DESIGN EVOLUTION OF FEED-IN TARIFFS FOR LOW-CARBON ELECTRICITY: TOWARDS A GLOBAL PICTURE

Magdalena M. Klemun, The Hong Kong University of Science and Technology, (+852) 3469 255, magdalena@ust.hk

Overview

Feed-in tariffs (FITs) are a class of policies that guarantee a fixed remuneration ("tariff") for electricity generated from specific energy technologies such as solar photovoltaics (PV). Following their early implementation in Germany, Spain, and Italy in the 2000s, FITs are used in over 30 countries in all world regions to promote renewable energy technology capacity additions, with the largest number of FIT policies supporting wind, PV, and hydropower (IEA 2022).

Due to their prevalence, importance for inducing renewables market growth (e..g, Trancik 2015), and associated costs, the efficacy of FITs in promoting reductions in unit cost and technology improvement more broadly has been studied widely (e.g., Jenner 2013). Design features of solar PV FITs have been compared across individual countries, including Canada and Germany (Mabee 2012), Switzerland and Germany (e.g., Haelg 2022), and multiple European and Asian countries (Jacobs 2016, Le 2022). Yet despite growing experience with FITs in both developed and developing economies, few studies have attempted to develop a global understanding of how FITs design features (e.g., degression mechanisms, presence of capacity or funding caps) and implementation practices (e.g., number of FIT revisions) have changed over time. Studying the time evolution of FITs is important, however, to better understand how FITs characteristics are shaped by country- and technology-specific as well as temporal conditions, and which FITs features are more likely to diffuse from one country to the next or between groups of early and late-adopting countries.

Methods

A set of quantitative metrics is developed to study the design evolution of feed-in tariff policies, including the number of tariff revisions per unit of time (over the full time horizon of each FIT policy), the ratio of FIT rates to levelized costs of electricity in each year and country, and the ratio of realized and expected PV capacity additions, and the capacity and/or generation targets set normalized to a country's total energy supply capacity. The metrics are computed for each year during which a FIT policy is in effect and compared across countries. Data on policy timeframes and scopes are sourced from the IEA's Policies Database (IEA 2022), from the peer-reviewed literature (e.g., Antonelli 2014, Hoppmann 2014, Ye 2017, Del Rio 2007, Del Rio 2008, Couture 2010, Poruschi 2018, Wen 2021, Chu 2022), and from archives of government press releases (e.g., METI 2022, Schweizerische 2022).

Results

Preliminary results indicate that early solar FIT adopters such as Germany, Italy, and Switzerland implemented more FIT revisions per policy-year than countries adopting FITs later, indicating that FIT policies have become less rather than more flexible and responsive to evolving market and technology conditions. The United Kingdom, having implemented 10 revisions during the 2010-2021 time frame, is an outlier among late FIT adopters. Looking at FIT degression rates over time, fixed and transparent mechanisms for FIT adjustment have not necessarily become more common. Some European countries have adopted higher degression rates than Germany in its initial version of the FIT (9% and 8% in the UK and Switzerland, respectively, starting in 2010 and 2009, compared to 5% in Germany before the first adjustment); however, some recent adopters have not implemented fixed or dynamically adjusted degression rates (e.g., Thailand, Turkey). In Vietnam, the FIT remained below solar PV's LCOE for several years, hindering PV market growth. Several problems observed in early FIT adoption (uneven PV capacity growth across regions that was not justified by better irradiation conditions) reappear at later stages of global FIT adoption.

Conclusions

The continuous adjustment of FIT systems to market, political, and technology conditions has been identified as one of the reasons for their success in sustainably driving PV market growth and cost reductions (e.g., Hoppmann 2014). However, looking at the evolution of FITs, it appears that the ability to replicate a dynamic FIT implementation process across countries may be limited. These preliminary findings raise questions about potential differences in solar policy convergence at the global compared to the regional level, where previous work has pointed to increasing similarity of FiTs (e.g., in the EU (Jacobs 2016)). Institutional capacity gaps, limited knowledge exchange across

continental boundaries, and political barriers are among the possible reasons that should be explored further in future research.

References

Antonelli, M. and Desideri, U., 2014. The doping effect of Italian feed-in tariffs on the PV market. *Energy Policy*, *67*, pp.583-594.

Chu, L. and Takeuchi, K., 2022. The non-operating solar projects: Examining the impact of the feed-in tariff amendment in Japan. *Energy Policy*, *160*, p.112712.

Couture, T.D., Cory, K., Kreycik, C. and Williams, E., 2010. Policymaker's guide to feed-in tariff policy design (No. NREL/TP-6A2-44849). *National Renewable Energy Lab* (NREL), Golden, CO (United States).

Del Río González, P., 2008. Ten years of renewable electricity policies in Spain: An analysis of successive feed-in tariff reforms. *Energy Policy*, *36*(8), pp.2917-2929.

Del Río, P. and Gual, M.A., 2007. An integrated assessment of the feed-in tariff system in Spain. *Energy policy*, 35(2), pp.994-1012.

Haelg, L., Schmidt, T.S. and Sewerin, S., 2022. The design of the swiss feed-in tariff. In *Swiss Energy Governance* (pp. 93-113). Springer, Cham.pp.994-1012.

Hoppmann, J., Huenteler, J. and Girod, B., 2014. Compulsive policy-making—The evolution of the German feed-in tariff system for solar photovoltaic power. *Research policy*, *43*(8), pp.1422-1441.

International Energy Agency (IEA), Policies Database, https://www.iea.org/policies (accessed in February 2022)

Jacobs, D., 2016. Renewable energy policy convergence in the EU: The evolution of feed-in tariffs in Germany, Spain and France. *Routledge.*

Jenner, S., Groba, F. and Indvik, J., 2013. Assessing the strength and effectiveness of renewable electricity feed-in tariffs in European Union countries. *Energy policy*, *52*, pp.385-401.

Mabee, W.E., Mannion, J. and Carpenter, T., 2012. Comparing the feed-in tariff incentives for renewable electricity in Ontario and Germany. *Energy Policy*, *40*, pp.480-489.

METI (Ministry of Economy, Trade, and Industry, Japan), 2022. The Excess Electricity Purchasing Scheme for Photovoltaic Power. https://www.meti.go.jp/english/policy/energy_environment/renewable/photovoltaic.html

Poruschi, L., Ambrey, C.L. and Smart, J.C., 2018. Revisiting feed-in tariffs in Australia: A review. *Renewable and Sustainable Energy Reviews*, *82*, pp.260-270.

Schweizerische Eidgenossenschaft, Bundesamt fuer Energie, 2022. Einspeisevergütung. https://www.bfe.admin.ch/bfe/de/home/foerderung/erneuerbare-energien/einspeiseverguetung.html/

Trancik, J.E., Jean, J., Kavlak, G., Klemun, M.M., Edwards, M.R., McNerney, J., Miotti, M., Brown, P.R., Mueller, J.M. and Needell, Z.A., 2015. Technology improvement and emissions reductions as mutually reinforcing efforts: Observations from the global development of solar and wind energy. *MIT Energy Initiative.*

Wen, D., Gao, W., Kuroki, S., Gu, Q. and Ren, J., 2021. The effects of the new Feed-In Tariff Act for solar photovoltaic (PV) energy in the wake of the Fukushima accident in Japan. *Energy Policy*, *156*, p.112414.

Ye, L.C., Rodrigues, J.F. and Lin, H.X., 2017. Analysis of feed-in tariff policies for solar photovoltaic in China 2011–2016. *Applied energy*, *203*, pp.496-505.