1,951 | 2,038 | 2,110 | 2,191 | 2,270 | 2,338 | 2,384 | 2,438 | 2,474 | 2,507 | 2,540 | 2,571 | 2,603 | 2,636 |
| | | | % | 2.2 | 4.2 | 4.3 | 4.2 | 4.1 | 4.1 | 4.2 | 4.1 | 4.4 | 4.3 | 4.2 | 4.2 | 4.1 | 4.1 | 3.9 | 3.9 | 3.8 | 3.8 | 3.7 |
| | | - Plan RE | MW | - | - | 60 | 290 | 560 | 840 | 1,120 | 1,430 | 1,740 | 2,100 | 2,320 | 2,540 | 2,760 | 2,980 | 3,200 | 3,420 | 3,640 | 3,860 | 4,080 |
| | | | % | - | - | 0.2 | 0.7 | 1.2 | 1.8 | 2.3 | 2.8 | 3.5 | 4 | 4.1 | 4.5 | 4.6 | 4.9 | 5 | 5.3 | 5.4 | 5.6 | 5.8 |
| | | - Import | MW | 2,105 | 2,105 | 2,105 | 2,105 | 2,105 | 2,105 | 2,764 | 3,984 | 3,984 | 4,284 | 4,584 | 4,884 | 5,184 | 5,484 | 5,784 | 6,084 | 6,384 | 6,684 | 6,858 |
| | | | % | 6.1 | 5.8 | 5.3 | 4.9 | 4.6 | 4.5 | 5.7 | 7.8 | 7.9 | 8.1 | 8.2 | 8.6 | 8.7 | 9.1 | 9 | 9.4 | 9.5 | 9.6 | 9.7 |
| | | **Subtotal** | MW | 7,288 | 8,327 | 8,993 | 9,745 | 10,734 | 11,768 | 12,817 | 14,534 | 14,968 | 15,709 | 16,298 | 16,878 | 17,404 | 17,907 | 18,457 | 19,065 | 19,532 | 20,098 | 20,546 |
| | | | % | 21 | 23 | 23 | 23 | 24 | 25 | 27 | 28 | 30 | 30 | 29 | 30 | 29 | 30 | 29 | 29 | 29 | 29 | 29 |
| **Combined Cycle** | | - EGAT | MW | 6,866 | 6,866 | 8,417 | 9,317 | 9,317 | 9,003 | 8,364 | 8,364 | 7,723 | 8,623 | 9,523 | 8,851 | 10,651 | 11,551 | 12,451 | 14,251 | 16,051 | 17,851 | 18,751 |
| | | | % | 20 | 18.8 | 21.3 | 21.6 | 20.5 | 19.1 | 17.3 | 16.3 | 15.3 | 16.3 | 17 | 15.6 | 17.9 | 19.1 | 19.5 | 21.9 | 24 | 25.7 | 26.5 |
| | | - IPP | MW | 9,225 | 9,225 | 10,825 | 11,250 | 11,472 | 11,472 | 11,472 | 11,472 | 10,772 | 11,672 | 12,572 | 13,122 | 14,022 | 14,222 | 15,122 | 13,081 | 12,368 | 12,368 | 12,368 |
| | | | % | 26.9 | 25.3 | 27.4 | 26.1 | 25.2 | 24.3 | 23.7 | 22.3 | 21.4 | 22.1 | 22.4 | 23.1 | 23.6 | 23.5 | 23.6 | 20.1 | 18.5 | 17.8 | 17.5 |
| | | **Subtotal** | MW | 16,091 | 16,091 | 19,242 | 20,567 | 20,789 | 20,475 | 19,836 | 19,836 | 18,495 | 20,295 | 22,095 | 21,973 | 24,673 | 25,773 | 27,573 | 27,332 | 28,419 | 30,219 | 31,119 |
| | | | % | 47 | 44 | 49 | 48 | 46 | 43 | 41 | 39 | 37 | 38 | 39 | 39 | 41 | 43 | 43 | 42 | 42 | 44 | 44 |
| **Cogeneration** | | - SPP | MW | 2,340 | 3,510 | 3,780 | 4,320 | 4,770 | 5,490 | 6,169 | 6,704 | 6,614 | 6,594 | 6,624 | 6,763 | 6,313 | 6,313 | 6,493 | 6,673 | 6,673 | 6,673 | 6,673 |
| | | | % | 6.8 | 9.6 | 9.6 | 10 | 10.5 | 11.6 | 12.8 | 13.1 | 13.1 | 12.5 | 11.8 | 11.9 | 10.6 | 10.4 | 10.1 | 10.3 | 10 | 9.6 | 9.4 |
| | | - VSPP | MW | 27 | 43 | 59 | 76 | 96 | 96 | 97 | 102 | 102 | 103 | 108 | 108 | 109 | 113 | 113 | 114 | 119 | 119 | 120 |
| | | | % | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| | | **Subtotal** | MW | 2,367 | 3,553 | 3,839 | 4,396 | 4,866 | 5,586 | 6,266 | 6,806 | 6,716 | 6,697 | 6,732 | 6,871 | 6,422 | 6,426 | 6,606 | 6,787 | 6,792 | 6,792 | 6,793 |
| | | | % | 7 | 10 | 10 | 10 | 11 | 12 | 13 | 13 | 13 | 13 | 12 | 12 | 11 | 11 | 10 | 10 | 10 | 10 | 10 |
| **Thermal** | Gas Turbine/Diesel | - EGAT | MW | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 254 | 504 | 754 |
| | | | % | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.4 | 0.7 | 1.1 |
| | Heavy Oil | - EGAT | MW | 315 | 315 | 315 | 315 | 315 | 315 | 315 | 315 | 315 | 315 | 315 | 315 | 315 | 315 | 315 | 315 | 315 | 315 | 315 |
| | | | % | 0.9 | 0.9 | 0.8 | 0.7 | 0.7 | 0.7 | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| | Heavy Oil/Natural Gas | - EGAT | MW | 2,204 | 2,204 | 1,152 | 1,152 | 1,152 | 1,152 | 1,152 | 1,152 | 1,152 | 1,152 | 1,152 | 1,152 | 1,152 | 1,152 | 1,152 | 576 | 0 | 0 | 0 |
| | | | % | 6.4 | 6 | 2.9 | 2.7 | 2.5 | 2.4 | 2.4 | 2.2 | 2.3 | 2.2 | 2.1 | 2 | 1.9 | 1.9 | 1.8 | 0.9 | 0 | 0 | 0 |
| | | - IPP | MW | 1,510 | 1,510 | 1,510 | 1,510 | 1,440 | 1,440 | 1,440 | 1,440 | 1,440 | 1,440 | 1,440 | 1,440 | 1,440 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | % | 4.4 | 4.1 | 3.8 | 3.5 | 3.2 | 3.1 | 3 | 2.8 | 2.9 | 2.7 | 2.6 | 2.5 | 2.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Lignite | - EGAT | MW | 2,180 | 2,180 | 2,180 | 2,180 | 2,180 | 2,180 | 2,180 | 2,180 | 2,180 | 2,180 | 2,180 | 2,180 | 2,180 | 2,180 | 2,180 | 2,180 | 2,180 | 1,910 | 1,640 |
| | | | % | 6.4 | 6 | 5.5 | 5.1 | 4.8 | 4.6 | 4.5 | 4.2 | 4.3 | 4.1 | 3.9 | 3.8 | 3.7 | 3.6 | 3.4 | 3.4 | 3.3 | 2.8 | 2.3 |
| | | - Lao PDR | MW | 0 | 0 | 0 | 982 | 1,473 | 1,473 | 1,473 | 1,473 | 1,473 | 1,473 | 1,473 | 1,473 | 1,473 | 1,473 | 1,473 | 1,473 | 1,473 | 1,473 | 1,473 |
| | | | % | 0 | 0 | 0 | 2.3 | 3.2 | 3.1 | 3.1 | 2.9 | 2.9 | 2.8 | 2.6 | 2.6 | 2.5 | 2.4 | 2.3 | 2.3 | 2.2 | 2.1 | 2.1 |
| | Coal | - EGAT | MW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 800 | 800 | 800 | 1,600 | 1,600 | 1,600 | 2,400 | 2,400 | 2,400 | 3,200 | 3,200 | 3,200 |
| | | | % | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.6 | 1.6 | 1.5 | 2.9 | 2.8 | 2.7 | 4 | 3.8 | 3.7 | 4.8 | 4.6 | 4.5 |
| | | - IPP | MW | 2,007 | 2,007 | 2,007 | 2,007 | 2,277 | 2,547 | 2,547 | 2,547 | 2,547 | 2,547 | 2,547 | 2,547 | 2,547 | 2,547 | 2,547 | 2,547 | 2,547 | 2,547 | 2,547 |
| | | | % | 5.9 | 5.5 | 5.1 | 4.7 | 5 | 5.4 | 5.3 | 5 | 5.1 | 4.8 | 4.5 | 4.5 | 4.3 | 4.2 | 4 | 3.9 | 3.8 | 3.7 | 3.6 |
| | Nuclear | - EGAT | MW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,000 | 2,000 | 2,000 | 2,000 | 2,000 |
| | | | % | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.6 | 3.1 | 3 | 2.9 | 2.8 |
| | | **Subtotal** | MW | 8,220 | 8,220 | 7,168 | 8,150 | 8,841 | 9,111 | 9,111 | 9,911 | 9,911 | 9,911 | 10,711 | 10,711 | 10,711 | 10,071 | 11,071 | 11,495 | 11,969 | 11,949 | 11,929 |
| | | | % | 24 | 23 | 18 | 19 | 19 | 19 | 19 | 19 | 20 | 19 | 19 | 19 | 18 | 17 | 17 | 18 | 18 | 17 | 17 |
| **EGAT - TNB, HVDC** | | | MW | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| | | | % | 0.9 | 0.8 | 0.8 | 0.7 | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.4 | 0.4 |
| **Total** | | | MW | 34,265 | 36,491 | 39,542 | 43,157 | 45,530 | 47,240 | 48,329 | 51,386 | 50,389 | 52,912 | 56,135 | 56,732 | 59,509 | 60,477 | 64,007 | 64,979 | 67,012 | 69,358 | 70,686 |
| | | | % | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

