# Feed-in Tariffs under Thailand Renewable Electricity Plan – Appropriate Price for Producer and Consumer

Pawinee Suksuntornsiri*
Paiboon Limpitipanich
Mechanical Engineering Department
Faculty of Engineering, Burapha University, Saensook District, Chonburi, Thailand
* pawinee@eng.buu.ac.th

Warunee Tia
School of Energy and Environment, King Mongkut's University of Technology Thonburi Bangkok, Thailand

Bundit Limmeechockchai
Piti Pita
Pemika Misila
Sirindhorn International Institute of Technology, Thammasat University, Pathumthani, Thailand

***Abstract*— To motivate private investment in electricity generated from renewable energy in Thailand, an adder program has been firstly subsidized to the wholesale electricity supplied to the national grid. With the program, renewable energy share to the grid was found under the target. Recently, FIT measure has been substituted in some generation technologies with some questions on their proper wholesale price that affects the electricity retail price and the country burden. This study proposes FIT's in 4 technologies i.e. solar photovoltaics (PV), biomass, wind farm, and small hydro power plant in 2012, by using a financial analysis based on capital and operating data from sites survey and reference data. At least 3 sites of each technology were surveyed for each technology. With the cost trend experienced in the country and worldwide, expected FITs in 2020 and 2030 were forecasted. As a result, proposed solar PV FIT in 2012 was 6.12-7.12 Baht/kWh as the highest one, and biomass FIT was 3.81–4.07 Baht/kWh as the lowest one. Expected FITs for small hydro and wind farm in 2012 were 4.50–7.00 Baht/kWh and 6.02 Baht/kWh, respectively. The future FITs for solar PV and wind turbine were forecasted to be decreased due to expecting decreasing in their capital cost. In the other hands, FITs for small hydro and biomass power plants were expecting to be increased, accordingly to the increase in capital cost of these power plants and fuel price. Average FITs that the grid has to subsidize to the renewable electricity producers are estimated to be fixed annually in long-term contracts, according to each technology's quantity. These predictions were based on the quantities of renewable electricity generation as expected by Alternative Energy Development Plan 2012–2021 and prioritized according to PDP2010 during 2010-2030. A long term comparative assessment presents that the FIT policy under PDP2010 could induce less subsidizing burden and finally induces less additional Ft than the Adder policy.**

***Index Terms*—Feed-in tariffs, Adders, Ft, financial analysis, renewable energy, electricity generation, energy planning.**

## I. INTRODUCTION

Electricity demand in Thailand has been increasing. Its generation has been depending on fossil fuels, particularly on natural gas. Fuel consumption in 2010 was 34,211 ktoe with the share of fossil fuels by 93.6%. The shares of fossil fuels were 72.8% by natural gas, 19.8% by coals, 0.7% by fuel oil, and 0.1% by diesel [1], mostly invested by public sector. The share of renewable energy that is mostly invested by private sector was only 6.4% [1].

Alternative Energy Development Plan (AEDP) 2012-2021 [2] was continuously developed in order to increase contribution of renewable energy, reduce $CO_2$ emissions, reduce import of energy and increase energy security in Thailand. Four potential renewable energy sources for electricity generation supplied to the grid are solar PV, wind, small hydro and biomass, but their return on investments are not interesting comparing with other power generation. Since 2006, the adder program has been announced to subsidize the small power producer (SPP) and the very small power producer (VSPP) programs to motivate a private sector investment in electricity generation from renewable energy i.e biomass, biogas, waste, hydro, wind, and solar electricity [3]. The subsidy was paid to top up the floating electricity price to the renewable electricity producer that increases the grid electricity cost. Under the adder program, only biomass and PV are nominated.

Subsidizing the private, renewable energy by the Adder policy could launch the renewable energy contributions into the grid, but its penetration was under expectation. Many companies requested for delay of the committed company Schedule commercial operation date (SCOD) to the grid [4]. New target has been placed according to the 15-Years Renewable Energy Plan and the AEDP 2012-2021with higher adder price [5].

