The Impact of Renewable Energy Pricing Incentive Policies in Thailand

Pasapong Gamonwet, Shobhakar Dhakal, and Koranat Thammasiri

***Abstract*— *Since 2006, renewable energy integration level in Thailand has been increased dramatically, especially electricity sector, due to the result of government pricing incentive policies, i.e., Adder program and Feed-in tariff (FiT) program. Adder program will provide the additional amount of money per unit, depended on type of technology, on the top on wholesale electricity price. In 2013, new incentive policy, FiT program was announced which implemented only for Solar PV Rooftop. FiT program will represent the flat rate for different types of technology. However, the payment for these power producers under these incentive programs, to be subsidized, which will be considered as government policy, expenses (PE). This PE will be added in Automatic Tariff Adjustment Mechanism or F_t which is one component of customer electricity bill. The study will show history and trend of RE pricing incentive policies in Thailand, included with the concept of pass-through PE in F_t. Moreover, the comparing and measuring between Adder and FiT burden cost are also concerned in this preliminary study. The study found that, from year 2021 onward, the subsidized cost from adder will be sharply reduced, while FiT will generate higher cost in F_t, especially for electricity which generated from the biomass and solar power.*

***Keywords*— Renewable Energy (RE), adder, feed-in tariff (FIT), automatic tariff adjustment mechanism (F_t).**

1. INTRODUCTION

In the past decade, Renewable Energy (RE) integration level in Thailand has been increased dramatically, especially for electricity sector. Provincial Electricity Authority (PEA), one of the main electricity utility who responsible for more than 95% of power distribution area in Thailand, has to purchase power from Very Small Power Producer (VSPP) since 2006. Interestingly, the number of VSPP has jumped up from 3 units in 2003 to 129 and 635 units in 2009 and 2015, respectively. This VSPP booming phenomena was ignited by government pricing incentive policy to induce the power producers for moving from generating power from conventional fuel, e.g. coal, diesel, or natural gas, to RE resource instead. This incentive used the additional subsidy concept called "Adder" program which provides the additional amount of Baht (Thailand currency unit) per kWh, depended on type of technology, on the top of power tariff (Base tariff plus Automatic Tariff Adjustment Mechanism (F_t)) [1]. Therefore, for the Adder program, the power producers will be guaranteed for the financial level to complete with the barrier to entry for the new incomer in the electricity market. However, due to the government underestimated for the growth of RE under Adder program, the cost for subsidizing this program has been increased year by year Hence, to reduce this burden, in 2013, new pricing incentive policy or called "Feed-in Tariff" (FiT) program has been announced and implement later in 2015. This FiT program has been implemented only for those who produces electricity from Solar PV which installed on the roof or the top of the building, and directly sell power back to the utility grid. Moreover, expected within the end of year 2016, the FiT program for other RE, e.g. Biomass, Biogas, Waste, etc., [2] and ground-mounted solar farm, which is located in government office and agricultural cooperative area, e.g. farm, livestock, will be implemented by the Regulatory Commission (ERC) [3].

According to the cost for producing 1 kWh of electricity from RE is higher than conventional resource, thus there will be the higher level of subsidy for those who produce power from RE. Furthermore, the portion of subsidy will also be increased which depend on the type and cost of technology, for example, 1 kWh produced from solar power will be subsidized for 8 Baht or 22.85 US cent (1 US$ = 35 Baht) on the top of power tariff at the given time. These RE subsidy cost are considered as government policy expense (PE) which is one of the three components of F_t which will be every 4 months recalculated and announced for being one part of the monthly retail electricity bill. Likewise, not only for the adder program but also FiT program that the additional cost will pass-through the F_t, the different between fixed FiT price and average wholesale price included with wholesale F_t at the given time, will be redeemed, by the distribution utility, in the Retail F_t.

The study is divided into 4 parts where the study for history and the future of RE pricing incentive policies in Thailand will be the first. Secondly, concept of pass-through PE, i.e. Adder and FiT, into retail Ft in Thailand electricity market will be analyzed. Moreover, the

Pasapong Gamonwert (corresponding author) is with the Asian Institute of Technology, P.O. Box 4, Klong Luang, Pathumthani 12120, and with Provincial electricity Authority (PEA), 200 Ngam Wongwan, Lad Yao, Chatuchak, Bangkok, 10220, Thailand. Phone: +66-2-590-9125; Fax: +66-2-590-9133; E-mail: Pasapong.gam@gmail.com.

Shobhakar Dhakal is with Energy field of study, Asian Institute of Technology, P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand. E-mail: shobhakar.dhakal@gmail.com, shobhakar@ait.ac.th.

Koranat Thammasiri is with Provincial Electricity Authority (PEA), 200 Ngam Wongwan, Lad Yao, Chatuchak, Bangkok, 10220, Thailand. E-mail: Koraman@gmail.com.

definitions and characteristic of FiT are also included. Later for the third part, the effect of the burden between Adder and FiT are both compared and measuring how much electricity customers have to be absorbed. For last, 10 years forecasting for the trend of both Adder and FiT, in term of PEA power purchasing, will be generated and analyzed which program will has the potential effect to the electricity customers.

2. THAILAND POWER SECTOR AND RENEWABLE ENERGY POLICIES

2.1 Thailand Electricity market

The electricity generation and supply under the Government of Thailand is originally managed by three power Utilities, i.e., the Electricity Generating Authority of Thailand (EGAT), the Metropolitan Electricity Authority (MEA), and Provincial Electricity Authority (PEA) [4]. The market is not very different from the vertically integrated markets of Indonesia and Malaysia. Over the past 20 years, Thailand's electricity sector has evolved from a government monopoly to a semi-unbundled structure called the "Enhanced Single Buyer" model. This model, shown in Figure 1 consists of EGAT owning about 50% of generation assets and 100% of transmission assets. The other half of the generation assets are developed and owned by private companies, including Independent Power Producers (IPPs), Small Power Producers (SPPs), and Very Small Power Producers (VSPPs). IPPs and SPPs produce and sell power to the high-voltage transmission system owned by the only buyer, EGAT. VSPPs sell power through the two state-owned distribution systems, the MEA and PEA. Thailand's policies related to energy, including electric power and renewable energy policies are drafted and proposed by the Ministry of Energy (MOE). Policies related to electric power and natural gas transmission are regulated by the ERC [5].