# Projection of energy generation by fuel types or power demand from 2012 to 2030

| Fuel Types | | Unit | Year | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| **Renewable Energy** | - Domestic | GWh | 13,843 | 14,823 | 14,709 | 16,322 | 17,620 | 20,080 | 21,284 | 22,378 | 23,472 | 24,441 | 24,937 | 25,367 | 25,587 | 25,685 | 25,814 | 26,184 | 26,343 | 26,298 | 26,673 |
| | | % | 7.9 | 8.1 | 7.7 | 8.1 | 8.4 | 9.1 | 9.3 | 9.5 | 9.5 | 9.6 | 9.4 | 9.2 | 9 | 8.7 | 8.5 | 8.3 | 8.1 | 7.8 | 7.7 |
| | - Import | GWh | 12,605 | 12,306 | 11,527 | 11,073 | 12,346 | 11,120 | 13,269 | 15,959 | 19,990 | 21,530 | 23,070 | 24,040 | 26,150 | 27,689 | 29,229 | 30,769 | 32,309 | 33,279 | 34,205 |
| | | % | 7.2 | 6.7 | 6 | 5.5 | 5.9 | 5.1 | 5.8 | 6.8 | 8.1 | 8.4 | 8.7 | 8.8 | 9.2 | 9.4 | 9.6 | 9.8 | 9.9 | 9.9 | 9.9 |
| | **Subtotal** | GWh | 26,448 | 27,130 | 26,237 | 27,395 | 29,967 | 31,200 | 34,553 | 38,337 | 43,463 | 45,971 | 48,007 | 49,407 | 51,737 | 53,374 | 55,043 | 56,953 | 58,652 | 59,577 | 60,878 |
| | | % | 15.1 | 14.8 | 13.7 | 13.7 | 14.2 | 14.2 | 15.2 | 16.2 | 17.7 | 18 | 18.1 | 18 | 18.2 | 18.1 | 18.1 | 18.1 | 18 | 17.7 | 17.6 |
| **Natural Gas/LNG** | - EGAT/IPP | GWh | 102,387 | 103,846 | 108,810 | 109,754 | 106,569 | 104,598 | 104,573 | 101,125 | 101,624 | 108,483 | 112,351 | 118,087 | 126,606 | 132,603 | 133,073 | 132,997 | 131,500 | 143,147 | 154,873 |
| | | % | 58.5 | 56.7 | 56.8 | 54.7 | 50.6 | 47.6 | 45.9 | 42.8 | 41.3 | 42.4 | 42.4 | 43 | 44.5 | 45 | 43.7 | 42.2 | 40.4 | 42.6 | 44.7 |
| | | MMCFD | 2,166 | 2,178 | 2,217 | 2,211 | 2,102 | 2,051 | 2,039 | 1,978 | 1,974 | 2,096 | 2,173 | 2,279 | 2,435 | 2,551 | 2,568 | 2,576 | 2,539 | 2,763 | 2,975 |
| | - SPP/VSPP | GWh | 10,627 | 17,350 | 21,250 | 24,823 | 28,756 | 32,859 | 37,475 | 42,475 | 43,789 | 43,971 | 44,115 | 43,917 | 43,865 | 44,225 | 45,013 | 45,751 | 46,286 | 46,286 | 46,288 |
| | | % | 6.1 | 9.5 | 11.1 | 12.4 | 13.7 | 15 | 16.5 | 18 | 17.8 | 17.2 | 16.6 | 16 | 15.4 | 15 | 14.8 | 14.5 | 14.2 | 13.8 | 13.4 |
| | **Subtotal** | GWh | 113,013 | 121,197 | 130,060 | 134,577 | 135,325 | 137,456 | 142,048 | 143,600 | 145,412 | 152,454 | 156,466 | 162,004 | 170,470 | 176,828 | 178,086 | 178,748 | 177,786 | 189,434 | 201,161 |
| | | % | 64.6 | 66.1 | 67.9 | 67.1 | 64.3 | 62.6 | 62.4 | 60.8 | 59.1 | 59.6 | 59 | 59 | 59.9 | 60.1 | 58.5 | 56.8 | 54.6 | 56.4 | 58 |
| | | MMCFD | 2,166 | 2,178 | 2,217 | 2,211 | 2,102 | 2,051 | 2,039 | 1,978 | 1,974 | 2,096 | 2,173 | 2,279 | 2,435 | 2,551 | 2,568 | 2,576 | 2,539 | 2,763 | 2,975 |
| **Import Coal** | - EGAT/IPP | GWh | 14,429 | 14,350 | 15,274 | 15,004 | 15,936 | 19,002 | 19,356 | 22,699 | 25,446 | 25,403 | 28,804 | 31,492 | 31,625 | 34,893 | 37,570 | 37,389 | 43,623 | 43,616 | 43,693 |
| | | % | 8.2 | 7.8 | 8 | 7.5 | 7.6 | 8.7 | 8.5 | 9.6 | 10.3 | 9.9 | 10.9 | 11.5 | 11.1 | 11.9 | 12.3 | 11.9 | 13.4 | 13 | 12.6 |
| | | MTons | 6 | 6 | 6 | 6 | 6 | 7 | 7 | 9 | 10 | 10 | 11 | 12 | 12 | 13 | 14 | 14 | 17 | 17 | 17 |
| | - SPP | GWh | 2,168 | 2,123 | 2,055 | 2,027 | 2,132 | 2,589 | 2,528 | 2,523 | 2,523 | 2,523 | 2,523 | 2,523 | 1,472 | 158 | - | - | - | - | - |
