ASSESSMENT AND DESIGN OPTIONS OF THAILAND'S FEED-IN POLICIES

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Abstract— Thailand has been one of the successful countries in promoting electricity generation from renewable energy sources (RES-E). The main mechanism is driven by feed-in policies. These programs were firstly implemented as fixed premium tariffs, so-called Adder scheme, in 2006. Since the policy implementation, it effectively stimulates the national renewable electricity market. Renewable energy uses for electricity, in Thailand, increase steadily over the last decade. The proportion of the RES-E generation increased from 4.3% in 2007 to 9.9% in 2014. The policies have now been in the transition stage from Adder to fixed feed-in tariff (or FIT) schemes. The fixed FITs of rooftop solar power were initially promulgated in 2013. Afterward, the FITs of other RES-E generations were then applied in 2015. From the ten-year experiences, the policy implementation has achieved in attracting many private RES-E generators. The investors, however, still face the main problems of uncertainty and discontinuity. The several policy options are then discussed.

Keywords— Feed-in tariff, Renewable energy policy, Policy option, Thailand.

I. INTRODUCTION

The rapid growth of energy consumption in the last few decades is becoming global concerns about its adverse impacts. The transition from conventional energy to renewable energy has been now taking place for sustainable energy future [1]. The motivation of renewable energy policies has become of earnest concerns internationally. Feed-in policies, widely known as feed-in tariffs (FITs), have subsequently been recognized as the most famous and effective policies of encouragingrenewable energy in electricity generation [2, 3]. As of year-end 2015, feed-in policies have been adopted in 75 countries at the national level and in 35 states/provinces [4].

The FIT mechanism is a price driven support instrument of electricity generation from renewable energy sources (RES-E). The programs offer incentive long-term fixed-price electricity purchase agreements to private RES-E investors. Purchase obligation and priority grid access are also assured to increase the investment security [5]. The programs are, lastly, improve the competitiveness of RES-E investment compared with other conventional fuels [2].

Similar to most developing countries, Thailand energy supply is based on fossil fuel dominance and net energy importer. The important of renewable energy has long been recognized in national energy policies, and the feed-in programs have been implemented since 2006. The subsequent results have been impressive soliciting many private RES-E investors, especially for solar and biomass power. Nevertheless, the tariff schemes are still not satisfied by many operators which challenge the policy makers to improve the policy.

II. THAILAND'S ENERGY POLICIES AND RENEWABLE ELECTRICITY TARGETS

Thailand's power demand has been consistently increasing at an average of 3% per year for the last ten years. It is now up to 27,346 MW (or 183,390 GWh) in 2015 and expected to reach 49,655[1] MW (or 326,119 GWh) in 2036. The power generations are also expanding to meet the continuing growth in electricity demand and, at the same time,tomaintain the reliability of national power supply. Like other developing countries, Thai electricity generation is highly dominated by fossil fuels comprising 67% of natural gas, 18% of lignite and hard coal and 0.5% of diesel and fuel oil. Other sources were 7.5% of import electricity from neighboring countries and 7.2% of renewable energy (including hydropower) in 2015 [6].

However, renewable energy uses for electricity generation, in Thailand, increase steadily over the last decade. The proportion of RES-E (including off-grid power generation) increased from 4.3% in 2007 to 9.9% in 2014[2][7].

2.1 Long-term energy master plans

In 2014, the National Energy Policy Council (NEPC) approved the Thailand Integrated Energy Blueprint (TIEB) in order to guide the direction of national energy plans which focus on three main principles as follows:

[1] The forecast based on social and economic development direction addressed by the office of National Economic and Social Development Board (NESDB) of Thailand with assumptions of average growths of long term GDP (between 2014 and 2036) and population are 3.94% and 0.03% respectively.

[2]Excluding large hydropower.

1) Energy security – response to energy demand which consistent in the national economic and social development plan and eligible fuel diversification.
2) Economy – maintain appropriate and acceptable energy production cost.
3) Ecology – mitigate environmental impacts especially for CO_2 intensity reduction.

According to the TIEB principles, Ministry of Energy (MoE) has reviewed and integrated five long-term energy master plans during the year 2015-2036 consisting of (1) Thailand Power Development Plan (PDP), (2) Energy Efficiency Plan (EEP), (3) Alternative Energy Development Plan (AEDP), (4) Natural Gas Supply Plan, and (5) Petroleum Management Plan.

The EEP sets a target to reduce energy intensity (EI) by 30 percent in 2036[3] compared with baseline in 2010[4] for all energy sectors. That means the total final energy consumption is to be decreased to 131,000 ktoe in 2036. MoE also sets three strategic plans consisting of compulsory, voluntary, and complementary programs for main energy sectors (industrial, building, residential, and transportation) [8]. This target is integrated into all other energy master plans. The AEDP emphasizes the promotion of energy production to the full potential of local renewable energy resources and development of appropriate technologies together with social and environmental benefits[7]. In the case of electricity generation sector, the PDP focuses on fuel diversification in order to diminish the dependence of one particular fuel and increases the power system reliability [9].