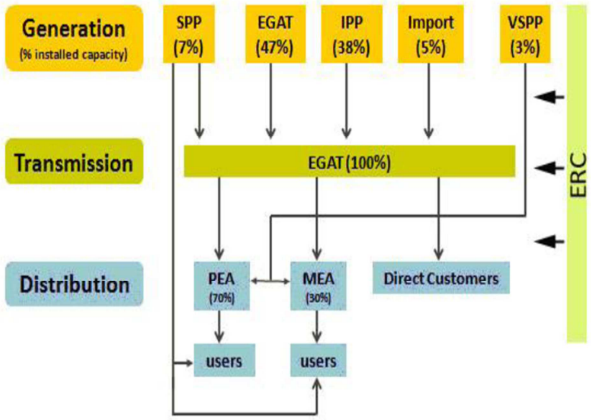

Fig.1. Thailand Power Industry Structure.

To address the lack of a national body to implement energy planning, formulate policies and regulate the energy sector, the National Energy Policy Council (NEPC) Act was passed in 1992, and the National Energy Policy Office (NEPO) was established as its secretariat [6]. The NEPO was later upgraded into a permanent department under the office of the Prime minister to become a regulatory body supervising. In 2002, the NEPO were downgraded to Energy Policy and Planning Office (EPPO) under the Ministry of Energy (MOE).

EGAT has the sole right and a significant role in the generation and transmission of Thai electricity. EGAT is presently the largest electricity producer, owning and operating its own power plants throughout the country. It also has the sole right to purchase power from other private producers and neighboring country under the government regulation of the Enhance Single Buyer scheme (ESB). EGAT maintain its shareholding in the country's two largest IPPs, i.e., Ratchaburi Electricity Generating Holding Public Company Limited (RATCH) at 45 percent, Electricity Generating Public Company Limited (EGCO) at 25 percent, and District Cooling System and Power Plant Co., Ltd (DCAP) at 35 percent. Though there are many IPPs and SPPs provision power to the EGAT grid, the RATCH and EGCO are the two largest with the market share 14 and 11 percent, respectively.

PEA is a government enterprise under the ministry of Interior. The authority's responsibility is primarily concerned with the generation, distribution, sales and supply of electric energy to the business and industrial sector as well as to the general public in provincial area, with the exception of Bangkok, Nonthaburi and Samut Prakarn provinces. The PEA has expanded electricity supply to all areas covering approximately 510,000 km^2, accounted for 99 percent of the country's total area. As same as PEA, MEA is also under the ministry of Interior, which established in 1985, this organization was responsible for generating and selling electrical power in the metropolitan area until 1961, when the generating aspect was transferred to EGAT. MEA provides high-class service while laying emphasis on sustainable growth of related business as well as responsibility for the society and the environment [7].

2.2 Thailand power sector and Renewable energy policy

Compared to other neighborhood countries around Thailand, Thailand has highest electricity demand, with plans for increasing imports from nearby countries, i.e. Myanmar, Laos, and Vietnam. In year 2012, Thailand consumes electricity more than 140 TWh, moreover, in the past 10 years, there was a high growth of electricity demand which is around 770 MW per year and still be continued. In 2014, Thailand can produce electricity more than 180 TWh, with majorly 66% from natural gas and 21% from coal, while renewable and hydro contribute for less than 5% from the share of total power generation mixed (figure 2) [8].

However, due to the energy security concern and climate change issues have been majorly brought up to the table. Therefore, in year 2008, Thailand had initiated the long term renewable energy (RE) plans. The country first RE plan was the 15-year Renewable Energy Development Plan, (REDP 2008 – 2022), which sought to bring renewable energy to 20% of final energy consumption by 2020. However, there was a revised of this plan and, the new revised plan is finally called

'Renewable and Alternative Energy Development Plan' (AEDP). This plan is aim for increasing to portion of renewable energy to 25% of final energy consumption in 10 years (2012 – 2021) [9] which show in figure 3.

Under Thailand electricity system, there are several reasons for investor to do the business in Thailand's renewable energy sector [10] which are 1) Consistent energy policy 2) Policy formulation is based on 'sufficient Economy Philosophy', 3) Harboring private investment, e.g. firm governmental targets, financial and non-financial supports, promotion package, 4) Clean Development Mechanism (CDM) opportunity, 5) Low-risk Power Purchasing Agreement (PPA) and credible contracting partner, i.e. EGAT, MEA, PEA, 6) Continuous growing demand for RE, 7) Substantial RE resources, essentially, solar and bio-energy, and 8) Friendly investment environment.

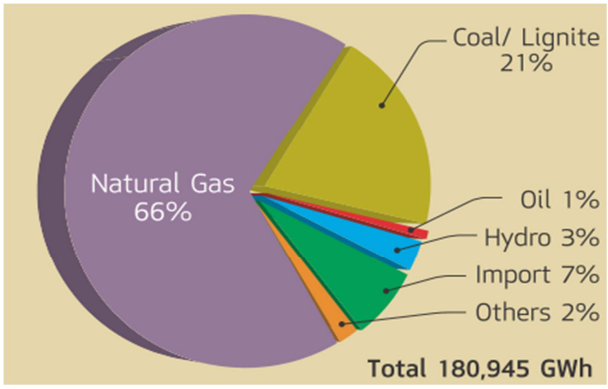

Fig.2. Share of Thailand power generation by type of fuel.

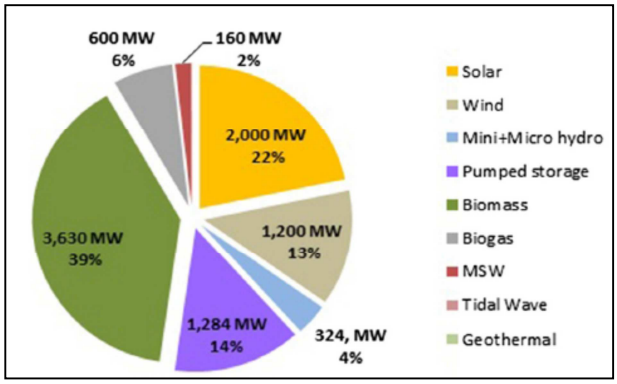

Fig.3. Thailand's RE targets according to the AEDP (2012 – 2021).