| | | % | 1.2 | 1.2 | 1.1 | 1 | 1 | 1.2 | 1.1 | 1.1 | 1 | 1 | 1 | 0.9 | 0.5 | 0.1 | - | - | - | - | - |
| | **Subtotal** | GWh | 16,596 | 16,473 | 17,328 | 17,032 | 18,068 | 21,591 | 21,884 | 25,221 | 27,969 | 27,926 | 31,326 | 34,015 | 33,097 | 35,051 | 37,570 | 37,389 | 43,623 | 43,616 | 43,693 |
| | | % | 9.5 | 9 | 9 | 8.5 | 8.6 | 9.8 | 9.6 | 10.7 | 11.4 | 10.9 | 11.8 | 12.4 | 11.6 | 11.9 | 12.3 | 11.9 | 13.4 | 13 | 12.6 |
| | | MTons | 5.66 | 5.63 | 6.07 | 5.89 | 6.32 | 7.35 | 7.49 | 8.74 | 9.77 | 9.75 | 11.02 | 12.03 | 12.08 | 13.31 | 14.31 | 14.24 | 16.57 | 16.57 | 16.6 |
| **Lignite** | - EGAT | GWh | 16,749 | 16,696 | 16,736 | 16,738 | 16,614 | 17,120 | 17,030 | 17,024 | 17,077 | 17,031 | 17,031 | 17,039 | 17,090 | 17,041 | 17,037 | 17,019 | 17,078 | 14,910 | 12,786 |
| | | % | 9.6 | 9.1 | 8.7 | 8.3 | 7.9 | 7.8 | 7.5 | 7.2 | 6.9 | 6.7 | 6.4 | 6.2 | 6 | 5.8 | 5.6 | 5.4 | 5.3 | 4.4 | 3.7 |
| | | MTons | 16 | 16 | 16 | 16 | 16 | 16 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 12 | 10 |
| | - Lao PDR | GWh | - | - | - | 4,612 | 10,292 | 11,253 | 11,252 | 11,248 | 11,281 | 11,249 | 11,249 | 11,247 | 11,283 | 11,254 | 11,252 | 11,236 | 11,278 | 11,249 | 11,245 |
| | | % | - | - | - | 2.3 | 4.9 | 5.1 | 4.9 | 4.8 | 4.6 | 4.4 | 4.2 | 4.1 | 4 | 3.8 | 3.7 | 3.6 | 3.5 | 3.4 | 3.2 |
| | **Subtotal** | GWh | 16,749 | 16,696 | 16,736 | 21,349 | 26,906 | 28,373 | 28,282 | 28,273 | 28,358 | 28,280 | 28,281 | 28,286 | 28,374 | 28,296 | 28,289 | 28,255 | 28,356 | 26,159 | 24,031 |
| | | % | 9.6 | 9.1 | 8.7 | 10.6 | 12.8 | 12.9 | 12.4 | 12 | 11.5 | 11.1 | 10.7 | 10.3 | 10 | 9.6 | 9.3 | 9 | 8.7 | 7.8 | 6.9 |
| | | MTons | 16.04 | 15.99 | 16.03 | 16.03 | 15.92 | 16 | 13.81 | 14.02 | 14.16 | 14.12 | 14.12 | 14.13 | 13.87 | 13.74 | 13.62 | 13.61 | 13.66 | 11.84 | 9.78 |
| **Nuclear** | - EGAT | GWh | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 4,600 | 12,620 | 16,090 | 16,042 | 16,046 |
| | | % | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1.5 | 4 | 4.9 | 4.8 | 4.6 |
| | | Tons | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 9 | 25 | 32 | 32 | 32 |
| **Heavy Oil** | | GWh | 1,944 | 1,366 | 876 | 168 | 166 | 32 | 32 | 16 | - | - | - | - | - | - | - | - | - | - | - |
| | | % | 1.11 | 0.75 | 0.46 | 0.08 | 0.08 | 0.01 | 0.01 | 0.01 | - | - | - | - | - | - | - | - | - | - | - |
| | | MLiters | 499.43 | 353.32 | 222.08 | 36.18 | 36.06 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Diesel** | - EGAT | GWh | 130 | 133 | 172 | 75 | 55 | 26 | 23 | 23 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 |
| | | % | 0.1 | 0.1 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | MLiters | 29.1 | 31.86 | 40.6 | 20.92 | 13.47 | 7 | 6.3 | 6.3 | 5.61 | 5.6 | 5.6 | 5.6 | 5.61 | 5.6 | 5.6 | 5.6 | 5.61 | 5.6 | 5.6 |
| **EGAT - TNB,HVDC** | | GWh | 209 | 290 | 221 | 131 | 132 | 939 | 939 | 939 | 941 | 939 | 939 | 939 | 941 | 939 | 939 | 938 | 941 | 938 | 938 |
| | | % | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| **Total** | | GWh | 175,089 | 183,283 | 191,630 | 200,726 | 210,619 | 219,616 | 227,760 | 236,408 | 246,164 | 255,591 | 265,039 | 274,672 | 284,640 | 294,508 | 304,548 | 314,925 | 325,470 | 335,787 | 346,767 |

