A SYSTEMIC APPROACH TO EVALUATE PV ECONOMICS AND PV POLICY STRATEGIES

Hyun Jin Julie YU, CEA (French Alternative Energies and Atomic Energy Commission), Phone +33169086710, E-mail:julie.yu@cea.fr

Overview

Until recently, PV sector has been developed mainly based on political support in the energy transition context. The reduction of solar PV energy production costs has been one of the most important pillars related to the national PV energy policies in many countries. For example, the objective of demand-side policies (e.g. FIT system) was to create the market to help reduce the PV costs along with technological progress and industrialization. Faced with globalization, PV power has largely gained economic competitiveness over the last decade. As a result, the lowest PV prices without policy support have fallen below 3 c$/kWh in 2016 (i.e. Abu-Dhabi).

Nevertheless, power generation plants coexist with other parts of the energy mix. They influence each other and interact with customers through the power grid, affected by a set of conditions. In this context, all power plants cause system effects. However, the traditional approach to evaluate the economics of PV power is mainly limited to the concept of PV LCOE and grid parity. The concept of 'grid-parity', which compares PV LCOE with the electricity retail price, is not enough to identify the competitiveness of PV electricity in the electricity mix. It is thus critical to consider the systemic approach to evaluate the real economic value of PV power in the system.

In this context, there is an increasing demand in a comprehensive way to evaluate the PV power. The approach enables policymakers to take the strategic decisions of energy policies related to the PV development. They should be taken strategically by taking a set of critical conditions into account to maximize the benefit or minimize possible damages in the energy system. Therefore, this study aims to clarify and visualize the most important variables to define the economics of PV power in the energy system.

The application of the proposed method will vary from one country to another due to differences in energy system and policy context. This approach can be benchmarked for the policy design related to PV development in the emerging countries.

Methods

The study aims to propose a tool of strategic management of PV developing in the energy system. The systemic approach was examined according to the following steps:

1. **Propose a method of systemic analysis:** the author developed the criteria of policy evaluation (detailed mappings) to visualize any key variables of PV policy systems in a single diagram. The detailed mapping is constructed inspired by a technological prospective method (méthode de prospective technologique) proposed by N. Popiolek. The detailed systemic map explains the causal relationships between key variables and helps evaluate policy efficiency. This method is useful to analyze the dynamics of PV policy mechanisms. It thus enables us to identify problematic points and to discuss about critical risks of PV policy system. In addition, the identified important variables of PV systemic economic value are described with measurable units. Therefore, this method can be used as a base of modeling of PV economics.

2. **Conduct a case study**: the application of the proposed method with an empirical analysis was then conducted. The author aimed to clarify the rationale of strategic PV development by taking the systemic aspect into account. French case was mainly taken to give the precisions. The study explained the strategic position of PV decentralized systems and its development perspectives based on the analysis tool. For example, we evaluated the economic feasibility of French PV systems in 2030 based on PV LCOE calculation to represent the end-user's perspectives. However, the approach should be extended to include systemic impacts of PV integration to evaluate the real economic values of PV power in the mix. For example, the revenues loss of grid financing, impacts on the load duration curve can be defined. Based on the results, we can propose PV integration strategies.

3. **Policy recommendations and conclusion**

Results

Most considers plant-level costs as costs of PV electricity. The plant-level cost is directly related to the levelized cost of PV electricity (PV LCOE). This cost is used as a reference cost in various international studies (e.g. IEA PVPS, IRENA, EPIA, etc) to follow the progress of the PV technologies. However, this indicator is limited to fix the real value of the PV installation in the energy mix. The electricity system is very constrained and the increase of the penetration of non-dispatchable energies, like wind and solar PV, influences the balance of the whole electricity system. Taken the characteristics of intermittent PV power into account, the grid-level costs with large penetration of PV power became significantly important. In addition, externalities refer positive or negative effects, which have yet to be internalized into the PV system price. There are various aspects to be considered: environmental, electricity market, technology, economic and energy position. This helps have more holistic point of view to decide strategic orientations for the PV development in the future energy system.