A. Characteristic of Feed-in Tariff program

There are many meaning for Feed-in tariff policy, for instance, it is an umbrella term for policies using a fixed purchase price for electricity from renewable sources, and in addition, this policy aims to substantially increase the production of renewable electricity by giving investors economic incentives [11]. Moreover, from Ref. [12] the policy is to offer guaranteed prices for fixed periods of time for electricity produced from Renewable Energy Sources (RES). These price are generally offered in a non-discriminatory manner for every kWh of electricity produced, and can be differentiated according to the size of the installation, the type of technology, the location of the project, the number of other project specific variables, and the type of technology[13]. From Ref. [14], it also describes for FITs that they are intended to dramatically increase the amount of electricity produced from RES and create green jobs. Moreover, from Ref. [15] explained that FiT is a monetary reward for feeding electricity generated by renewable energy source such PV. It can either be equal to the retail electricity rate or greater than this rate (known as enhance FiT), while most FiT are usually financed by a levy added to all electricity bill.

Generally, FiT have the following characteristics which are:

- The utility is required to connect the RE to the grid and absorb the connection lost;
- Smaller capacity RE have higher incentive rates than larger capacity RE;
- There are different rates for different types of RE reflecting underlining cost. That is, FiT for wind are typically lower than for solar photovoltaic (PV);
- The FiT rates are declined by some percentage following the first year in which they are established to reflect assumed improvements in RES technological efficiency and the reward early entrants. Hence, power producers who contract in first year the policy is established get higher FiT rate than second, and so on contracts; and
- Utilities are required to buy all the electricity produced by the generators eligible for FiT at a fixed price every single year under the specific contract mostly 15 – 20 years or related on the lifetime of that power plant by different technology.

Thailand was one of the Asian Countries with a comprehensive (FiT) program, with interconnection regulation adopted by Thai cabinet in 2002, and technology-specific tariff or variable FiT which from now on will be called 'Adders' in 2006. This program called Adder due to it added additional payment to RE generators on top of the normal prices that power producers would receive when selling electricity to the power utilities. However, for some reason, essentially, customer equity due to the burden from increasing amount of supported money in term of adder which will pass directly through end-user, therefore, fixed-FiT or called from now on only FiT program, has been announced in middle of 2013 for those who installed solar PV rooftop. The application process was opened between October –November 2013; moreover, under this new FiT scheme for Thailand, it is more stringent regulation reflects learning past lessons.

B. Adder Program (Variable FiT)

Since year 2006, Thailand has introduced pricing incentive policy for pursue investor to invest for producing electricity from renewable energy, and that policy called ''Adder program'. The adder program can be considered as premium FiT or market-dependent approach, due to it adds more payment on the top of electricity price in Thailand. This program guaranteed the attractive power purchasing rates. This program is

implemented under all main 3 electricity utilities in Thailand, i.e. the Electricity Generating Authority of Thailand (EGAT), the Metropolitan Electricity Authority (MEA), and the Provincial Electricity Authority (PEA). The three utilities are obliged to purchase electricity from renewable electricity generators using with mainly two different regulations which are:

- Small Power Producer (SPP) regulations: for generators sized greater than 10 MW and less than 90 MW, moreover, these generators are permitted to sell power to EGAT only.
- Very Small Power Producer (VSPP) regulation: for generator sized equal or less than 10 MW, moreover, these generators are allowed to offered power to MEA and PEA, which depended on location grid connected.

Adder rates in Thailand are differenced by technology, geography, duration of payment, and installed capacity as shown in table 1. There are only winds and solar which have 10 years supported for Adder program, while other technologies can retain in program only 7 years. As for location, the higher rate of adder will be given for those VSPPs that located in three southern most provinces of Thailand. Under six different type of technologies, solar will gain highest payment, while wind and municipal solid waste will be second and third, respectively. It is also founded that for each technology, size of power plant or capacity for producing electricity are divided. For last consideration from adder rates table, RE power producer who locates in area that PEA supplies power which is generated by diesel will get higher premium subsidization.

Table 1. Thailand Adder Rates (As of 2013)

Type of RE	Unit: US Dollars per kWh					Years Supported
	2007 Adder Rate	2009 Adder Rate	2010 Addder Rate	Special Adder for Diesel Replacement	Special Adder for Three Southern most Provinces	
Biomass						
Installed Capacity ≤ 1 MW	0.010	0.017	0.017	0.033	0.033	7
Installed Capacity > 1 MW	0.010	0.010	0.010	0.033	0.033	7
Biogas						
Installed Capacity ≤ 1 MW	0.010	0.017	0.017	0.033	0.033	7
Installed Capacity > 1 MW	0.010	0.010	0.010	0.033	0.033	7
Waste						
Landfill and Digestor	0.083	0.083	0.083	0.033	0.033	7
Thermal Process	0.083	0.117	0.117	0.033	0.033	7
Wind						
Installed Capacity ≤ 50 kW	0.117	0.150	0.150	0.050	0.050	10
Installed Capacity > 50 kW	0.117	0.117	0.117	0.050	0.050	10
Small/Micro Hydro						
50 kW <Installed Capacity < 200 kW	0.013	0.027	0.027	0.033	0.033	7
Installed Capacity ≤ 50 kW	0.027	0.050	0.050	0.033	0.033	7
Solar	0.267	0.267	0.217*	0.050	0.050	10

Source: Provincial Electricity Authority (PEA), 2013

C. Solar PV Rooftop FiT program (Fixed FiT)

On 16th July 2013, NEPC approved solar rooftop policy to support this development in Thailand and increased the total government target from 2,000 to 3,000 MW [16]. Most of regulations for solar PV Rooftop were similar to VSPPs, especially for technical area. However, for financial regulations are different for instance,