Recently, feed-in tariffs (FIT) program has been announced by the National Energy Policy Board in 2013, according to the AEDP 2012-2021, with higher target of electricity supplied from renewable energy [2]. The FIT is a fixed wholesale electricity price that is expected to be a fair measure for private producer and the consumers. The subsidizing policy has been viewed for a higher contribution of renewable energy in the grid. However, the higher cost induces a higher level of Ft in retail electricity price. The emerging electricity generation sectors also indirectly affect many activities in most sectors in the economy in long run.

In this study, FITs of four potential technologies of renewable electricity are estimated by using financial analysis, which capital cost and operating cost are included. Proper quantities of each electricity technology supplied to the national grid were provided to present the long term monetary burden from adder and FITs program during 2010 to 2030.

## II. Methodologies

### *A. FITs by Financial Analysis*

The wholesale electricity prices that the grid bought from each technology of renewable energy power plants, i.e. feed in tariffs (FITs), were derived base on discount cash flow analysis, that the plants could gain a proper returns and benefits on their investments. There are four selected potential renewable technologies mostly considered to be supplied into Thai grid i.e. Solar PV, Biomass, Wind Farm, and Small Hydro power plants.

This study assessed FIT's in 4 potential technologies i.e. solar photovoltaics (PV), biomass, wind farm, and small hydro power plant in 2012. Capital and operating data were gathered from sites survey and reference data. At least 3 active sites of each technology were surveyed for each technology.

Common assumptions made are

- FITs' contracted were fix for each plant and covered during the 20 years plants life time
- Discount rate was 10%
- After tax equity IRR was 11%

*Specific assumptions provided in each technologies among 4 technologies in this study are as followings;*

*1) Solar PV*

- Inverter will be replaced after 10 years. The operating and maintenance costs were
  - Fixed 10,000 Baht in a residential PV plant
  - 20% of the implemented inverter in a commercial PV plant
  - 10% of the implemented inverter in a utility PV plant
- Land renting cost was only required for utility plant base on the formal price estimated by [6] where land required for
  - Crystalline technology: 10 Rai/MW
  - Amorphous technology: 25 Rai/MW
- Cost of PV cells were based on the prices from a supplier [7]
- Expected life time is 20 years

*2) Biomass*

- The plants sold only electricity
- Operating and maintenance costs was 3-4% of the total investment
- Land cost and related electrical wiring equipment were included in the investment cost
- Individual biomass fuels were rice husk, bagasse, fast-growing wood, and frond palm. Their costs were assumed to be increased by 3% per year during 2013-2020 and 4% beyond 2020
- Capacity factor was 85%

*3) Wind farm*

- Land for wind farm was not located in environmental reserved area, but easy to connect to the grid.
- Operating and maintenance costs was 3.47% of the total investment
- Plant factors were varied from 4 different sites in Thailand approximately 20%
- Debt ratio was 50%

*4) Small hydro*

- Investment data was gathered from existing small hydro plants own by EGAT with self-investments
- Plant factors were varied from 4 different sites in Thailand from 11-22% due to geographic locations

### *B. Contribution of Renewable Electricity in AEDP 2012-2021*

The buying with each individual plant's FITs contract was based on the quantity of renewable electricity generation. As a short term assessment, contributions of renewable technologies supplied to the grid, during 2012 to 2021 were derived according to AEDP 2012-2021 [2] as presented in Fig. 1. In long term assessment, share of renewable electricity supplied to the grid was prioritized by cost according to the PDP2010 [8] as presented in Fig. 2.

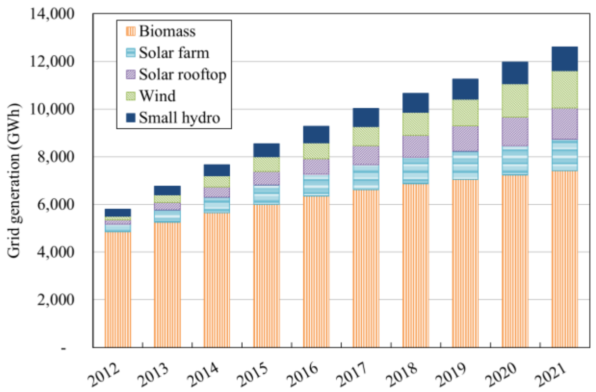


Fig. 1. Share of grid generation of the selected renewable electricity: AEDP 2012-2021

