FORECAST OF ROOFTOP PV PENETRATION IN BANGKOK, THAILAND

Aksornchan Chaianong, The Joint Graduate School of Energy and Environment, King Mongkut's University of Technology Thonburi, Bangkok, Thailand, Phone (+66) 89-969-3537, achaianong@gmail.com

Athikom Bangviwat, The Joint Graduate School of Energy and Environment, King Mongkut's University of Technology Thonburi, Bangkok, Thailand, Phone (+66) 2872-9014–5 ext. 4136, athikom.bangviwat@outlook.com

Christoph Menke, Trier University of Applied Sciences, Trier, Germany and The Joint Graduate School of Energy and Environment, King Mongkut's University of Technology Thonburi, Bangkok, Thailand, Phone +49 (0) 651-8103-368, c.menke@blv.hochschule-trier.de

Overview

Among the emerging economies, Thailand is one of the leading markets for solar power with the building blocks of solar PV development in the country already in place. The target for solar PV has been set by the latest Alternative Energy Development Plan (AEDP 2015–2036) to 6,000 MW by 2036. However, Thailand still lacks an annual target for rooftop PV to address the planning processes and concerns, such as the required utility infrastructure and policy implications, of stakeholders. This paper focuses on proposing a systematic approach based on international practices to forecasting annual rooftop PV penetration in Thailand and discussing a case study of residential scale in Bangkok for visualizing the proposed approach.

Methods

The customer-adoption model, which is a systematic approach to forecasting rooftop PV penetration on the basis the market conditions of PV investment, was used on the basis of international experiences [1-4]. The payback period is mainly used to define the maximum market share fraction, then the technology diffusion model is used to calculate the annual/cumulative PV penetration. Additionally, a case study of residential rooftop PV in Bangkok was conducted using this proposed method as an example to visualize the applications of this systematic method.

Results

The proposed systematic approach to forecasting rooftop PV penetration contains three main steps illustrated in Figure 1.

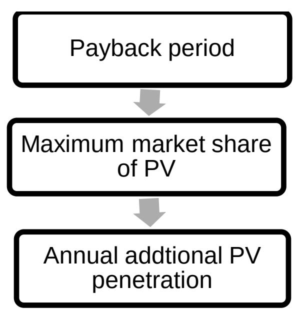

Figure 1 The proposed approach to forecast rooftop PV penetration in Thailand (Adapted from [1-4]).

<u>Step 1 and 2: Use payback period to address maximum market share fraction</u>

The payback period can be addressed using the System Advisor Model (SAM), which was developed by the National Renewable Energy Laboratory (NREL) in the United States. The next step is to apply the relationship between the payback period and maximum market share. According to Beck, R.W. [3], the fraction of customers willing to adopt a technology is a function of the payback period, as shown in Equation 1, which was averaged from various studies. Then, The maximum market share of PV can be converted into total PV penetration (i.e. in MW) by multiplying the maximum market share fraction by the total number of each customer group (i.e. residential, commercial and industrial customers) and the assumed typical PV sizes according to customer group.

$$\text{Maximum market share fraction} = e^{-0.3\times\text{payback time}} \qquad (1)$$

<u>Step 3: Convert maximum market share fraction to technology penetration curve using Bass Diffusion Model</u>

According to [1, 2 and 4], the Bass Diffusion Model was selected to perform as rooftop PV diffusion curve and we also agreed to use Bass Diffusion Model based on Thai context. The Bass diffusion equations are summarized below (Equation 2-3).

$$F(t) = \frac{1 - pe^{-(p+q)t}}{1 + \frac{q}{p} e^{-(p+q)t}} \quad (2)$$

$$f(t) = \begin{cases} F(t), & t = 1 \\ F(t) - F(t-1), & t > 1 \end{cases} \quad (3)$$

Where:

- f(t) is the additional PV installation at time t.
- F(t) is the cumulative PV installation.
- p is the innovation coefficient (external influence, i.e. advertising effect).
- q is the imitation coefficient (internal influence, i.e. word-of-mouth effect).