- The approaches for calculating the rate is market-independent or Fixed FiT instead of Market dependent likes adder.
- The applicant who wants to join this FiT solar PV rooftop program has to produce power for distributed utility which has currently supply power for applicant, and the selling power from Solar PV rooftop can be approval as maximum 1,000 kWp.
- There is only allow for those who use PV technology and installation has to be on the roof not the garage or part of building that is not considered by law the roof.
- The rates are categorized in 3 different contracts, i.e. 0-10 kWp, 10-250 kWp, and 250 – 1000 kWp (table 2).
- The maximum capacity that Thailand will allow for this round applied is 200 MW by classified to 100MW for those residential and another 100 MW for total from commercial and industrial. Additionally, for each 100 MW classification, PEA and MEA will be shared by 60:40, respectively.
- The installation is divided into three types which are residential, small commercial and medium-large commercial. PEA will use monthly electricity consumption, which shown in monthly electricity bill as the reference for identifying the installation type.

Table 2. Solar FiT for three scales of installations

Classification	Scale	FiT Rate (US Cent/kWh)	Quata
Residential	0-10 kWp	19.89	100 MW
Small Commercial	10-250 kWp	18.71	100 MW
Medium/Large Commercial	250-1000 kWp	17.60	

(1 US$ = 35 Baht)

D. Fixed - FiT for RE (Excluded Solar Power)

On 26th June 2015, ERC announced the government gazette for fixed - FiT rate for purchasing from Very Small Power Producer (VSPP) (excluded solar energy) under the transition period from Adder (Variable Fit) to FiT (Fixed-FiT), where the detail is show in table 3 [17].

As can be seen from Table 3, the subsidized payment for biomass has specifically increased, compared with Adder program, from 0.017 to 0.1526 US$ per kWh. Therefore, according to this consequence, many biomass projects which has been COD under Adder program, has appeal for changing from Adder rate to FiT instead, and it has been success. On 24th June 2016, ERC has announced the government gazette for those already COD biomass project under adder program can be switched from Adder subsidizing program to FiT in program, and the contract period for getting the

subsidization is 20 years [18].

Table 3. FiT rate for VSPP (As of 2015)

Type	FiT (Baht/kWh)	FiT (US$/kWh)	Supported Duration (Year)
Waste < 1 MW	6.34	0.1811	20
Waste > 1- 3 MW	5.82	0.1663	20
Waste > 3 MW	5.08	0.1451	20
Landfill Waste	5.6	0.1600	10
Biomass < 1 MW	5.34	0.1526	20
Biomass > 1- 3 MW	4.82	0.1377	20
Biomass > 3 MW	4.24	0.1211	20
Biogas	3.76	0.1074	20
Biogas (Energy crop)	5.34	0.1526	20
Hydro < 200 kW	4.9	0.1400	20
Wind	6.06	0.1731	20

(1 US$ = 35 Baht)

3. CONCEPT OF THAILAND ELECTRICITY TARIFF, Ft, AND POLICY EXPENSE

3.1 Thailand Electricity tariff

Electricity tariff in Thailand can be determined in Wholesale and retail tariff. As for wholesale tariff, which is the tariff that PEA and MEA, the distribution utility, purchase from EGAT, while retail tariff is the price that PEA and MEA selling to end-users, in addition, both tariffs are uniform tariff? For determine pricing structure in Thailand, there are four criteria for determining the tariff, which are 1) Marginal cost – means 'the incremental costs resulting from the most appropriate adjustment of the power generation and distribution system to meet the continuously increasing demand per unit'. Marginal cost in electricity sector, presently, divided into four levels, i.e., generation, transmission, distribution, and retailing. 2) Load pattern – the Time of Use (TOU) rate was introduced due to the changing load pattern in early 1997. The TOU rate was offered as an alternative rate for the existing Time of Day (TOD) customer and as a compulsory rate for new power consumers. The current load pattern of the power system, in the present time is divided to peak from 9 a.m. – 10 p.m. on Monday – Friday, while Off-peak is from 10 p.m. – 9 a.m. on Monday – Friday and the whole day on Saturday, Sunday and public holidays. 3) Revenue requirement of the power utilities and financial criteria – there are two main requirements, revenue requirement and financial criteria. 4) Social criteria for the electricity tariff determination. – there are 3 essential political and social requirements which are, uniform tariff, subsidization for residential consumers, particularly for small residential consumers whose consumption is low, and the structure of electricity tariff for other consumer categories should be designed to best represent the marginal cost [19].

For retail tariff, it is comprised with two parts, i.e., the base tariff and Ft, as same as bulk supply tariff. Base tariff is comprised with the cost of generation, transmission, and distribution which are clearly unbundled. Tariff varies according to each end-user category with its own particular group's load pattern. There are mainly eight categories, i.e., household, small, medium and large general service, government institution and non-profit organization, specific business service, Agricultural Pumping Service, and Temporary Service [20]. Additionally, the structure of retail electricity tariffs will vary depended on consumption and voltage level.

3.2 Automatic Tariff Adjustment Mechanism (F_t) and Policy Expense (PE)

Since 2000, Thailand has restructured the tariff to be more cost reflection, and it have been the obligation to revise the electricity tariff every 4 – years. However, due to the inaccurate cost forecasting and fluctuation in resource price, e.g. Natural gas and Diesel oil, the adjustment price, which is added to the based tariff, is needed; it is called the Automatic Tariff Adjustment Mechanism or F_t.

Ft is one component of electricity bill (there are Based tariff, Ft and Value Added Tax – VAT), which can be changed due to the fluctuation of fuel price and cost of electricity that EGAT purchases from Independence Power Producer (IPP) and Small Power Producer(SPP), and import power from neighboring countries, e.g. Laos, and Malaysia, which are uncontrollable [21]. Ft will be changed every 4 months (January-April, May-August, and September – December) for reflecting real cost of power producing at the given time and in October 2003, Ft has been cut the components to be depended on only cost of purchased electricity, fuel cost, and government expenditure which come from energy policies.