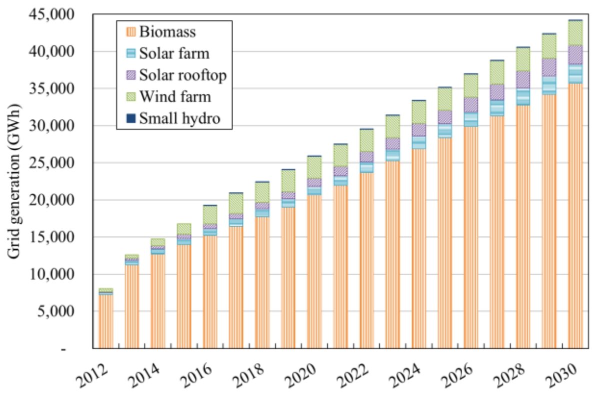


Fig. 2. Share of grid generation of the selected renewable electricity: Optimization by PDP2010 (2012-2030)

*C. Projection of future business-as-usual electricity retail price*

Average electricity retail price in Thailand has experienced in increasing related to the future crude oil price. A projection of future business-as-usual electricity retail price has been provided as annual base prices for estimation of the subsidy burden. This projection is presented in Fig.3 and it is the same as one provided in [9].

*D. Projection of future FITs*

With financial analysis for current FITs for each selected technology, a projection for the future FITs was performed by projected cost of each typical technology according to historic data and the technology roadmap reported by IEA [10] i.e.

- Investment cost of residential PV power plants was expected to be decreased from 3,800 USD/kWp in year 2012 to 1,960 USD/kWp in year 2020, and 1,405 USD/kWp in year 2030.
- Investment cost of utility PV power plants was expected to be decreased from 3,120 USD/kWp in year 2012 to 1,390 USD/kWp in year 2020, and 1,100 USD/kWp in year 2030.
- Investment cost of on-shore wind farm plants was forecasted to be decreased by 17% by 2030. The investment were expected to be decreased from 2,434 USD/kWp in year 2012 to 2,200 USD/kWp in year 2020, and 2,027 USD/kWp in year 2030.
- Total capital cost of biomass power plant was expected to be decreased by 20% within 2030, but constant in operating cost. However, the most important cost of electricity generation from biomass is the operating fuel consumption. IEA in 2010 provided average biomass fuel cost in a range of 4-8 USD/GJ in 2010-2030. In [11], the fuel cost was presented for 3.46 USD/GJ in 2009-2012, expected to be 4.23 USD/GJ in year 2020 and 4.94 USD/GJ in year 2030. This study provided 3% increasing annually i.e. 2.97 USD/GJ in 2012, 3.99 USD/GJ in year 2020 and 5.36 USD/GJ in year 2030

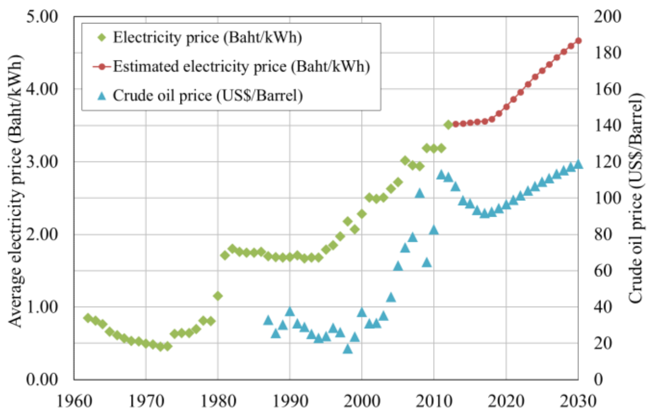


Fig. 3. Projection of annual retail electricity price to 2030 [9].

- Investment cost of small hydro power plant is normally varied by geographic potential of the hydropower. It is varied from 1,300 to 8,000 USD/kW The energy cost could be varied between 180-227 USD/MWh. [10], while the World Energy Outlook 2010 presented that the cost could be 71/141/247 USD/MWh (min/mean/max) during 2010-2020, and 70/143/245 USD/MWh (min/mean/max) during 2021-2030. A constant cost was considered in long term projection of the small hydro in this study.