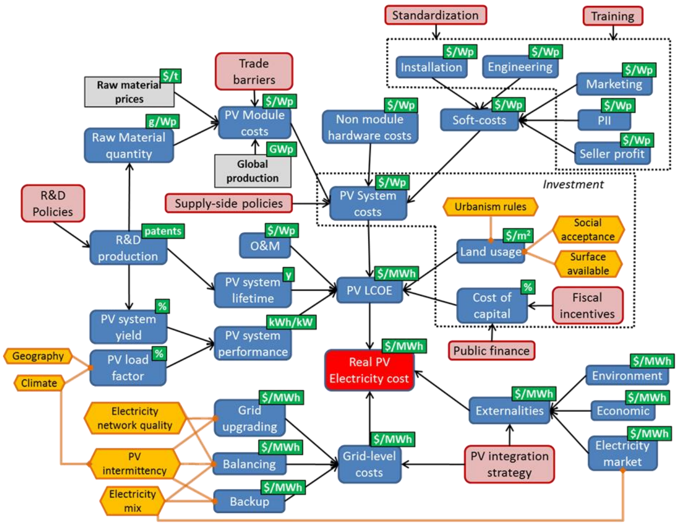

Figure 1: Detailed mapping to evaluate the economics of PV power in the system

The application of this method will be further defined with French case and lessons. For example, the comparative analysis of PV systemic effects according to different choices were conducted based on the French empirical data (ex. distributed with PV self-consumption vs. utility-scale).

Conclusions

This study indicates the increasing importance of variables related to systemic effects to define the PV economics. The narrow vision of the reduction of PV production costs should be extended to include the systemic effects to define the economic value of PV power. In particular, the systemic approach is very useful at the early stage of policy design to prepare strategic orientation of PV development in the energy system. Many emerging countries aim to expand the share PV power in the mix to address the increasing energy demand or to realize the energy transition. The proposed method provides stakeholders with a common tool of dialogue based on a comprehensive perspective in terms of PV economics.

Each country has different condition to developed PV power due to the national energy system features and political context. The ex-ante systemic evaluation enables to take optimal decision of PV policies in the system. In addition, the ex-post policy evaluation can help improve the policy system by adapting market dynamics. A reflection on the following questions is very useful to take smart policy decisions.

- What strengths or weak conditions to develop PV energy in a given county? (They can be analyzed by using defined variables)
- What strategic choice in terms of the type of PV systems (e.g. utility-scale or decentralized), geographic location, or grid condition?

It is very important to prepare a consistent and progressive policy for PV integration in the energy system. Policy would put more focus on limiting the systemic impact of PV power in the future. A proper institutional framework supported by a systemic and long-term vision will affect the success of PV integration.

References

Haas, R., Lettner, G., Auer, H. & Duic, N. (2013) : “The looming revolution: How photovoltaics will change electricity markets in Europe fundamentally”, Energy, Volume 57, pp. 38-43.

Hirth, L., Ziegenhagen, I.(2015): “Balancing Power and Variable Renewables: Three Links”, Renewable & Sustainable Energy Reviews

IEA (2014): “Technology Roadmap: Solar Photovoltaic Energy”

Joskow, P. L. (2011): “Comparing the costs of intermittent and dispatchable electricity generating technologies”, The American Economic Review, pp. 238-241.

OECD/NEA (2012): “Nuclear energy and renewables: System effects in low-carbon electricity systems”, OECD/NEA Nuclear development 2012

Partlin, S., T. Thierschmidt, F. Kever and M. Rothert (2015): “Optimised Storage for increased PV Self Consumption”

Popiolek, N. (2015): “Prospective technologique: un guide axé sur des cas concrets”, s.l.:EDP Sciences.

Pudjianto, D., Djapic, P., Dragovic, J. & Strbac, G. (2013): “Grid Integration Cost of PhotoVoltaic Power Generation”, London: Energy Futures Lab, Imperial College.

Ueckerdt, F., Hirth, L., Luderer, G. & Edenhofer, O. (2013): “System LCOE: What are the costs of variable renewables?”, Energy, Volume 63, pp. 61-75.