In November 2015, both wholesale and retail electricity tariff has been revised. Therefore, Ft, which is one part of electricity bill, also be revised and approved by ERC. New Ft formula has still considered cost from pricing incentive policies, i.e. Adder and FiT, as the government policy expense, and also other expenses [22] which are

- **Adder** – Both additional payments which utilities pay for SPP and VSPP.
- **Power Development Fund (PDF)** – Payment which utilities and power producer have to pay to central fund which will be used for various energy development projects and miscellaneous.
- **FiT** – The different payment between FiT rate and average power tariff included Ft.
- **Etc.** – Other expenses, e.g. Demand Response.

There are two types of Ft which are 1) wholesale Ft, where is the price that EGAT uses to charge MEA, PEA and direct customers for the power purchasing, and 2) Retail Ft, where PEA and MEA will be used to charge the customers, e.g. Residential, Commercial, Industrial, etc. The trend of retail Ft is shown in figure 4.

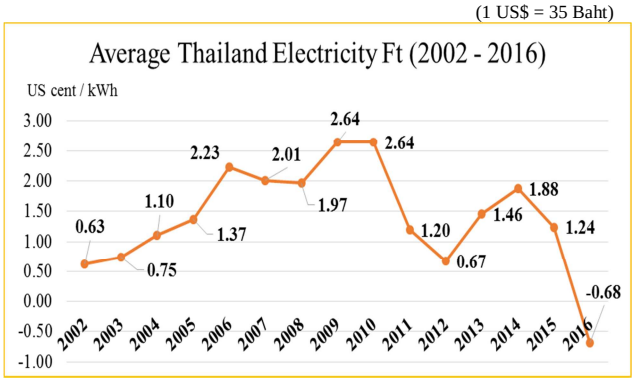

Fig.4. Data of Average Thailand's Electricity retail Ft (2002 – 2016).

On December 2006, NEPC has approved subsidization costs or Adder that utilities have to pay for SPP and VSPP, as the PE cost in Ft. Later in 2013, due to the implementation of FiT program, therefore NEPC has approved, like Adder, that the different cost between FiT and average wholesale (include Ft), that PEA and MEA purchase from EGAT, can be included in PE.

4. THE EFFECTS OF ADDER AND FiT

Due to these price incentive policies, i.e. Adder and FiT, the number and amount of power which installed to the utilities grid, especially PEA grid has been increased. Therefore, the effect from these RE policies has to be studied. This chapter will show both technical and cost effects from RE power producer, both SPP and VSPP.

4.1 Technical Effects (To the utilities)

For PEA, RE power producers, who either join Adder or FiT program, are limited the maximum power to be installed to PEA grid only at 8 MW for 22 kV line and 10 MW for 33 kV line in the southern of Thailand. This RE power producers are called VSPP and it has showing the sharply increasing number of power installation since 2006, especially solar power which the power is vary to the radiation of the sun. Due to this increasing numbers, there are many technical effects to PEA grid [23], which are

- **Reverse power flow** - In case that, large amount of RE power flow through the PEA grid, the reverse power flow will be occurred and causes trouble for controlling and power planning
- **Over Voltage** – Due the supply from RE power exceed the demand load in feeder line at the given time, will increase the voltage to be higher than the grid code standard which can later causes damage in customers' appliances or machines.
- **Transformer and cable overloading** – In case that there is no appropriated controlling regulation for RE installation, it will cause transformer and cable to take the responsibility with the overcapacity which may increase the temperature of power equipment, and increases the numbers of power unit losses in the system, moreover; the lifetime of equipment may be shorter.
- **System Loss** – The system losses may occurred when RE power is installed to far from load, which may take long distance for the power to reach the load in that feeder.
- **Voltage unbalance** – Due to RE power supplies power more in one phase than other two phases, which cause the voltage in the system to be imbalance.
- **Harmonics** – Especially for solar power which needs the inverter to convert the direct current to alternative current, the inverter will generate the harmonics which cause the voltage and current have misshaped and cause the equipment has fault operated or damaged.

According to Ref. [24], shows that purchased power from VSPP generate losses in PEA system. In table 4, shows losses classified by locational grid connected, where Northeastern region of PEA shows the highest rate of losses due to RE power plants are installed too far from load area. On the other hand, other regions show negative value of losses rate which mean that VSPP can reduce losses in area, due to in these areas, VSPP mostly be connected near load. Moreover in table 5, which shows losses classified by different technology, most of technology, except hydro and wind, creates losses, especially solar energy, due to most of solar power plants are located far from load.

Table 4. Losses classified by locational grid connected

PEA Region	Loss rate (%)
Northern	-6.16%
Northeastern	10.28%
Central	-5.57%
Southern	-11.67%
Average	-3.28%

Table 5. Losses classified by technology

Technology	Loss rate (%)
Biomass	3.09%
Biogas	0.09%
Waste	2.16%
Solar	6.04%
Hydro	-1.00%
Wind	0.00%

4.2 Cost effects (To the Electricity customers)

Due to the subsidization cost of Adder and FiT are considered as the PE, which utilities has to pay for subsidized renewable power producer i.e. SPP and VSPP. However, the utilities can reclaim these costs through retail Ft or called pass-through mechanism. According to the pass-through mechanism, the more subsidized amount for Adder and FiT, the more burden cost for customer which will be shown in their electricity bill. As be shown in figure 5, the number of energy sale to end-user in Thailand since October 2007 – December 2016 (estimated) has been increased, the figure shows

data of energy sale in every 4 months [25], which later this data will be used as the unit of power sale to calculate the burden of PE, i.e. Adder and FiT later.

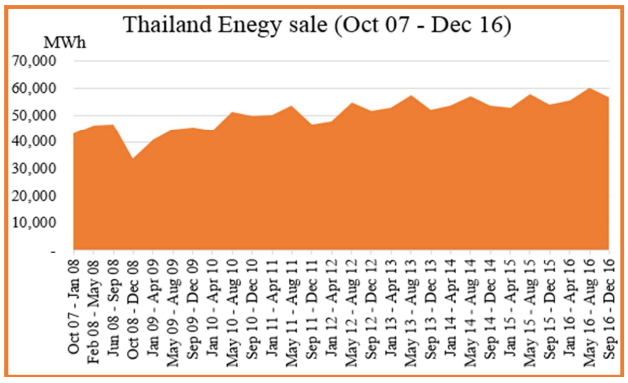

Fig.5. Thailand Energy sale since October 2007.