*E. Consumer Burden on 2 different subsidizing policies*

This study assumed that the subsidize burden caused by FITs or Adders contract was annually absorbed within the economy and the grid electricity cost was increased. The adder subsidy was paid to top up the floating electricity price to the renewable electricity producer. The FITs was set to buy the wholesale renewable electricity on a higher price than the consumer's price. Both of them increases the cost of the grid and finally increase consumer's electricity price.

Generally, fuel adjustment charge (Ft) has been implemented to charge in retail electricity price due to monthly variable in fuel cost of the grid since September 1992 [12]. Since the subsidy in renewable energy induced higher grid cost, the Ft would be levelled up from the projected business-as usual activity. A long term comparison was made to the difference increase in Ft by 2 possible scenarios i.e. FITs scenario and Adder scenario during AEDP25% in 2011-2021 and during PDP2010 ver3 in 2012-2030.

Increments in the grid cost from the business-as-usual Ft was estimated by increasing in the wholesale payment to private sectors by 2 different subsidizes i.e. subsidy with adder program ($S_{Adder}$) and subsidy with FIT program ($S_{FIT}$) as in Eq. 1 and Eq. 2, respectively. The increasing in electricity energy Ft's were the higher cost divided by the country electricity sale.

$$S_{Adder} = \text{Renewable electricity} \times \text{Adder} \tag{1}$$

$$S_{FIT} = \text{Renewable electricity} \times (\text{FIT}-P_{elec}) \tag{2}$$

Where Adder and FIT are adder and feed-in tariffs (Baht/kWh), respectively, and $P_{elec}$ is the business-as-usual electricity retail price (Baht/kWh). The renewable electricity is its quantity supplied to grid in kWh.

## III. FITs from Surveyed Plants

Individual proper FITs derived from each type of surveyed plants, i.e. solar PV rooftop, amorphous PV farm, crystalline PV farm, small hydro, biomass, and wind, are presented in TABLE I, II, III, IV, V and VI, respectively.

TABLE I. SURVEYED FITS: SOLAR PV ROOFTOP.

| Parameter | Unit | Plant | | |
|---|---|---|---|---|
| | | ***Residential 3 kW*** | ***Commercial 200 kW*** | ***Industrial 330 kW*** |
| Debt ratio | | 1:1 | 1:1 | 3:2 |
| Payback period | Year | 7.8 | 7.9 | 7.9 |
| O&M cost | % of total investment cost | 1% | 0.8% | 0.6% |
| Income tax | % | 12.5 | 15 | 30 |
| BOI incentive | Year | No | No | 8 |
| Plant load factor | % | 15.0 | 15.0 | 15.0 |
| System operating factor | % | 80.76 | 80.76 | 80.76 |
| Feed-in tariff | Baht/kWh | 7.12 | 6.82 | 6.50 |

TABLE II. SURVEYED FITS: SOLAR FARM PV POLYCRYSTALLINE.

| Parameter | unit | Plant | |
|---|---|---|---|
| | | ***Installed capacity 10 MW*** | ***Installed capacity 30 MW*** |
| Payback period | Year | 7.7 | 7.7 |
| Fraction of debt | % | 54 | 54 |
| O&M cost | % of total investment cost | 0.5 | 0.5 |
| Land rent | Baht/Year | 3,000,000 | 9,000,000 |
| Plant load factor | % | 16.0 | 16.0 |
| System operating factor | % | 80.7 | 80.7 |
| Feed-in tariff | Baht/kWh | 6.12 | 5.92 |

TABLE III. SURVEYED FITS: SMALL HYDRO.

