Conference Proceedings

November 22-24, 2016

KYOTO JAPAN

ACEAT

Annual Conference on Engineering and Applied Science

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International Conference on Life Science & Biological Engineering

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International Conference on Life Science & Biological Engineering

Power & Energy Engineering (1) &

Aeronautics and Aerospace Engineering

Wednesday, November 23, 2016 10:30-12:00 Room A

Session Chair: *Prof. Chairoj Rattanakawin*

ACEAT-1027

Single Switch High Step-Up Dc-Dc Converter for photovoltaic Cell Energy Sources

Anusak Bilsalam | *King Mongkut's University of Technology North Bangkok, Rayong Campus*
C. Ekkaravarodome | *King Mongkut's University of Technology North Bangkok*
J. Haema | *King Mongkut's University of Technology North Bangkok*

ACEAT-1105

A Study on Thailand Solar Energy Business Opportunity in Very Small Power Producer (VSPP) Sector Contributed by Feed-In Tariff

Lerdlekha Sriratana | *Ramkhamhaeng University*
Sawatdee Poochong | *Ramkhamhaeng University*
Kridsda Bisalyaputra | *Ramkhamhaeng University*

ACEAT-1183

Hardgrove Grindability Index and Approximate Work Index of Sodium Feldspar

Chairoj Rattanakawin | *Chiang Mai University*
Lay Tin Aung | *Yangon Technological University*

ACEAT-980

Design and Test of a Near Zero-Energy Office

Bin-Juine Huang | *National Taiwan University*
Po-Chien Hsu | *National Taiwan University*
Yi-Hung Wang | *National Taiwan University*
Jong-Han Tsai | *National Taiwan University*
Kang Li | *National Taiwan University*
Kung-Yen Lee | *National Taiwan University*

ACEAT-1188

Multi-Purpose HILS Design and Implementation for Optimal Operation of Distributed Energy Resources with EMS

Chul-Sang Hwang｜*Changwon National University*
Jongho Choi｜*Changwon National University*
Minwon Park｜*Changwon National University*
In-Keun Yu｜*Changwon National University*
Jin-Hong Jeon｜*Changwon National University*
Changhee Cho｜*Changwon National University*

ACEAT-1120

A Study on Developing Airport Risk Assessment Algorithm by FOQA Event Analysis and SMS

Je Hyung Jeon｜*AirBusan*
Hyunsoo Kim｜*Chodang University*
DongJin Sin｜*Korea Aerospace University*

ACEAT-1105
A Study on Thailand Solar Energy Business Opportunity in Very Small Power Producer (VSPP) Sector Contributed by Feed-In Tariff

Lerdlekha Sriratana*, Sawatdee Poochong, Kridsda Bisalyaputra
Faculty of Engineering, Ramkhamhaeng University, Thailand
E-mail address: lerdlekha@hotmail.com

Abstract

In recent Thailand energy business, solar power plants have high potential due to a clean and renewable energy of solar power. However, the information about solar energy business opportunity is also essential for private sector investment. Since 2013, Feed-in Tariff (FiT) has been announced to replace the Adder measure that also results in the difference of electricity cost structures. This study presents the review of solar energy business opportunity contributed by FiT focusing on Very Small Power Producer (VSPP) sector. The analysis of Adder and FiT measures in terms of business promotion was performed. Also, an 8 MW VSPP solar farm project was selected as a case study for investment analysis contributed by FiT. From analysis, it can be noted that the benefit from electricity purchase rate contributed by FiT would be lower than that of the Adder due to the high costs of PV system recently which is also included in the initial investment. However, if the technology and other related costs of PV system decrease, the solar power projects subsidized by the FiT would be more worthwhile for investment in the future.