**Power Demand Statistics and Load Forecasts for PDP**
**(EGAT System and Purchase from VSPP)**

**Case : May 2012 (EE20%)**

| Year | Peak | | | Energy | | | Load Forecast | Elasticity |
|---|---|---|---|---|---|---|---|---|
| | MW | Increase | | GWh | Increase | | | |
| | | MW | % | | GWh | % | % | |
| | Actual: NET Generation | | | | | | | |
| 2008 | 22,093.70 | 56.4 | 0.26 | 145,816.50 | 2,002.90 | 1.39 | 75.14 | 0.56 |
| 2009 | 22,155.00 | 61.3 | 0.28 | 146,279.70 | 463.2 | 0.32 | 75.37 | -0.14 |
| 2010 | 24,174.40 | 2,019.40 | 9.11 | 161,350.20 | 15,070.50 | 10.3 | 76.19 | 1.32 |
| | 24,069.60 | -104.8 | - 0.43 | 160,705.50 | -644.7 | -0.4 | 76.22 | -5.18 |
| _ | Forecast: NET Generation | | | | | | | |
| 2012 | 26,355 | 2,285 | 9.49 | 175,089 | 14,383 | 8.95 | 75.84 | 1.38 |
| 2013 | 27,443 | 1,088 | 4.13 | 183,283 | 8,194 | 4.68 | 76.24 | 0.92 |
| 2014 | 28,790 | 1,348 | 4.91 | 191,630 | 8,348 | 4.55 | 75.98 | 0.8 |
| 2015 | 30,231 | 1,441 | 5 | 200,726 | 9,096 | 4.75 | 75.8 | 0.79 |
| 2016 | 31,809 | 1,577 | 5.22 | 210,619 | 9,893 | 4.93 | 75.59 | 0.96 |
| 2017 | 33,264 | 1,455 | 4.58 | 219,616 | 8,997 | 4.27 | 75.37 | 0.91 |
| 2018 | 34,593 | 1,329 | 4 | 227,760 | 8,144 | 3.71 | 75.16 | 0.9 |
| 2019 | 35,869 | 1,276 | 3.69 | 236,408 | 8,648 | 3.8 | 75.24 | 0.91 |
| 2020 | 37,326 | 1,457 | 4.06 | 246,164 | 9,756 | 4.13 | 75.29 | 0.97 |
| 2021 | 38,726 | 1,400 | 3.75 | 255,591 | 9,428 | 3.83 | 75.34 | 0.91 |
| 2022 | 40,134 | 1,409 | 3.64 | 265,039 | 9,448 | 3.7 | 75.39 | 0.91 |
| 2023 | 41,567 | 1,433 | 3.57 | 274,672 | 9,633 | 3.63 | 75.43 | 0.9 |
| 2024 | 43,049 | 1,482 | 3.57 | 284,640 | 9,968 | 3.63 | 75.48 | 0.9 |
| 2025 | 44,521 | 1,471 | 3.42 | 294,508 | 9,868 | 3.47 | 75.51 | 0.87 |
| 2026 | 46,003 | 1,482 | 3.33 | 304,548 | 10,040 | 3.41 | 75.57 | 0.86 |
| 2027 | 47,545 | 1,543 | 3.35 | 314,925 | 10,377 | 3.41 | 75.61 | 0.87 |
| 2028 | 49,115 | 1,570 | 3.3 | 325,470 | 10,544 | 3.35 | 75.65 | 0.87 |
| 2029 | 50,624 | 1,509 | 3.07 | 335,787 | 10,318 | 3.17 | 75.72 | 0.83 |
| 2030 | 52,256 | 1,632 | 3.22 | 346,767 | 10,979 | 3.27 | 75.75 | 0.87 |