| Parameter | Unit | Plant | | | |
|---|---|---|---|---|---|
| | | ***Installed capacity 200 kW*** | ***Installed capacity 1,360 kW*** | ***Installed capacity 20 kW*** | ***Installed capacity 37 kW*** |
| Cost | Baht/kW | 45,950 | 75,110 | 108,869 | 101,705 |
| Expected lifetime | Year | 30 | 30 | 30 | 30 |
| Debt ratio | % | 0 | 0 | 0 | 0 |
| Inflation rate | % | 2.5 | 2.5 | 2.5 | 2.5 |
| Payback period | Year | 8.8 | 8.7 | 8.8 | 8.6 |
| O&M cost | Baht/Year | 10,000 | 50,000 | 1,000 | 5,000 |
| Periodical cost | k Baht/Year | 91.9/10 | 1,000/10 | 40.0/5 | 70.0/5 |
| Plant capacity factor | % | 11 | 22 | 20 | 17 |
| Electricity generation | MWh/Year | 191 | 2,615 | 35 | 55 |
| Feed-in tariff | Baht/kWh | 5.50 | 4.50 | 7.00 | 8.00 |

From these surveyed plants, expected FITs of each technology in 2012 could be summarized by Fig. 4, and the future FITs on each technology were presented in Fig. 5

TABLE IV. SURVEYED FITS: SOLAR FARM PV AMORPHOUS.

| Parameter | unit | Plant | |
|---|---|---|---|
| | | ***Installed capacity 10 MW*** | ***Installed capacity 30 MW*** |
| Total investment | Baht/kW | 51,000 | 48,000 |
| Payback period | Year | 7.0 | 7.0 |
| Fraction of debt | % | 54 | 54 |
| O&M cost | % of total investment cost | 0.5 | 0.5 |
| Land rent | Baht/Year | 7,500,000 | 22,500,000 |
| Plant load factor | % | 16.0 | 16.0 |
| System operating factor | % | 80.49 | 80.70 |
| Feed-in tariff | Baht/kWh | 5.87 | 5.67 |

TABLE V. SURVEY FITS: BIOMASS.

| Parameter | Unit | Plant | | | |
|---|---|---|---|---|---|
| | | ***Rice husk 9.9 MW*** | ***Bagasse 9.5 MW*** | ***Fast growing plant 9.9 MW*** | ***Frond palm 9 MW*** |
| Power to grid | MW | 7.5 | 8.0 | 8.0 | 8.1 |
| Loan ratio | % | 60 | 60 | 60 | 60 |
| Fuel cost in 2013 | Baht/ton | 1,000 | 550 | 1,050 | 1,000 |
| Lower heating value | MJ/kg | 13.517 | 7.368 | 8.514 | 11.000 |
| Income tax | % | 30 | 30 | 30 | 30 |
| Feed-in tariffs | Baht/kWh | 3.91 | 3.81 | 4.07 | 3.85 |

TABLE VI. SURVEYED FITS: WIND.

| Parameter | Unit | Plant | | | |
|---|---|---|---|---|---|
| | | ***Installed capacity 103.5 MW*** | ***Installed capacity 103.5 MW*** | ***Installed capacity 82.5 MW*** | ***Installed capacity 59.8 MW*** |
| Power to grid | MW | 90.0 | 90.0 | 82.5 | 59.8 |
| Plant capacity factor | % | 19.6 | 21.6 | 20.4 | 20.9 |
| Total capital cost | M Baht | 6,392.9 | 6,714.6 | 5,666.2 | 4,524.6 |
| Annual cost | M Baht | 144.7 | 152.2 | 80.55 | 64.00 |
| Average annual wind velocity | m/s | 6.1 | 6.3 | 6.3 | 6.2 |
| Electricity generation | GWh | 177.533 | 174.440 | 147.561 | 109.612 |
| Debt ratio | % | 50 | 50 | 50 | 50 |
| Feed-in tariff | Baht/kWh | 5.71 | 6.02 | 5.57 | 6.02 |

As a result, proposed solar PV FIT, in 2012, was 6.12-7.12 Baht/kWh as the highest one, and biomass FIT was 3.81–4.07 Baht/kWh as the lowest one. Expected FITs for small hydro and wind farm in 2012 were 4.50–7.00 Baht/kWh and 6.02 Baht/kWh, respectively.

The future FITs for solar PV and wind turbine were projected for 2010, 2020, and 2030 related to expecting decreasing in their future capital cost as addressed in [10]. In the other hands, FITs for small hydro and biomass power plants were expecting to increased, accordingly to increasing in capital cost of these power plants and fuel price.