Keywords: Solar Energy, Policy, Subsidy, Measure, Investment

1. Introduction

In Thailand, energy requirements in industrial and residential sectors have been increasing continuously. However, energy resources from fossil fuels such as coal and oil are very limited that can influence the shortage of energy resources for generating electricity and lead to unsustainability of national electricity system. Since 2007, the government has attempted to promote renewable energy for generating electricity by issuing several policies to support private energy producers selling the electricity to EGAT (Electricity Generating Authority of Thailand) namely SPPs and VSPPs. SPPs (Small Power Producers) and VSPPs (Very Small Power Producers) are termed the private sectors with the capacity of 10 – 90 MW and up to 10 MW, respectively. Regulation, subsidies, and financial incentives were amended for more practical and less complicating actions of private sectors. These policies are expected to ensure the sustainability of electricity system in Thailand. In recent energy business, solar power plants have high potential due to a clean and renewable energy of solar power. However, the information about solar energy business opportunity is also essential for private sector investment. Since 2013, Feed-in Tariff (FiT) has been issued to replace the Adder measure that also results in the difference of electricity cost structures.

This study presents the review of business opportunity of VSPP solar energy sector contributed by FiT. The analysis of Adder and FiT measures in terms of business promotion was performed. Also, an 8 MW VSPP solar farm project was selected as a case study for investment analysis contributed by FiT.

2. Potential of Solar Energy in Thailand

Thailand is located in the tropics that can receive sunlight throughout the year. The annual average solar irradiation is about 18 $MJ/m^2/day$ which indicates high potential of solar power of this region. The average solar irradiation map of Thailand is as illustrated in Fig. 1. Comparing to other countries, the potential of solar energy in Thailand is also significant as shown in Fig. 2.

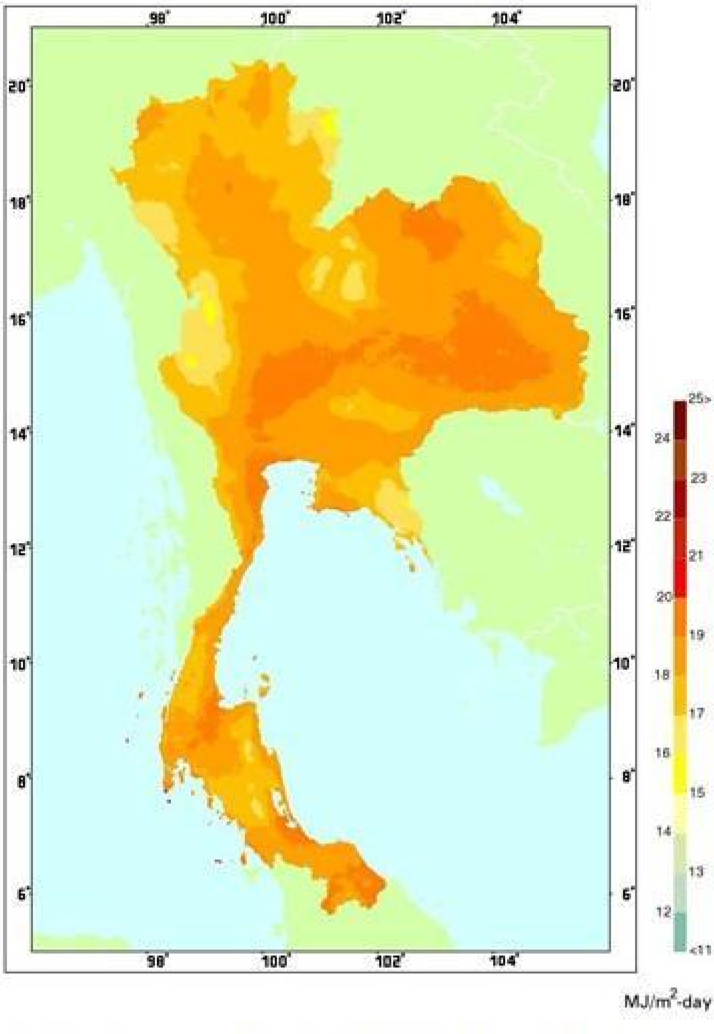

Fig. 1: Average Solar Irradiation Map of Thailand
Source: DEDE (2002)