(1 US$ = 35 Baht)

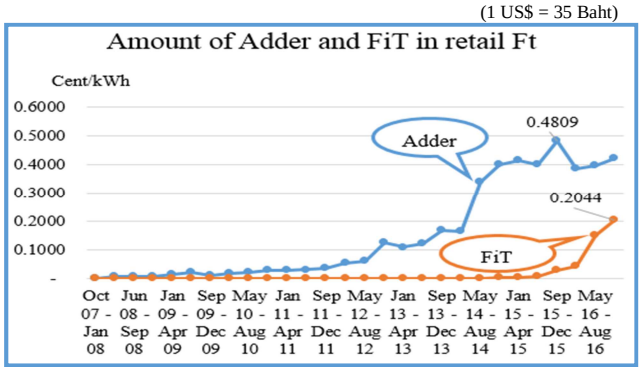

Fig.6. Average cost of Adder and FiT in Thailand retail Ft.

In figure 6, it shows the trend of Adder and FiT which cost US cent per kWh to end-user in part of retail Ft charge. Adder has been added more as PE to be part of Ft since Jan 2011. The sharp increasing in 2013 was the result from high rate of solar installation and keep continuing due to there are still some solar power plants which have not been yet operated. In the period of Ft during September – December 2015, Adder subsidization has cost the highest burden to customer in the amount of 0.4809 US cent/kWh. Compared to FiT, which has not been occurred until May 2014 and continuing increased but in small number, this is due to the first program of FiT is Solar Rooftop which has small number of area to generate power compared to solar farm under Adder program. However, since September 2015, the cost of FiT in Ft has increased due to large building and industry which has high solar power generating capacity can connect to the utility grid. The sharp increase in May 2016 and keep continuing are the result from installation of Biomass and solar farm under FiT program. Therefore, it can be inferred that the amount of subsidization for PE, i.e. Adder FiT will be increased continuously. However, although there is an increasing trend for renewable subsidization cost, it shows the contrary trend if compared with the historical data of Ft which is shown in figure 4. This is because, as mentioned in section 3.2, the component of Ft is not only policy expense (PE) but also fuel cost and power which EGAT purchases from IPP and SPP which both factors have more portion than PE. Therefore, although adder and FiT are increased but the decreasing in fuel price will affect more in change of Ft. In the next part, it will present the forecasting amount of Adder and FiT in next 10 years as a case of PEA who is the utilities that has the highest amount of power purchasing from RE under Adder and FiT program.

5. FORECASTING FOR ADDER AND FiT

5.1 Status of VSPP under Adder and FiT program that connected to PEA grid

PEA has purchased power from renewable energy under Adder program since 2006 when there were only 3 units of very small power plants joined this program. However, due to the influence of incentive policy which guarantees the return for those who invest in renewable energy, the number of VSPP, which connected to PEA grid, has been dramatically increased. As can be seen in figure 7, in 2007 the amount of MW for those VSPP that connected to PEA grid was less than 100 MW and continuously increased to 500 MW in 2010 and most were biomass power which produced from various energy sources, e.g. sugarcane, risk-husk, and woodchip. However, since 2011, the number of installed solar farm have risen and increased sharply yearly. In June 2016, the total number of MW of installed VSPP is reaching 3,000 MW and the capacity of solar power is more than half which is more than 1,500 MW.

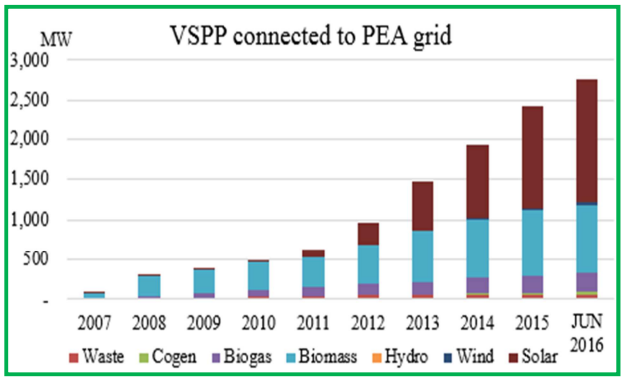

Fig.7. Capacity of VSPP under Adder Program.

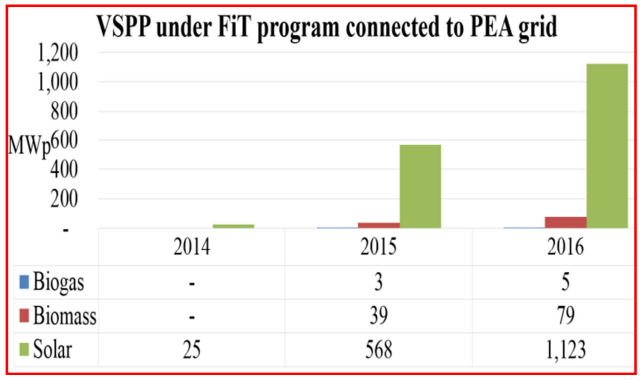

Fig.8. Capacity (MWp) of VSPP under FiT program.

In February 2014, the first solar PV rooftop, under FiT program, has been operated and selling power to PEA.

However, as shown in figure 8, due to the complexity of process, e.g. licenses approval, legal condition, the total power installed to PEA grid was only 25 MW. The amount of generating capacity from solar was huge increased to 568 MW in 2015 and double up to 1,123 MW in June 2016 [21]. This solar FiT booming phenomena was the result from solar farm who was late applied for joining Adder program, thus this solar farm projects have to be moved to FiT program instead where the total payment will reduce from 0.31 US$ per kWh to 0.16 US$ per kWh. Moreover, not only solar farm has been increased but also biomass project that increase amount of power installation from 39 MW in 2015 to 79 MW in 2016, and expected to by increased in the future.