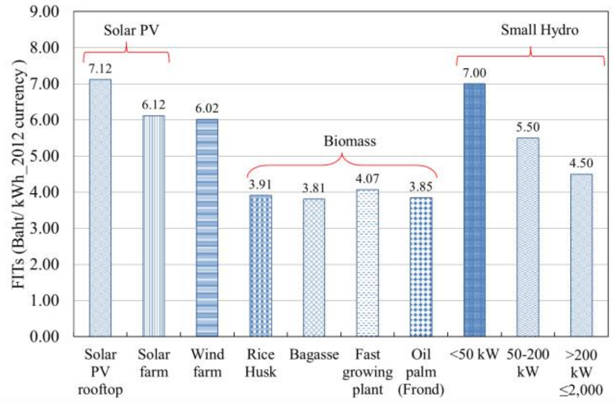


Fig. 4. Survey FITs of the selected technologies.

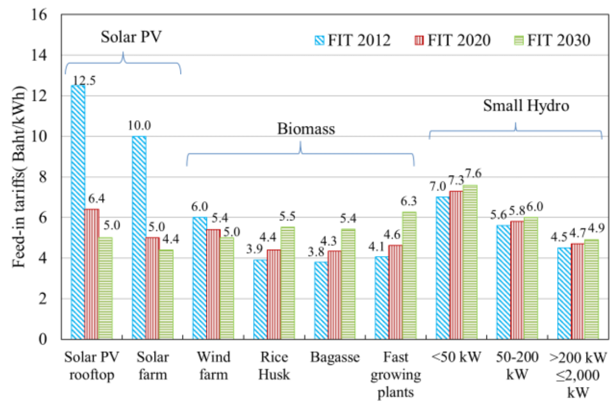


Fig. 5. Forecasted FIT prices.

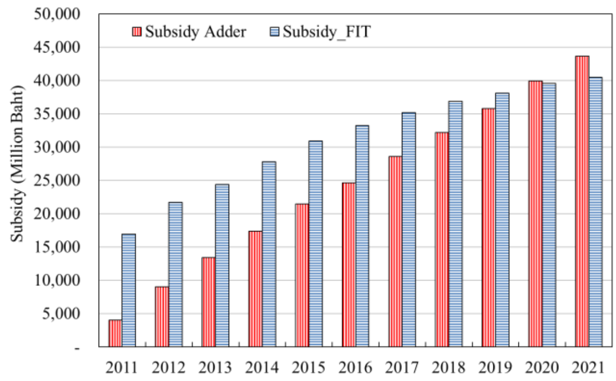


Fig. 6. Subsidize burden by FIT and Adder: AEDP in 2011-2021.

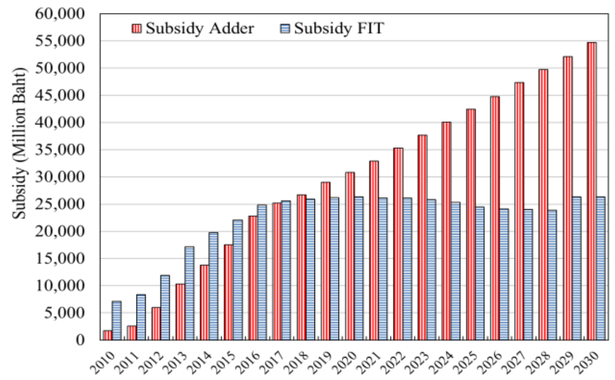


Fig. 7. Subsidize burden by FIT and Adder:PDP2010 in 2011-2030.

Thereafter, the average FITs that grid has to subsidize to renewable electricity producer are estimated to be fixed annually in 20-years contracts based on individual plant's COD year, according to each technology's quantity.

## IV. Effects of FITs and Adders Policies on Ft

Implementation of FITs or Adders would finally increase the Ft, which is the floating cap of retail electricity price. According to renewable electricity quantity supplied to the grid via AEDP in 2011-2021, subsidize burden by FITs was mostly higher than Adders as presented in Fig.6. Since the FITs policy was aimed to motivate the private sector by quick return on investment, the subsidy by FITs were higher than the subsidy by Adders in first years. High contribution of biomass electricity was supplied into the grid, and the wholesale price under FITs for biomass was higher that the Adders.

