Global heterogeneity in financing cost for renewable energy projects

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Overview

In many countries, policymakers aim at a rapid deployment of renewable energy (RE) plants to reduce CO_2 emissions from the electricity sector. For major RE technologies such as wind turbines and solar photovoltaics, the lion's share of costs occurs for the upfront investment, which needs to be financed. Hence, RE's private cost of capital is an important part of these technologies' levelised cost of electricity (LCOE) (Egli et al., 2018; Schmidt, 2014). Previous research illustrated that LCOE-based technology choices are highly sensitive to cost of capital assumptions (Hirth and Steckel, 2016; Stocks, 1984).

While sound assumptions on RE cost of capital are crucial for energy system models that shall assess technology choices in a meaningful way, suitable data is hardly available for researchers. The key reason is that many RE projects are being realized using non-recourse project finance where financial details remain private information (Steffen, 2018). Indeed, the "cost of capital is a competitive advantage (meaning that many will be reluctant to disclose it)" (Krupa and Harvey, 2017, p. 919). Further complicating the matter, various studies suggest that the cost of capital for RE projects differ widely between countries (Angelopoulos et al., 2016), between technologies (Egli et al., 2018), and over time (ibid).

Realising the need of a better understanding, researchers recently started to estimate such data (e.g., Angelopoulos et al., 2016; Dobrotkova et al., 2018; Egli et al., 2018; Partridge, 2018). However, these studies use different measures for cost of capital, apply very different estimation methods, and study a great variety of RE technologies and geographic contexts. Hence, a consistent picture of the state of knowledge on RE financing cost is missing to date. To address this gap, here we present a meta-analysis of RE financing cost, addressing two research questions: (1) Which methods have been developed to estimate RE financing cost, and how suitable are these methods?, and (2) What is the state of knowledge in RE financing cost by country and technology? Based on our results, we discuss the large heterogeneity in financing cost that can be observed, and implications for researchers and policymakers.

Methods

This article is based on a systematic review of existing empirical studies which estimate cost of capital for renewable energy projects. First, we compile a literature base of relevant articles in an explicit and reproducible way. Second, we evaluate the selected articles concerning their estimation methods, categorize the methods, and discuss them along their strengths and weaknesses (first research question). Third, we extract empirical data on financing cost and related parameters from the articles, convert the data from different studies into comparable quantities using additional assumptions where necessary, and compile a database suitable for a meta-analysis. Important harmonization steps thereby include a uniform treatment of tax impacts, and deflating values as appropriate. In total, the preliminary analyses presented here is based on 358 data points including various financing cost parameters for solar PV, wind onshore, and wind offshore plants. Finally, we evaluate the data and discuss empirical results holistically (research question 2).

Results

The systematic review of methodologies for financing cost estimation shows that four different methods have been used in recent literature. First, researchers drew on *elicitation of project finance data*, by collecting deal data for a representative sample of projects directly from investors (e.g. Egli et al., 2018). While the most direct approach to gather relevant data, it is a laborious task that cannot be replicated for larger samples of countries, especially as confidentiality concerns need to be overcome. In addition, deal data elicitation requires a sufficient track record of projects in the country under study. Second, researchers relied on *surveys of expert estimates* regarding financing cost more generally, typically using a "baseline cost of capital" and discussing technology/country-specific risk premiums or discounts (e.g. Angelopoulos et al., 2016). While less laborious than deal data elicitation, the

representativeness and external validity of such qualitative assessments is hard to compare across studies. Third, recent studies drew on *replication of auction results* (e.g. Dobrotkova et al., 2018). In such studies, authors used an LCOE model to reproduce renewable energy auction bids where many cost parameters are known. In some cases, the cost of capital is the only undisclosed variable which can hence be inferred from the winning bid, but further assumptions might be needed. Fourth, several *financial market-based estimates* have been presented, drawing on price data of traded securities as a proxy for (untraded) RE project finance (e.g. Partridge, 2018). For example, cost of debt is inferred from utility bonds, and cost of equity is based on a CAPM model with leverage-adjusted betas. While these approaches can be applied for many countries, transferring insights from financial market proxies to untraded project finance debt and equity faces numerous challenges.

In total, comparable quantitative data regarding cost of capital is available for 46 countries for the period 2009–2017. We find a globally consistent rank order among technologies, with the cost of capital increasing from solar PV to onshore wind to offshore wind power. On average, the cost of capital in developing countries is significantly higher than in industrialized countries, with large heterogeneity also within the groups of industrialized or developing countries.

Conclusions

In sum, the presented meta-analysis illustrates that several methods have been developed and refined to estimate financing costs. Taken together and converted to comparable measures, the available empirical evidence gives a multifaceted picture of financing cost for RE projects, which can be used for energy system models in the future. Our harmonized comparison shows a large heterogeneity in RE cost of capital, to be considered not only by researchers, but also policymakers that aim at mobilizing private finance for RE at reasonable cost (Polzin et al., 2019).

References

Angelopoulos, D., Brückmann, R., Jirouš, F., Konstantinavičiūtė, I., Noothout, P., Psarras, J., Tesnière, L., Breitschopf, B., 2016. Risks and cost of capital for onshore wind energy investments in EU countries. Energy Environ. 27, 82–104. https://doi.org/10.1177/0958305X16638573

Dobrotkova, Z., Surana, K., Audinet, P., 2018. The price of solar energy: Comparing competitive auctions for utility-scale solar PV in developing countries. Energy Policy 118, 133–148. https://doi.org/10.1016/J.ENPOL.2018.03.036

Egli, F., Steffen, B., Schmidt, T.S., 2018. A dynamic analysis of financing conditions for renewable energy technologies. Nat. Energy 3, 1084–1092.

Hirth, L., Steckel, J.C., 2016. The role of capital costs in decarbonizing the electricity sector. Environ. Res. Lett. 11, 114010. https://doi.org/10.1088/1748-9326/11/11/114010

Krupa, J., Harvey, L.D., 2017. Renewable electricity finance in the United States: A state-of-the-art review. Energy 135, 913–929. https://doi.org/10.1016/j.energy.2017.05.190

Partridge, I., 2018. Cost comparisons for wind and thermal power generation. Energy Policy 112, 272–279. https://doi.org/10.1016/J.ENPOL.2017.10.006

Polzin, F., Egli, F., Steffen, B., Schmidt, T.S., 2019. How do policies mobilize private finance for renewable energy?—A systematic review with an investor perspective. Appl. Energy 236, 1249–1268. https://doi.org/10.1016/J.APENERGY.2018.11.098

Schmidt, T.S., 2014. Low-carbon investment risks and de-risking. Nat. Clim. Chang. 4, 237–239. https://doi.org/10.1038/nclimate2112

Steffen, B., 2018. The importance of project finance for renewable energy projects. Energy Econ. 69, 280–294. https://doi.org/10.1016/j.eneco.2017.11.006

Stocks, K.J., 1984. Discount rate for technology assessment: An application to the energy sector. Energy Econ. 6, 177–185. https://doi.org/10.1016/0140-9883(84)90014-8