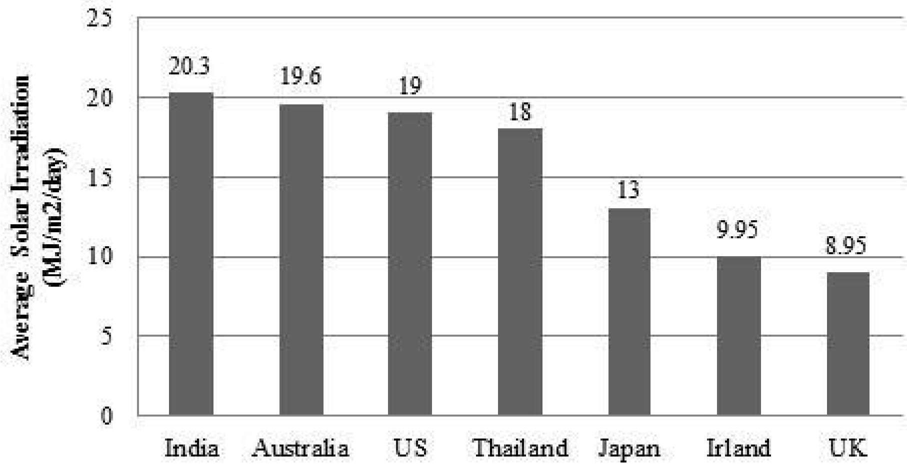

Fig. 2: Average solar irradiation of several countries
Source: Open Energy Information (2016)

3. Solar Energy Measures in Thailand

The Ministry of Energy has fully supported renewable energy regarding to Alternative Energy Development Plan (AEDP) which aims to achieve the target of 6000 MW of solar energy by 2036 (EPPO, 2015). Details of total electricity production capacity by solar energy in Thailand and applied measures during 1983 – 2015 are summarized in Fig. 3.

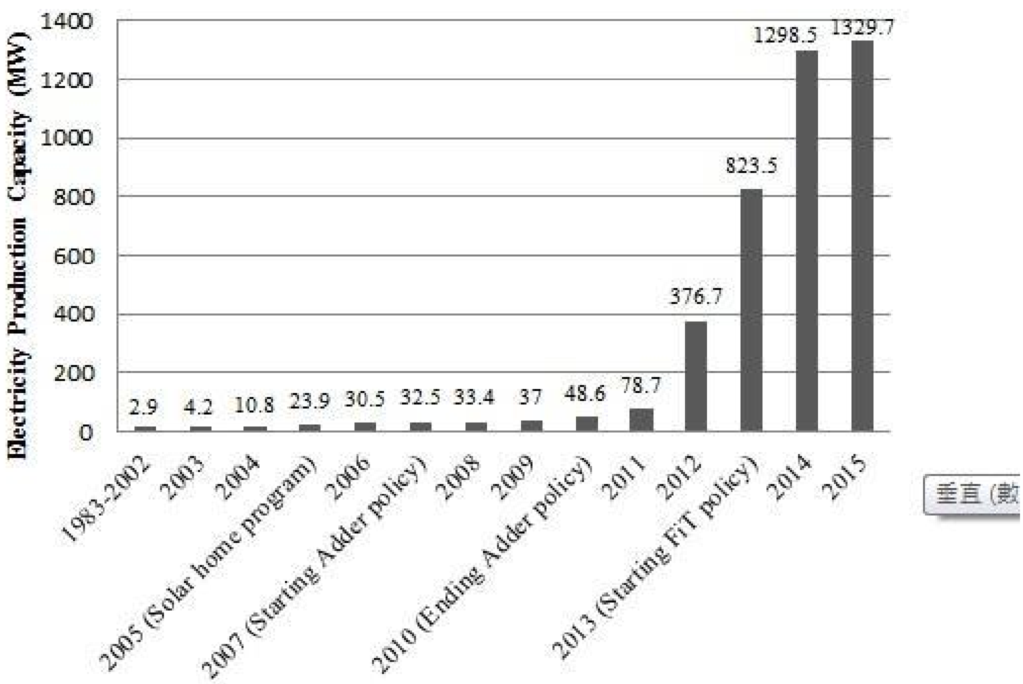

Fig. 3: Total electricity production capacity by solar energy in Thailand during 1983- 2015
Source: Chimres and Wongwises (2016)