## Appendix B:

Calculation of retired capacity for each year

## Calculation of retired capacity for each year

| Year | Project | Added Capacity (MW) | Fuel type | Projected capacity | Total additional capacity | Total capacity | Retired capacity |
|---|---|---|---|---|---|---|---|
| | SPP-Renewables | 498 | - | | | | |
| | SPP-Cogeneration | 254 | Gas | | | | |
| | VSPP-Renewables | 201 | - | | | | |
| | VSPP-Cogeneration | 8 | Gas | | | | |
| 2012 | GHECO-ONE Co.,Ltd. | 660 | Coal | | - | - | - |
| | Chao Phraya Dam #1-2 | 12 | Hydro | | | | |
| | Naresuan Dam | 8 | Hydro | | | | |
| | Khun Dan Prakarnchon Dam | 10 | Hydro | | | | |
| | Power Purchase from Lao PDR (Theun Hinboun Ext.) (Jul) | 220 | Hydro | 34,265 | | | |
| | SPP-Renewables | 249 | - | | 2,226 | | |
| | SPP-Cogeneration | 1170 | Gas | | | | |
| 2013 | VSPP-Renewables | 772 | - | | | 36,491 | 0 |
| | VSPP-Cogeneration | 16 | Gas | | | | |
| | Mae Klong Dam #1-2 | 12 | Hydro | | | | |
| | Pasak Jolasid Dam | 7 | Hydro | 36,491 | | | |
| | SPP-Renewables | 420 | - | | 4,103 | | |
| | SPP-Cogeneration | 270 | Gas | | | | |
| | VSPP-Renewables | 181 | - | | | | |
| | VSPP-Cogeneration | 16 | Gas | | | | |
| 2014 | Renewable Energy (Additional) | 60 | - | | | 40,594 | 1,052 |
| | Gulf Co.,Ltd. 1-Jun, Dec)(Assume CC) | 1600 | Gas | | | | |
| | Wang Noi CC #4 (Apr) | 769 | Gas | | | | |
| | Chana CC #2 (Apr) | 782 | Gas | | | | |
| | Thap Sakae Solar Cell | 5 | Solar | | | | |
| | Sirindhorn Dam Solar Cell | 0.1 | Solar | 39,542 | | | |
| | SPP-Renewables | 369 | - | | 4,791.1 | | |
| | SPP-Cogeneration | 540 | Gas | | | | |
| | VSPP-Renewables | 83 | - | | | | |
| | VSPP-Cogeneration | 17 | Gas | | | | |
| | Renewable Energy (Additional) | 230 | - | | | | |
| | Gulf Co.,Ltd. 1-Jun, Dec) | 1600 | Gas | | | | |
| | North Bangkok CC#2 (Oct) | 900 | Gas | | | | |
| 2015 | Bang Lang Dam (Renovated) | 12 | Hydro | | | 44,333 | 1,176 |
| | Kwae Noi Dam #1-2 | 30 | Hydro | | | | |
| | Khao Yai Thiang Wind Turbine (North) | 18 | Wind | | | | |
| | Chulabhorn Hydropower | 1 | Hydro | | | | |
| | Klong Tron Hydropower | 3 | Hydro | | | | |
| | Kiew Kohma Hydropower | 6 | Hydro | | | | |
| | Mae Karm Solar Cell | 0.1 | Solar | | | | |
| | Power Purchase from Lao PDR (Hongsa TH #1-2) (Jun, Nov) | 982 | Lignite | 43,157 | | | |