2.2 Renewable electricity targets

According to the AEDP and PDP, the proportion of RES-E generation is set to achieve 20 percent of total electricity energy demand in 2036. Inorder to identify the merit order, levelized cost of electricity (LCOE), social and environmental benefits, and RE zoning are taken into account. The selected renewable sources areas follows:

- MSW
- Biomass
- Biogas (WW/SW)
- Small hydro
- Biogas (energy crop)
- Wind
- Solar
- Geothermal

Table 1 presents the current and future plans of thenew energy mix. Recent and targeted installed capacities of the renewable sources are also shown in **Fig.1**.

III. TEN-YEAR EXPERIENCES OF FEED-IN POLICIES IN THAILAND

Promotion of RES-E policy in Thailand was firstly endorsed by Thai Cabinet in 2002. The distribution system operator utilities used the net-metering approach for purchasing RES-E produced from VSPP which had a capacity less than or equal to 1 MW. After that, the feed-in policies were fully implemented in 2006 with technology-specific premium tariffs, so-called Adder scheme, by pricing support instrument. This mechanism was implemented using two main schemes as follows [3]:

- SPP scheme – generation capacity is greater than 10 MW and less than 90 MW,to be purchased by Electricity Generating Authority of Thailand (EGAT).
- VSPP scheme – generation capacity is less than or equal to 10 MW,to be purchased by Provincial Electricity Authority (PEA) and Metropolitan Electricity Authority (MEA).

Recently, the program has been changed from Adder to fixed feed-in tariffs scheme. Thai Cabinet firstly approved FIT to support rooftop solar power in 2013. The other renewable energy FIT for VSPP were also approved in 2015.

3.1 Adders scheme

In 2006, Thailand's premium tariff feed-in policies, or Adders, were introduced to encourage the private sector to generate electricity from renewable energy sources. The programs were implemented by guaranteeing fixed premiums paid on top of the wholesale electricity price fed into the grid within a specific period. The tariffs were determined by renewable technology-specific. The guarantee period was initially set to seven years for all renewable energy sources. Extra premiums were also set for three southernmost border provinces of Thailand and for replacement of electricity generation from diesel in a remote area.

In the early state, there were no applications of solar and onshore wind power because the programs were still not enough cost-effectiveness for investors. The guarantee periods of solar and wind power was then reviewed and extended to 10 years at the end of 2007. After that, the Adder rates were adjusted by capacity-specific for all types of the RES-E supports (except for solar power).

The Adder scheme had been successful in encouraging renewable investment from private electricity producers. There were 1075 applications accounted for 5147 MW of renewable installed

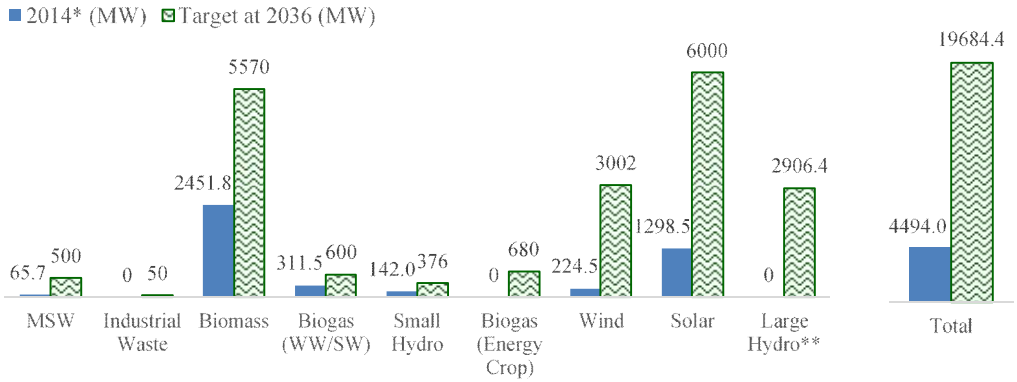
[3] EI_{2036}(target) is equal to 10.70 ktoe/THB bn
[4] EI_{2010}(actual) is equal to 15.28 ktoe/THB bn

capacity at the end of 2008. Most of them were fromsolar applications with exceeding total 2000 MW

Table 1 Status and target of fuel requirement proportion[9]

Fuel	Percentage in 2014*	Percentage in 2026	Percentage in 2036
Imported hydro power	6.6	10-15	15-20
Clean coal (including lignite)	20.2	20-25	20-25
Renewable (including hydro)	7.6	10-20	15-20
Natural gas	64.7	45-50	30-40
Nuclear	-	-	0-5
Diesel/Fuel oil	0.9	-	-

* update data from energy statistics [6]



*** Including off grid power and not including large hydro power generation**
**** Existing large hydro power capacity which was included in the Target of AEDP2015**

Fig.1. Status and target of renewable electricity capacity by fuel type[7]

capacity [3]. The problem was caused by significant cost reduction of solar power plant. Afterward, the Adder rate of solar power was reduced from 8 to 6.5 THB kWh^{-1}. The Adder program for solar power was then suspended since 2010. In addition, the Adder programs for other RES-E were offered until 2014.

