MODELLING LONG TERM IMPACTS OF RENEWABLE ELECTRICITY SUPPORT DESIGNS ON SOCIAL WELFARE

Kaveri Iychettira, Delft University of Technology, +31152781841, k.k.iychettira@tudelft.nl
Rudi Hakvoort, Delft University of Technology, +31152782497, r.a.hakvoort@tudelft.nl
Pedro Linares, Comillas Pontifical University, +34 91 5406257, pedro.linares@comillas.edu

Overview

The governance of Renewable Energy Sources for Electricity (RES-E) in Europe beyond 2020 is still uncertain. The European Commission has only indicated that national level targets will be abolished beyond 2020, and that most RES-E support schemes should take the form of competitive bidding. It still remains to be seen whether these choices will lead to the desired policy outcomes in the long-term. Moreover, it cannot be excluded that the same outcomes might be achieved in more cost effective ways, implying a different design of the support schemes. It is equally possible that competitive bidding, subject to specific designs, will result in undesired outcomes.

The objective of this paper is to assess the impact of policy choices, the so-called Design Elements, related to Renewable Energy Sources – Electricity (RES-E) support schemes on social welfare. A single (isolated and uncongested) region has been modelled using a long-term agent-based model of the electricity market, with endogenous investments. Design elements refer to the detailed components that make up a certain policy, for instance, technology specificity, location specificity, duration of support etc. Two seemingly different support policies can be designed such that they have an equivalent effect on the market. The Design Elements analyzed are price warranty versus quantity warranty, or electricity market revenue accounted for ex-post or ex-ante, and technology specificity versus technology neutrality.

Methods

Presently, simulation and optimization models are commonly applied for assessing the value of policy choice. Methodologically, however, all such models assume perfect foresight, and perfect market conditions [1]–[4]. As [3] and [5] have pointed out, this implies that capacity investments and production decisions are taken instantaneously, under conditions of free entry and exit. But such assumptions can hardly be expected to hold in the real-world, especially in sectors where investment decisions, which happen under knowledge of past trends, and imperfect foresight, are a major determinant of welfare outcomes.

The approach adopted in our research follows the design framework presented in [6]. This approach is fundamentally different from the aforementioned works in two main aspects. First, there is a shift from a 'policy' view to a 'design element' based approach of RES-E support assessment. This allows the policy analyst to relate the design characteristics of a support scheme to their effects on the electricity market, and related policy goals. Secondly, a fundamental difference lies in the methodological approach employed in this work, Agent-Based Modelling (ABM). As [7] explains, ABM is said to be appropriate especially for modelling out-of-equilibrium economics, the process of formation of equilibrium, and accounting for historical path dependencies. The electricity market model employed, EMLab, consists of generation companies as agents who make investment decisions based on past decisions and imperfect foresight.

Results

The paper provides interesting results, some of which are represented in in Figure 1. It appears that in general quantity-warranty schemes are more cost-effective than price-warranty schemes, unless there are interconnections or storage options in the power system. Technology-neutrality is less cost-effective than technology-specificity, subject to renewable generation targets. Ex-ante accounting for expected electricity market prices accrues higher subsidy costs than accounting for electricity prices ex-post. The latter result, however, seems to be sensitive to the accuracy of agents' (producers' or regulator's) expectations of future electricity prices, and the risk which agents attribute to uncertainty in future electricity prices. The design element configuration that leads to the highest increase in social welfare is

the combination of quantity-warranty, ex-ante accounting for electricity prices, and technology-specificity.