3.1 Adder

Adder is subsidized for each unit of electricity specifically generated from renewable energy which reflects the initial costs of electricity generation. The adder subsidy is therefore the price added to the regular rate of electricity. For solar power plants, this subsidy yields 10 years of supporting duration regarding to the Commercial Operation Date (COD). Thailand's adder rates for solar energy are as shown in Table 1 and electricity unit rate can be calculated by:

$$\textit{Unit rate for year 1 to 10} = \textit{Regular rate} + \textit{Float time (Ft) rate} + \textit{Adder cost} \quad (1)$$

$$\textit{Unit rate after year 10} = \textit{Regular rate} + \textit{Float time (Ft) rate} \quad (2)$$

Table 1: Thailand's adder rates for solar energy (1 US Dollar = 33.5 Baht)

Details	Baht/kWh
2007 - 2009	8
2010	6.5
Special adder for diesel replacement	+1.5
Special adder for three southernmost provinces	+1.5

Source: EPPO (2016)

Details of VSPPs solar power plants on grid contributed by Adder measure since 2008 to 2016 are summarized in Table 2. It can be observed that the number of VSPP solar power producers have been increasing significantly due to the higher subsidy rate of solar energy and the continuous drop of PV system cost.

Table 2: Summary of VSPPs solar power plants contributed by Adder measure

Year	Number of Power Plants	Contract Capacity (MW)
2008	13	2
2009	20	5
2010	33	20
2011	60	94
2012	113	269
2013	184	601
2014	244	905
2015	318	1,293
2016	323	1,319
Total	**1,308**	**4,508**

Source: ERC (2016)

3.2 Feed-in Tariff or FiT

FiT has been issued since 2013. To evaluate the FiT, the initial investment, the return on investment, the debt-to-equity ratio, and the support duration of the project are taken into consideration that contributes to more reflective and agreeable subsidy rate of the FiT than that of the Adder. The FiT subsidy is the net price of the electricity purchasing rate and constant throughout the contract period or supporting duration which is 25 years. There are two FIT's rate groups, the rooftop and ground-mounted solar system. Details are as shown in Table 3. At present (2016), there is no VSPP project has been committed with FiT due to no announcement for purchasing electricity from private solar power plant projects (ERC, 2016).

Table 3: FiT rates for solar energy (1 US Dollar = 33.5 Baht)

Details	FiT Rate (Baht/kWh)	FiT Premium for three southernmost provinces (Baht/kWh)
Solar PV Rooftop		
- Capacity 0-10 kW	6.85	+ 0.50
- Capacity > 10-250 kW	6.40	+0.50
- Capacity > 250-1,000 kW	6.01	+ 0.50
Ground-Mounted Solar System	5.66	+0.50

Source: EPPO (2016)

The FiT was evaluated by considering several related factors as mentioned earlier. The cost of PV panel also plays an important role in the initial investment of solar energy projects due to high technology systems required. However, this cost is expected to be decreased in the future due to the fact that the PV systems have been continually developed with lower costs.

The benefits of FiT measure can be summarized as follows:

1. For the government and EGAT, the FiT subsidy paid to private sector is lower than the Adder one throughout the contract period.
2. For private sector, the regulation of FiT yields more availability of electricity trade and less complication of selling rate. As the FiT subsidy is constant throughout the supporting duration, the government can effectively predict and control the initial cost of electricity that contributes to less fluctuation of electricity price.
3. The private sector would be more confident to estimate the annual and total benefits from any energy project during 25 years of contract due to the constant rate of FiT comparing to the Adder.

At present, the efficiency of PV systems is relatively low while the initial costs of PV panel and installation are still high. After issuing the FiT measure, the cost structure of electricity purchased from private energy producers was varied and would lead to deceleration of solar energy projects in 2016 onward. It is because the purchasing rate of FiT is significantly lower than that of Adder and the financial incentives of FiT are also less beneficial than those of Adder at the same promotion period. Therefore, high attention should be paid in solar energy business in terms of financial worthiness and risk especially in VSPPs as the cost per unit of electricity would be much higher than SPPs. As the initial costs of PV systems play and important role in solar energy investment, the solar power projects subsidized by the FiT would be more worthwhile for investment if the technology and other related costs of PV system decrease with high efficiency of the systems in the future.