3.2 Feed-in tariff scheme

New fixed tariffs of FIT scheme for rooftop solar with 25 years guaranteed period were firstly implemented in 2013. The total target of the program was 200 MW which bifurcated into the residential-scale (installed capacity ≤ 10kWp) and commercial- and industrial-scale (installed capacity >10 – 1,000 kWp). The capacity cap was also set to 100 MWp for each scale. After the application period, the commercial- and industrial-scale easily met the 100 MWp target with a total capacity of applications more than six times of the target. The residential-scale, meanwhile, applied 55 MW and only 26 MW were approved [10]. In 2015, the residential scale reopened the new applications for the residual target.

In 2015, Energy Regulatory commission (ERC) announced a new fixed feed-in tariff (excluding solar power) for VSPP to replace the former Adder program. The programs are guaranteed for 20 years except waste-to-energy from landfill gas which is supported for only 10 years.

In order to address the tariffs, obvious disparity of fuel uses is taken into account. Two main groups of fuel types are considered. Natural fuels (i.e. solar, wind, and hydro) do not have to pay for the fuel costs. They, conversely, have to face the uncertain natural fuel patterns. On the other hand, biofuels (i.e. biomass, biogas, and waste) are taking a risk of fluctuating fuel prices. The tariffs are finally calculated from three components as follows:

$$FIT_i = FIT_F + FIT_{V,i-1} \times (1 + Coreinflation_{i-1}) + FIT_{premium}$$

where FIT_i represented the fixed tariff paid for RES-E in year *i*.

FIT_F stood for fixed-based tariff calculated from capital and O&M cost of each RES-E.

$FIT_{V,i-1}$ stood for variable-based tariff for biofuels (except landfill) calculated from fuel cost and adjusted for core inflation.

$FIT_{premium}$ was extra premium tariffs paid the project that usesbiofuel (except landfill) for the first 8 years and/or locates in southernmost border provinces of Thailand for the project lifetime.

So, the natural fuel group is supported by fixed-based tariff, FIT_F, and southernmost provinces' extra premium tariffs, $FIT_{premium}$, (if any). The biofuel group is, meanwhile, paid from all three elements.

The tariffs are shown in **Table 2**. However, the recent FIT mechanism was announced for the transition stage from Adder to fixed FIT scheme. The programs were paused for the newcomers since the end of 2015. The main reason of the discontinuity is to consider the related national policy clarification comprised of, for example, adjusted annual RE

targetaccording to TIEB, feeder and grid capacity allocation, competitive bidding approach.

Table 2 FIT rate for renewable electricity in Thailand

Type of RE / Capacity (MW)	FIT (THB kWh^{-1})			Support duration (years)	$FIT_{premium}$ (THB kWh^{-1})	
	FIT_F	$FIT_{V,2017}$	FIT		Bio-fuel (first 8 years)	Southernmost provinces (project lifetime)
Natural fuels						
Small hydro	4.90	-	4.90	20	-	0.50
Installed Capacity ≤ 200 kW						
Wind	6.06	-	6.06	20	-	0.50
Solar						
Rooftop ≤ 10 kWp	6.85	-	6.85	25	-	0.50
Rooftop > 10-250 kWp	6.40	-	6.40	25	-	0.50
Rooftop > 250-1,000 kWp	6.01	-	6.01	25	-	0.50
Ground mount	5.66	-	5.66	25	-	0.50
Bio fuels						
Waste (integrated waste management)						
Installed Capacity ≤ 1 MW	3.13	3.21	6.34	20	0.70	0.50
Installed Capacity > 1-3 MW	2.61	3.21	5.82	20	0.70	0.50
Installed Capacity > 3 MW	2.39	2.69	5.08	20	0.70	0.50
Waste (landfill)	5.60	-	5.60	10	-	0.50
Biomass						
Installed Capacity ≤ 1 MW	3.13	2.21	5.34	20	0.50	0.50
Installed Capacity > 1-3 MW	2.61	2.21	4.82	20	0.40	0.50
Installed Capacity > 3 MW	2.39	1.85	4.24	20	0.30	0.50
Biogas (waste water/ waste material)	3.76	-	3.76	20	0.50	0.50
Biogas (energy plants)	2.79	2.55	5.34	20	0.50	0.50

IV. FITS DESIGN OPTIONS

Although, FIT policies are proven to be the most effective policy for encouraging RES-E from several countries. The significant challenge for policy makers is to design the eligible support mechanisms and acceptability of all aspects. The quintessential FIT mechanisms are able to induce the continuous RE technology-specific improvements and their cost reductions [11]. These also can stimulate the RE market to compete with conventional fuel technologies in the near future.