# Calculation of retired capacity for each year (Cont')

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2016 | SPP-Renewables | 635 | - | | 3,121.1 | 46,278 | 748 |
| | SPP-Cogeneration | 450 | Gas | | | | |
| | VSPP-Renewables | 79 | - | | | | |
| | VSPP-Cogeneration | 21 | Gas | | | | |
| | Renewable Energy (Additional) | 270 | - | | | | |
| | National Power Supply Co.,Ltd. TH #1-2 (Nov) | 270 | Coal | | | | |
| | New Power Plant (South) (Jul) | 900 | Gas | | | | |
| | Phayaman Hydropower | 2 | Hydro | | | | |
| | Lam Pao Hydropower | 1 | Hydro | | | | |
| | Lam Ta Khong Hydropower | 2 | Hydro | | | | |
| | Bhumubol Dam Solar Cell | 0.1 | Solar | | | | |
| | Power Purchase from Lao PDR (Hongsa TH #3) (Mar) | 491 | Lignite | 45,530 | | | |
| 2017 | SPP-Renewables | 153 | - | | 2,205.1 | 47,900 | 660 |
| | SPP-Cogeneration | 900 | Gas | | | | |
| | VSPP-Renewables | 77 | - | | | | |
| | Renewable Energy (Additional) | 280 | - | | | | |
| | National Power Supply Co.,Ltd. TH #3-4 (Mar) | 270 | Coal | | | | |
| | LamTa Khong Pumped Storage #3-4 (Jun) | 500 | Hydro | | | | |
| | That Noi Hydropower | 2 | Hydro | | | | |
| | Rawai Stadium Wind Turbine | 3 | Wind | | | | |
| | Rajjaprabha Dam Solar Cell | 0.1 | Solar | | | | |
| | Pha Chuk Hydropower | 20 | Hydro | 47,240 | | | |
| 2018 | SPP-Cogeneration | 720 | Gas | | 2,370 | 49,610 | 1,281 |
| | VSPP-Renewables | 86 | - | | | | |
| | VSPP-Cogeneration | 1 | Gas | | | | |
| | Renewable Energy (Additional) | 280 | - | | | | |
| | Mae Moh TH #4-7 (Replaced) | 600 | - | | | | |
| | Yaso Thorn - Phanom Prai Hydropower | 4 | Hydro | | | | |
| | Khao Laem Hydropower # 1-2 | 18 | Hydro | | | | |
| | Kra Seao Hydropower | 2 | Hydro | | | | |
| | Power Purchase from Lao PDR (Nam-Ngiep 1) (Jan) | 269 | Hydro | | | | |
| | Power Purchase from Lao PDR (Xe-Pian) (Aug) | 390 | Hydro | 48,329 | | | |
| 2019 | SPP-Renewables | 60 | - | | 3,241 | 51,570 | 184 |
| | SPP-Cogeneration | 720 | Gas | | | | |
| | VSPP-Renewables | 72 | - | | | | |
| | VSPP-Cogeneration | 5 | Gas | | | | |
| | Renewable Energy (Additional) | 310 | - | | | | |
| | EGAT Coal-Fired TH #1 (Jun) | 800 | Coal | | | | |
| | Huai Sataw Hydropower | 1 | Hydro | | | | |
| | Bang Pakong Hydropower | 2 | Hydro | | | | |
| | Sirindhorn Dam Solar Cell | 1 | Solar | | | | |
| | Khao Yai Thiang Wind Turbine (South) | 50 | Wind | | | | |
| | Power Purchase from Lao PDR (Xaiyaburi) (Oct) | 1220 | Hydro | 51,386 | | | |

## Calculation of retired capacity for each year (Cont')

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | SPP-Renewables | 45 | - | | 532 | | |
| | SPP-Cogeneration (Additional # 1) | 90 | Gas | | | | |
| | VSPP-Renewables | 81 | - | | | | |
| 2020 | Renewable Energy (Additional) | 310 | - | | | 51,918 | 1,529 |
| | Mae Saruay Hydropower | 2 | Hydro | | | | |
| | Thatako Solar Cell #1 | 1 | Solar | | | | |
| | Klong See Yud Hydropower | 3 | Hydro | 50,389 | | | |
| | SPP-Cogeneration (Additional # 2-3) | 180 | Gas | | 2723 | | |
| | VSPP-Renewables | 79 | - | | | | |
| | VSPP-Cogeneration | 1 | Gas | | | | |
| | Renewable Energy (Additional) | 360 | - | | | | |
| 2021 | New Gas-fired Power Plant | 900 | Gas | | | 53,112 | 200 |
| | Bang Pakong CC #1 (Replaced) | 900 | Gas | | | | |
| | Chonnaboat Hydropower | 2 | Hydro | | | | |
| | Thatako Solar Cell #2 1 MW Solar | 1 | Solar | | | | |
| | Power Purchase from Neighbouring Countries | 300 | - | 52,912 | | | |
| | SPP-Cogeneration (Additional # 4-5) | 180 | Gas | | 3373.1 | | |
| | VSPP-Renewables | 67 | - | | | | |
| | VSPP-Cogeneration | 5 | Gas | | | | |
| | Renewable Energy (Additional) | 220 | - | | | | |
| 2022 | New Gas-Fired Power Plant | 900 | Gas | | | 56,285 | 150 |
| | Bang Pakong CC #2 (Replaced) | 900 | Gas | | | | |
| | EGAT Coal-Fired TH #2 | 800 | Coal | | | | |
| | Mahasarakam Hydropower | 1 | Hydro | | | | |
| | Chulabhorn Dam Solar Cell | 0.1 | Solar | | | | |
| | Power Purchase from Neighbouring Countries | 300 | - | 56,135 | | | |
| | SPP-Cogeneration (Additional # 6-7) | 180 | Gas | | 3461.1 | | |
| | VSPP-Renewables | 47 | - | | | | |
| | Renewable Energy (Additional) | 220 | - | | | | |
| | New Gas-Fired Power Plant | 900 | Gas | | | | |
| 2023 | South Bangkok CC #1-2 (Replaced) | 1800 | Gas | | | 59,596 | 2,864 |
| | Low Wind Speed Wind Turbine | 10 | Wind | | | | |
| | Huai Nam Sai Hydropower | 2 | Hydro | | | | |
| | Rasisalai Hydropower | 2 | Hydro | | | | |
| | Ubonrat Dam Solar Cell | 0.1 | Solar | | | | |
| | Power Purchase from Neighbouring Countries | 300 | - | 56,732 | | | |