4. A Case Study on Investment Analysis of VSPP Solar Energy Project

A private VSPP solar project in Thailand was selected as case study for investment analysis contributed by FiT. The power plant was located in Saraburi province with 9.50 MW-DC (8.50 MW-AC) capacity. The PV system was Poly Crystalline Silicon with Single Axis Solar Tracker constructed in the 329,412 m^2 operating area. The initial investment cost was about 1,003,000,000 Baht and the average electricity generating capacity was 16,000,000 kWh/yr. Project details are given in Fig.4, 5 and 6.

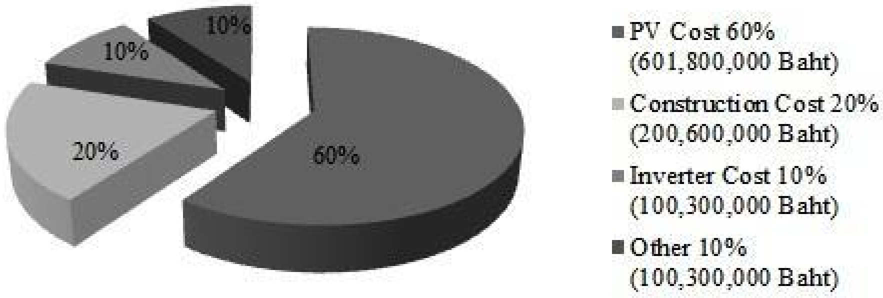

Fig. 4: Investment Costs of the selected project

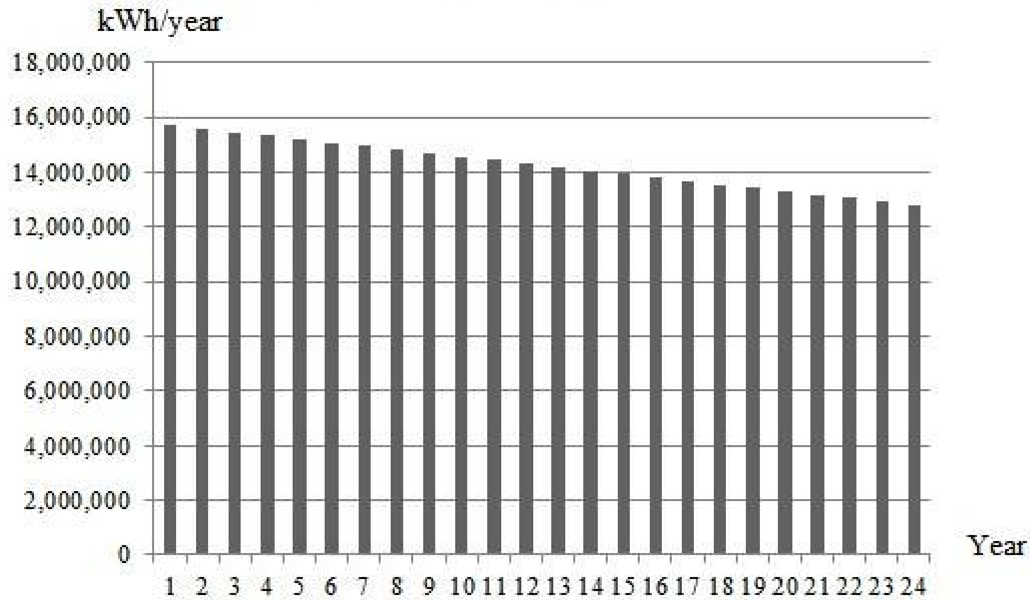

Fig. 5: Annual electricity generating capacity of the selected project

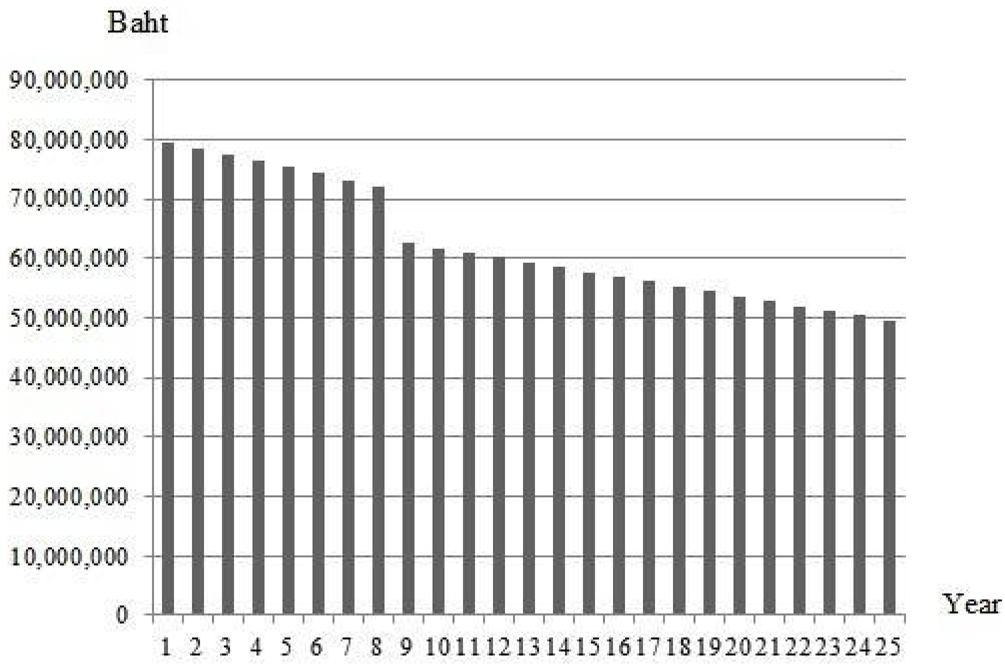

Fig. 6: Annual net income contributed by the FiT and its financial incentives

This project has been fully operated since 2012 and subsidized by the Adder. The FiT was taken in to investment analysis assuming the subsidy rate for ground-mounted solar system was applied for this existing project. Comparison of investment analysis contributed by Adder and FiT policies is illustrated in Table 4. Internal Rate of Return (IRR) and Payback period can be respectively estimated by:

$$NPV=\sum_{n=1}^{N} \frac{CF_n}{(1+i)^n} = 0 \quad (3)$$

$$Payback\ period = \frac{Initial\ Investment}{Estimated\ annual\ net\ cash\ flow} \quad (4)$$

where CF_n : Annual net cash flow of year n (Baht)

i : Rate that provides Net Present Value (NPV) = 0 or IRR

n : Year

N : Total number of years

From analysis, it can be noted that, with the FiT, the IRR is lower and the payback period is also longer than that contributed by the Adder. Therefore, the FiT subsidy would not be economically benefited for this project.