5.2 10 years forecasting for VSPP under Adder and FiT program: A case of PEA

According to the increasing amount of renewable power, which produced from VSPP, both under Adder and FiT program, has been installed to PEA grid, therefore, forecasting for the future amount of these kind of power are needed. The study collected the historical data from VSPP both under Adder and FiT program, included with status data for those VSPP who has been operated and has not been operated due to the process of construction or licenses approval. These collected data have been used for forecasting the trend of VSPP in the future both for produced power and subsidization cost as show in figure 9 and 10.

In figure 9, it shows the comparison, in term of power that PEA has to purchased (GWh), between EGAT, VSPP (Adder), and VSPP (FiT). This study uses the load forecast which is considered and approved by Thailand Load Forecast Sub-Committee for the forecasted number of RE in Thailand during 2016 – 2025. However, the amount of RE in mentioned load forecasted is not classified in VSPP (adder) and VSPP (FiT) category, therefore the author uses the historical proportion as the ratio between VSPP (Adder) and VSPP (FiT) amount. As be shown in figure 9, although the portion for renewable energy or VSPP, compared to EGAT, will be less than 5% in 2015, it will be increase to 7.5% and 10% in year 2021 and 2025, respectively. Moreover, considered only for VSPP, it can be seen that the power that PEA projects to be purchased in next 10 years from VSPP (Adder) is very stable, in the range of 5,500 – 6,000 GWh per year, this is due to ERC has announced that the applying process for joining Adder program has closed from 2014 onward. Whilst, VSPP (FiT) shows the different story, it shows the continuing increasing trend. Although, VSPP (FiT) has so few amounts of power produced in 2015, only 180 GWh but due to the incentive pricing concept which guarantee the payment for each unit that RE produced to the utility grid, VSPP (FiT) will be increased more than 10% each year and within 2025 it will be over than 10,000 GWh, which is double more than the unit produced from VSPP under Adder program.

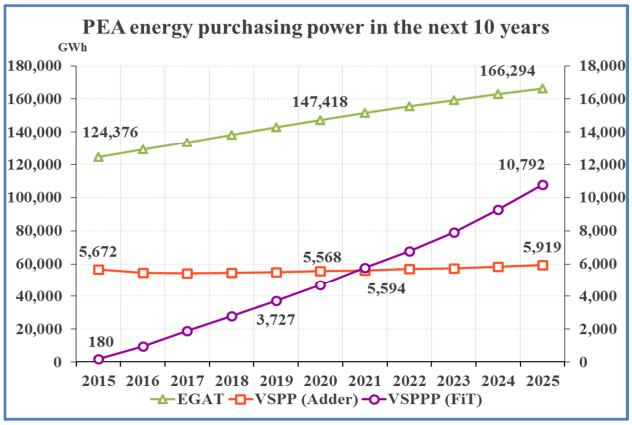

Fig.9. 10 Years forecast of power purchasing from EGAT, VSPP (Adder and FiT program).

In term of subsidization cost, which will be passing through to the Ft and can be considered as the electricity customer burden, in figure 10, it shows the subsidization cost between Adder and FiT program. As expected, the trend for Adder will be reduced year by year, where in 2015, the cost of VSPP(Adder) are more than 400 million US$ per year, but in 2025, it will be only 30.66 US$, which is 94% reduction compared to year 2016. There are 2 reasons for this huge reduction for Adder subsidization which are 1) The switching subsidization program from Adder to FiT in 2014, and 2) the subsidization period for each technology is limited, for instance solar and wind will be subsidized the adding payment on top of power tariff only for 10 years, while the other will be subsidized for 7 years. Thus, it is no surprise that the negative trend of subsidization cost for Adder will be occurred and will be reaching to zero within 2030. On the other hand, for VSPP (FiT), it will be growing with the positive trend. In 2016, FiT will cost only 50 million US$, but it will reach 280 and over 600 million US$ in year 2021and 2025, respectively. It can be inferred that, in the future, the burden from renewable energy subsidization will not be come from Adder program but will be from FiT program instead and expected to be more that Adder has been cost in the past 10 years.

(1 US$ = 35 Baht)

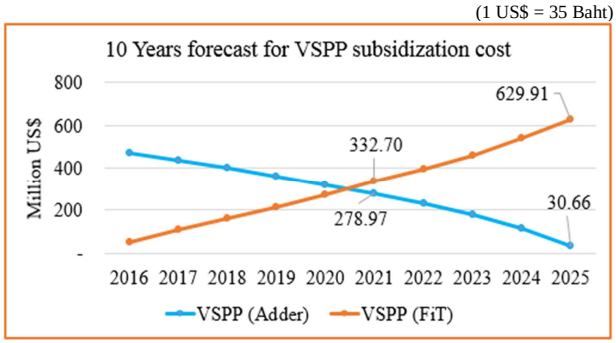

Fig.10. 10 Years forecast for VSPP subsidization cost.

Additionally, according to the forecasting FiT subsidization, (there will be considered only for Solar, Biomass, Biogas, due to in 2016, there is no other technologies have joined FiT program, thus there is no data for analyzed other kind of technologies) biomass

will play the vital role for producing power from renewable energy under FiT program and also create more than 60% of the subsidization cost, which will passing through the customer electricity bill, while solar and Biogas cost only 34% and 4%, respectively (figure 11). However, in the long run, Solar and biogas will be increased its portion to 40% and 11%, respectively, while biomass will be reduced to 49% instead.

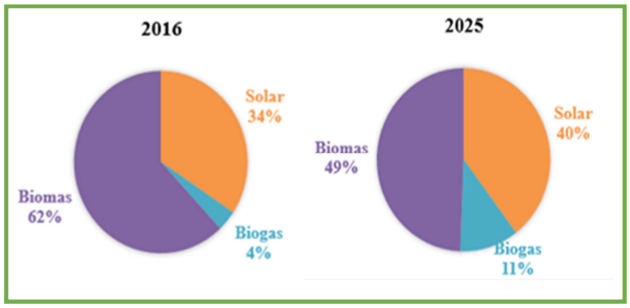

Fig.11. Subsidization cost for FiT classified by Technology.