In supporting the renewable electricity purchased into the grid under FITs and Adders according to the PDP2010, subsidize burden by FITs was mostly higher than Adders in first 7 years, but lower in overall latter period, as seen in Fig.7.

Fig.8 and Fig.9 present the effects of the Adders and FITs scenarios on increasing in Ft, under the quantity of renewable electricity bought into the grid under AEDP. The effect of Adders and the FITs to the Ft under AEDP were found increasing annually, but the increasing rate of the Adders was higher and end up with 0.176 Baht/kWh in 2021. The effect of the FITs on Ft in 2021 was 0.163 Baht/kWh.

Under PDP2010, where the priority of each types of renewable electricity supplied into the grid was optimized, the effects of the Adders and FITs scenarios on increasing in Ft, under the quantity of renewable electricity bought into the grid, were presented in Fig.10 and Fig.11. The effect of Adders to Ft under PDP2010 was also found increasing annually and found as high as 0.162 Baht/kWh in 2030. The effect of FITs to Ft under PDP2010 was found increasing annually only in the first 7 years (0.021 Baht/kWh in 2016), after that it was found decreasing to only 0.078 Baht/kWh in 2030.

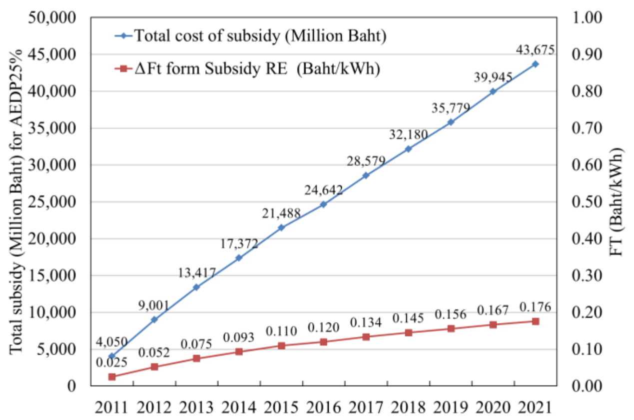


Fig. 8. Effects of Adders to Ft under AEDP.

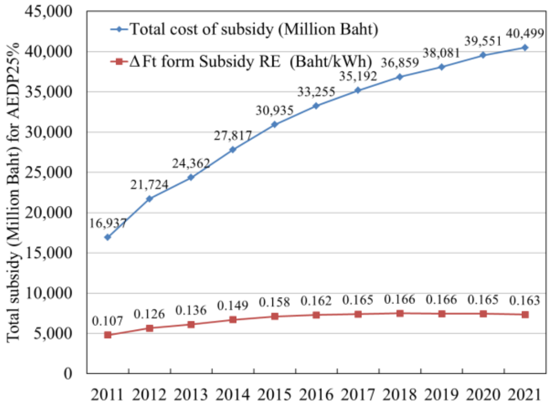


Fig. 9. Effects of FITs to Ft under AEDP.

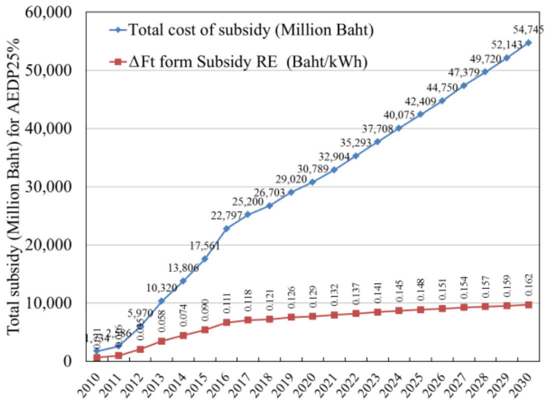


Fig. 10. Effects of Adders to Ft under PDP2010.