Table 4: Comparison of investment analysis contributed by Adder and FiT policies

No.	Data	Policy	
		Adder	FiT
1	Initial Investment Cost	1,003,000,000 Baht	
2	Average annual Capacity	16,000,000 kWh	
3	Operation Period	25 years	
4	Inflation rate	Assuming 3%	
5	IRR	9.71%	4.0%
6	Payback Period	10.1 years	24.6years

5. Conclusion

From analysis, it can be concluded that the electricity cost structures of the Adder and FiT measures are different. The adder subsidy is the price added to the regular electricity price while the FIT is the net price of the electricity purchase which is constant throughout the period of support. Moreover, the FiT is evaluated by considering, for instant, the initial investment, the return on investment, the debt-to-equity ratio, and the support duration of the project that contributes to more reflective and agreeable subsidies of FiT comparing to those of the adder. However, at present, the benefit from electricity purchase rate contributed by FiT would be lower than that of the Adder due to the high costs of PV system which is also included in the initial investment. From investment analysis of a case study, it can be concluded that the IRR and payback period of this project would not be attractive to investment in the private sector point of view compared to the same project contributed by Adder. However, it should be noted that this analysis was performed specifically for this project with high technology costs that affects the initial investment. Therefore, the FiT subsidy would not be economically benefited for this project. However, if the technology and other related costs of PV system decrease, the solar power projects subsidized by the FiT would be more worthwhile for investment in the future.

6. References

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