After that, a case study of the residential customers in Bangkok was conducted with the proposed method. The payback period of residential rooftop PV installation (5 kW) was calculated by SAM using various inputs, including load profiles from the Metropolitan Electricity Authority (MEA) in Thailand, as well as simulated PV production profiles from SAM and other technical, economic and financial parameters based on the Thai context. Then, the maximum market share fraction was calculated using Equation 1 and annual/cumulative rooftop PV penetration was addressed using Equation 2-3 (Bass Diffusion Model) with p and q values are 0.0038 and 0.35, respectively, which are in the range of its typical value according to the theory and 90 percent of penetration saturation is set at the end of AEDP (2036). It is found that with the current payback period of about 9 years and the assumption of 4% annual PV cost reduction by the end of the AEDP (2036), cumulative residential PV penetration in Bangkok is expected to be 4,232 MW, as compared to approximate 6,400 MW of projected residential peak demand in Bangkok at the end of AEDP (with assumptions of 3.75% of load growth and residential demand of 2015 was approximate 2,965 MW). When considering the annual PV penetration, the maximum annual PV penetration will be 452 MW in 2032. This forecast will help utilities to understand their system performances and the system upgrades needed to accommodate a high level of rooftop PV penetration.

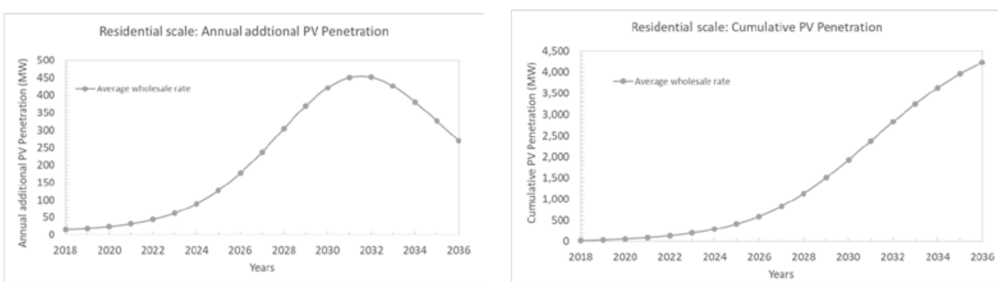

Figure 2 Annual PV penetration (right) and Cumulative PV penetration (left) of residential customer in Bangkok, calculated using the proposed method. Assume the buyback rate is equal to an average wholesale rate.

Conclusions

As of now, Thailand has a solar PV target without annual PV penetration based on market conditions; thus, the proposed method aims to forecast annual PV penetration in Thailand using payback period as the main input. The payback period is used to define maximum market share fraction and annual/cumulative PV penetration is then addressed using the Bass Diffusion Model. A case study of residential rooftop PV in Bangkok was performed using this proposed method and it is found that with the current payback period of about 9 years, assuming the buyback rate is equal to an average wholesale rate and PV cost decreases 4% annually, the cumulative residential PV penetration in Bangkok is expected to be 4,232 MW at the end of AEDP (2036) and maximum annual PV penetration is 452 MW in 2032.

Reference

[1] Denholm, P., Dury, Easan., Margolis,R., 2009, The Solar Deployment System (SolarDS) Model: Documentation and Sample Results, National Renewable Energy Laboratory, Golden, CO.

[2] Dong, Changgui., Sigrin,B., Brinkman, G., 2017, Forecasting Residential Solar Photovoltaic Deployment in California, Technological Forecasting and Social Change, v. 117, p. 251-265.

[3] R.W. Beck, Inc. ,2009, Distributed Renewable Energy Operating Impacts and Valuation Study.

[4] Sigrin,B., Gleason,M., Preus,R., Baring-Gould, I., Margolis, R., The Distributed Generation Market Demand Model (dGen): Documentation, National Renewable Energy Laboratory, Golden, CO.