## Calculation of retired capacity for each year (Cont')

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2025 | SPP-Cogeneration (Additional # 10-11) | 180 | Gas | | 3,346 | 62,855 | 2,378 |
| | VSPP-Renewables | 37 | - | | | | |
| | VSPP-Cogeneration | 5 | Gas | | | | |
| | Renewable Energy (Additional) | 220 | - | | | | |
| | New Gas-Fired Power Plant | 900 | Gas | | | | |
| | Bang Pakong CC #4 (Replaced) | 900 | Gas | | | | |
| | EGAT Coal-Fired TH #3 | 800 | Coal | | | | |
| | Pranburi Hydropower | 2 | Hydro | | | | |
| | Tabsalao Hydropower | 2 | Hydro | | | | |
| | Power Purchase from Neighbouring Countries | 300 | - | 60,477 | | | |
| 2026 | SPP-Cogeneration (Additional # 12-13) | 180 | Gas | | 3,534 | 64,011 | 4 |
| | VSPP-Renewables | 32 | - | | | | |
| | Renewable Energy (Additional) | 220 | - | | | | |
| | New Gas-Fired Power Plant | 900 | Gas | | | | |
| | Bang Pakong CC #5 (Replaced) | 900 | Gas | | | | |
| | EGAT Nuclear Power Plant #1 | 1000 | Uranium | | | | |
| | Kamalasai Hydropower | 1 | Hydro | | | | |
| | Numpung Dam Solar Cell | 1 | Solar | | | | |
| | Power Purchase from Neighbouring Countries | 300 | - | 64,007 | | | |
| 2027 | SPP-Cogeneration (Additional # 14-15) | 180 | Gas | | 3596.1 | 67,603 | 2,624 |
| | VSPP-Renewables | 33 | - | | | | |
| | VSPP-Cogeneration | 1 | Gas | | | | |
| | Renewable Energy (Additional) | 220 | - | | | | |
| | Wang Noi CC #1 (Replaced) | 900 | Gas | | | | |
| | Bang Pakong CC #6 (Replaced) | 900 | Gas | | | | |
| | EGAT Nuclear Power Plant #2 | 1000 | Uranium | | | | |
| | Mae Wong Hydropower | 12 | Hydro | | | | |
| | Vajiralongkorn Dam Solar Cell | 0.1 | Solar | | | | |
| | Chaiyaphum and Nakhon Ratchasima Wind Turbine | 50 | Wind | | | | |
| | Power Purchase from Neighbouring Countries | 300 | - | 64,979 | | | |
| 2028 | VSPP-Renewables | 32 | - | | 3,425 | 68,404 | 1,392 |
| | VSPP-Cogeneration\ | 5 | Gas | | | | |
| | Renewable Energy (Additional) | 220 | - | | | | |
| | EGAT Coal-Fired TH #4 | 800 | Coal | | | | |
| | Wang Noi CC #2-3 (Replaced) | 1800 | Gas | | | | |
| | Gas Turbine #1 | 250 | Diesel | | | | |
| | Mae Khan Hydropower | 16 | Hydro | | | | |
| | Huai Samong Hydropower | 1 | Hydro | | | | |
| | Mae Moh Solar Cell | 1 | Solar | | | | |
| | Power Purchase from Neighbouring Countries | 300 | - | 67,012 | | | |

## Calculation of retired capacity for each year (Cont')

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | VSPP-Renewables | 32 | - | | 2,616 | | |
| | Renewable Energy (Additional) | 220 | - | | | | |
| | South Bangkok CC #4 (Replaced) | 900 | Gas | | | | |
| | EGAT New Combined Cycle Power Plant | 900 | Gas | | | | |
| 2029 | Gas Turbine #2 | 250 | Diesel | | | 69,628 | 270 |
| | Ao Phai Wind Turbine | 10 | Wind | | | | |
| | Lam Dome Yai Hydropower | 1 | Hydro | | | | |
| | Kamphaeng Phet Solar Cell | 3 | Solar | | | | |
| | Power Purchase from Neighbouring Countries | 300 | - | 69,358 | | | |
| | VSPP-Renewables | 33 | - | | 1,745 | | |
| | VSPP-Cogeneration | 1 | Gas | | | | |
| | Renewable Energy (Additional) | 220 | - | | | | |
| | EGAT New Combined Cycle Power Plant | 900 | Gas | | | | |
| 2030 | Gas Turbine #3 250 MW Diesel | 250 | Diesel | | | 71,103 | 417 |
| | Solar Cell , Southern Part of Thailand | 10 | Solar | | | | |
| | Samut Sakhon Wind Turbine | 30 | Wind | | | | |
| | Klong Luang Hydropower | 1 | Hydro | | | | |
| | Power Purchase from Neighbouring Countries | 300 | - | 70,686 | | | |