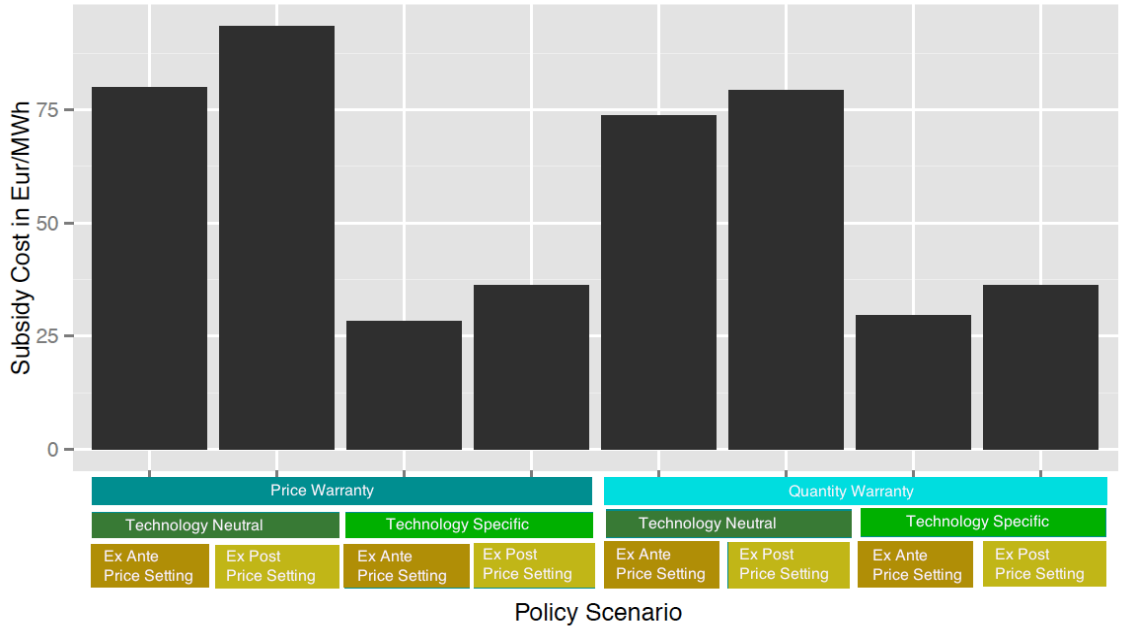

Figure 1: Policy Cost Effectiveness through the simulation lifetime (2015-2055), per scenario

Conclusions

The results demonstrate that design elements, irrespective of the RES-E policy they belong to, do have significant impacts on the energy system and on welfare distribution, and therefore that the approach is a useful one. The agent-based modelling framework enables modelling of bounded rationalities in investment decisions, allowing the modeller to incorporate real-world uncertainties in agents' behaviour. Given the current debate on the governance of renewable energy generation in the European Union beyond 2020, the present paper may offer guidance to policy makers and analysts who would like a better understanding of the relationship between policy design and social welfare.

References

[1] P. Capros *et al.*, "Description of models and scenarios used to assess European decarbonisation pathways," *Sustain. Energy Syst. Chang.*, vol. 2, no. 3–4, pp. 220–230, Feb. 2014.

[2] C. Huber *et al.*, "Deriving optimal promotion strategied for increasing hte share of RES-E in a dynamic European electricity market," 2004.

[3] D. Most and W. Fichtner, "Renewable energy sources in European energy supply and interactions with emission trading," *Role Trust Manag. Uncertainties Transit. Sustain. Energy Econ. Spec. Sect. Regul. Pap.*, vol. 38, no. 6, pp. 2898–2910, Jun. 2010.

[4] B. Fais, M. Blesl, U. Fahl, and A. Voß, "Comparing different support schemes for renewable electricity in the scope of an energy systems analysis," *Appl. Energy*, vol. 131, pp. 479–489, 2014.

[5] F. Olsina, F. Garcés, and H.-J. Haubrich, "Modeling long-term dynamics of electricity markets," *Energy Policy*, vol. 34, no. 12, pp. 1411–1433, Aug. 2006.

[6] K. Iychettira, R. Hakvoort, and P. Linares, "Towards a comprehensive policy for electricity from renewable energy I: A Structured Design Approach," *Energy Policy*, vol. Submitted, 2016.

[7] W. B. Arthur, "Chapter 32 Out-of-Equilibrium Economics and Agent-Based Modeling," vol. 2, L. Tesfatsion and K. L. Judd, Eds. Elsevier, 2006, pp. 1551–1564.