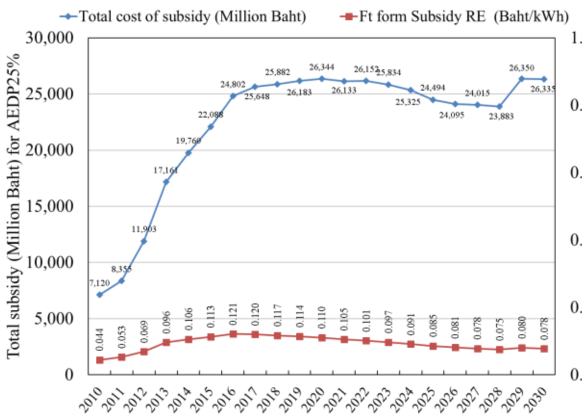


Fig. 11. Effects of FITs to Ft under PDP2010.

## V. Conclusions and Recommendations

The average FITs of small hydro and biomass power plants are lower than those of the PV and wind. Implementation of the FITs contract has to be offered in a long term fixed price; therefore, the share of each renewable technology supplied to the grid is a pool financial burden in higher retail electricity price in long term.

FITs policy was found to be the better choice in minimizing the grid cost burden and less in incremental of Ft in implementation of renewable electricity subsidizing policy with the lowest increase in the country's retail electricity price. Comparative assessment between the AEDP case and the PDP2010 case reveals that optimization among technologies should be performed to prioritize the majority of renewable energy supplied from the private sector.

## Acknowledgment

This paper was provided as a partial result of a research project titled "Appropriate Feed-In Tariffs and Macro Economic Impact by Energy Input-Output Analysis", financially supported by Electricity Generating Authority of Thailand (EGAT) and Thailand Research Fund (TRF) fund. The authors would like to thank Mr Prachuab Peerapong for his assistants in this research project.

## References

[1] Department of Alternative Energy Development and Efficiency, "Electric Power in Thailand year 2010," http://www.dede.go.th/dede/index.php [2 Jan 2013], 2012.

[2] Department of Alternative Energy Development and Efficiency, "The Renewable and Alternative Energy Development Plan for 25 Percent in 10 Year: AEDP 2012-2021," http://www.eia.gov/forecasts/aeo/er/early_prices.cfm [15July 2012], 2012.

[3] Energy Planning and Policy Office, "Promotion on Electricity Generation from Renewable energy by Adder Price," EPPO Annual Report 2010, pp. 66-67, 2011. (in Thai)

[4] Energy Planning and Policy Office, "Executive Report of Electricity Generation Promotion from Renewable Energy Administrative Committee," Energy Policy Journal, vol. 95, pp. 43-45, 2012. (in Thai)

[5] Energy Planning and Policy Office, "Improving the Promotion on Electricity Generation from Renewable Energy," Energy Policy Journal, vol. 83, pp. 53-56, 2009. (in Thai)

[6] Treasury Department, "Formal estimated property price," http://property.treasury.go.th/pvmwebsite/ [1 June 2014], 2014.

[7] SOLARTECH Center Limited Partnership, "Energy," http://www.solartech-center.com/ [20 Dec 2013], 2013.

[8] Energy Planning and Policy Office, "Power Development Plan 2010 Revision 3," http://www.eppo.go.th/power/PDP2010-r3/PDP2010-Rev3-Cab19Jun2012-T.pdf [1 Aug 2012], 2012.

[9] P.Suksuntornsiri, P.Limpitipanich, W.Tia, B.Limmeechokchai, P.Pita, "Energy Economic Impacts of Feed-in Tariff Programs under Thai Renewable Energy Electricity Plan: Energy Input-Output Analysis," 7th AUN-SEED/Net Regional Conference on Energy Engineering, Nov.2014, in press.

[10] International Energy Agency, "Energy," http://www.iea.org/publications/freepublications/publication/Solar_Energy_Perspectives2011.pdf [2 Jan 2013], 2012.

[11] B. Cosic, G. Krajacic, N. Duic, "A 100% renewable energy system in the year 2050: The case of Macedonia," Energy, vol. 48, pp.80-87, 2012.

[12] Energy Regulation Committee, "Resolution from the Energy Regulation Committee 4/2549", http://www.eppo.go.th/nepc/kpc/kpc-107.htm#8 [20 Dec 2013], 2006.