The prominent traits of FIT mechanisms are price and quantity driven RE support instruments which invite various scales of the private sector to participate in RES-E generation [1]. However, the effective FIT mechanisms are based on not only appropriate tariffs but also the design and implementation [2, 10]. For the policy making, the following design options are suggested to be taken into account.

1) Eligible renewable energy technologies – At the initial stage, the policy designs have to address the supported renewable energy technologies and their targets. The key important point is to research the potential and availability of technologies and resources. According to the merit order and RE zoning of Thailand [7], the sequentially selected types of RE are identified as above mention. Seven of eight RE types are already set and announced the fixed FITs (except for geothermal energy).
2) Calculation principal of support level – The appropriate support level is one of the most important issues for policy making. Too low support level cannot encourage the RES-E investors. Meanwhile, too much support level can cause unnecessarily burden to the final consumer. In general, the support tariffs are calculated from the reasonable profitability of investors and the avoided cost of conventional fuel generation. Furthermore, there are concealed cost, so-called externalities, of fossil fuel uses caused by potential impact to both local and global impacts [12]. These costs are also suggested to consider in the design approach.
3) Payment options – There are two main payment methods: fixed-premium vs. fixed-tariff. The fixed-premium is paid on top of wholesale electricity market prices while the fixed-tariff is guaranteed the total support. The fixed-premium scheme benefit mainly by taking market orientation into account. On the other hand, it can becauses of overcompensation. The fixed-tariff scheme is lower risk for investors and smaller direct burden for the final consumer [13, 14].
4) Technology-specific tariffs – This technique is used to differentiate the technology-specific generation cost. Therefore, all selected technologies can be supported according to difference levels. Immature technologies are normally encouraged by the higher support [11]. For these reasons, the optimal stimulationis then beneficial to technological learning effects.
5) Degression rates – The design of degression is based on the principal of technological learning and economies of scale. The generation cost is expected to reduce due to the effectiveness of significant capacity increments and market stimulation. The support level is reduced over time by annual reduction rate for the new plants. Degression, therefore, expedite the investments in order to obtain the higher supports.

6) Extra premium tariffs – In order to promote the specific purposes, the extra premium tariffs are in surplus the regular supports. These tariffs are determined by, for example, replacement of low-efficiency conventional fuel plant, location-specific tariff, and market demand-oriented tariff.
7) Support duration – The guaranteed period varies directly depended on support tariff level. The support durations normally range between 10 and 25 years. The agreement is a trade-off between contract duration and tariff level. If the investors are granted for a long period, the support tariff can be reduced. On the other hand, the shorter contract duration has to have higher support tariff.
8) Program funding and cost controlling – Cost of the FIT programs of most countries, same as Thailand, are equally distributed to all final electricity end-users. The programs obviously have the added advantages of environmental and social benefits. In order to take the polluter pays principle and social benefits into account, the financing mechanism can be considered to share with other pollutant taxpayers, and state budgets. Furthermore, capacity cap and cap on total costs are useful methods of cost containment.

CONCLUSIONS

Thailand's energy policies have been developed and integrated together with national long-term energy master plans. The ambitious targets were set for encouraging all potential RES-E generations. In the next 20 years, the total installed capacity of all RES-E is expected to grow about 4.4 times of 2014 status.

There have been now ten years evolution of feed-in policies in Thailand. The Adder scheme was firstly implemented since 2006. The program supports were designed high enough to encourage private RES-E generators. There were an impressive amount of investors attending the programs, especially for solar power. The mechanism, however, still lacked proper program revision which was the cause of windfall profits. This problem led to suspend the Adder program for solar power since 2010. The transition from Adder to FIT scheme start from rooftop solar power in 2013 and other RES-E in 2015. Nevertheless, the early FIT programs were briefly open for the applications and still not cleared implementation. It seems that main problems of Thai feed-in policies are uncertainties and discontinuity.

The effective FIT policies are not only based on proper support tariffs but also the design and implementation. The well-designed FITs provide the secure, transparent, and acceptable mechanisms. The most important of design principal is to take the equilibrium of all aspects into account. There are three main stakeholders: (1) the society and country as a whole, (2) final electricity end-users or funding sources, and (3) private RES-E investors. The cost-effective assessment should be, then, quantified for all levels of participants.

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