6. CONCLUSION

Since 2006, 2 major pricing incentive policies for renewable energy, Adder and FiT, have been implemented, and the result from both policies can be concluded with the success story. The number and unit of installed power from these RE power plant or call VSPP shown with the huge increased and expected to be continued with positive trend. However, there is not only the positive effect from these policies, e.g. green energy, low carbon society, but also the negative effects which cannot be look beyond, i.e. technical effect (Utility concerns) and cost effect (Electricity customer concerns). As for Technical effect, from utilities point of view, the overvoltage from solar farm and unit losses are highly concerned due to these two disadvantages affect the reliability of the system and the power losses in utility's revenue. As for cost effects, from customer point of view, due to the subsidization for renewable energy, electricity customers have to pay for this subsidization which will be part of electricity bill in form of Ft. This can be inferred that the more subsidization cost for RE, the more cost to be added in electricity bill. Therefore, if analyze only with VSPP that sell power to PEA, in the next 10 years the amount of power produced from VSPP under FiT program will be increased along with the subsidization cost which will be passed-through customer electricity bill. The cost are expected to be higher than 600 million US$ or will be more than 19 US cent per kWh in 2025 compared to 0.20 US cent per kWh in 2015. Therefore, the policy makers, especially both renewable energy policy and tariff policy, should both considered these crucial subsidization trend, due to, although higher level of renewable energy integration may be increased the level of welfare or lowering the level pollution in power sector, but the affordability for paying electricity bill is also needed to be considered. If the subsidization for these RE pricing incentive policies will be too high in the future thus, under the Ft passing-through mechanism, amount of payment in monthly electricity bill has to be increased definitely.

ACKNOWLEDGMENT

We thank our colleagues from Provincial Electricity Authority (PEA) who provided insight and expertise that greatly assisted the research.

REFERENCES

[1] Kuravat, W. (2012). Financial Mechanism for Renewable Energy. *Financial Scheme for Renewable Energy Projects.* Bangkok.

[2] National Energy Policy Council. (2015). *Resolution for Feed-in tariff for purchasing power from Renewable energy (excluded solar power).* Bangkok: www.eppo.go.th.

[3] Energy Regulatory Commission . (2015). *Announce a power purchase from Solar ground-mount farm for government and Agricultural cooperative area.* Bangkok: www.ERC.or.th.

[4] Manisa et al. (2000). Electricity prices in a competitive market: a preliminary analysis of the deregulated Thai electricity industry. *Utilities Policy*, 171-179.

[5] Tongsopit, S., & Greacen, C. (2013). An Assessment of Thailand's feed-in tariff program. *Renewable Energy*, 439-445.

[6] Wisuttisak, P. (2012). Regulation and competition issues in Thai electricity sector. *Energy Policy*, 185-198.

[7] World Alliance for Thai Decentralized Energy. (2012). *Smart/Intelligent Grid Development and Deployment in Thailand (Smart Thai).* Bangkok.

[8] Enegry Policy and Planning Office (EPPO). (2016, March). *EPPO*. Retrieved from www.eppo.go.th: http://www.eppo.go.th/info/cd-2015/pdf/cha5.pdf

[9] Peerapong, P., & Limmeechokchai, B. (2014). Investment incentive of grid connected solar photovoltaic power plant under proposed feed-in tariffs framework in Thailand. *Energy Procedia*, 179 – 189.

[10] Sutabutr, T. (2010). *Thailand Renewable Energy Policies and Wind Development potentials.* Bangkok: Department of Alternative Energy Development and Efficiency (DEDE).

[11] David, W. (2011). *The Swiss Feed-in Tariff System: Analysis of the Swiss Policy and its Implications on the Development of Photovoltaics in Switzerland*, Energy Economics and Policy.

[12] Toby, C. Yves, G. (2010). *An analysis of feed-in tariff remuneration models: Implications for renewable energy investment.* Energy Policy, 38. 955 – 965.

[13] Mendonca, M. Jacob, D. Sovacool, B.K. (2010). *Powering Green Economy:The Feed-in tariff handbook*.earthscan.

[14] Richard, A.B. (2009). *Feed-in Tariff: Are they right for Michigan*, Michigan Electric Cooperative Association.

[15] Geoff, S. Susan, N. (2012). Grid Connected Solar Electric Systems, The Earthscan Expert Handbook for Planning, Design and Installation.

[16] Chrometzka, T. (2014). *Tapping Thailand's Solar Potential.* Germany: GIZ Thailand.

[17] Energy Regulatory Commission. (2015, June 26th). *FiT rate for VSPP (Excluded Solar Energy) under the transition period from Adder to FiT*. Retrieved from Energy Regulatory Commission (ERC): http://www.erc.or.th/

[18] Energy Regulatory Commission. (2016, 24 June). *FiT Rate for VSPP (Biomass project) under the transition period from Adder to FiT*. Retrieved from Energy Regulatory Commission (ERC): http://www.erc.or.th/ERCWeb2/

[19] United States Agency for International Development (USAID). (2013). *Challenges in Pricing Electric Power Service in Selected ASEAN countries.* Philippines: Final Report April 2013.

[20] Provincial Electricity Authority (PEA). (2015). *Electricity Tariff*. https://www.pea.co.th

[21] Electricity Generating Authority of Thailand. (2016). *What is the Automatic Tariff Adjustment Mechanism?* http://www3.egat.co.th/ft/

[22] Energy Regulaory Commission (ERC). (2015). *Tariff restructuring (November, 2015) : Automatic Tariff Adjustment Mechanism (Ft).* Bangkok: ERC.

[23] Corporate Business Development Division. (2016). *Prelimiary study on the effect of Solar PV Rooftop to PEA.* Bangkok: Provincial Electricity Authority (PEA).

[24] Gamonwet, P. (2014). A Study of the cost effect from purchasing power from Very Small Power Producer (VSPPs) : A case of Thailand. *AORC Technical Meeting.* Tokyo: CIGRE-Japan.

[25] Power Economics Department. (2016, September). *Automatic Tariff Adjustment Machanism (Ft)*. Retrieved from www.egat.co.th: http://www3.egat.co.th/ft/Web/Total%20sep59_dec59.htm