Benefits and distributional effects of regionally integrating support schemes for renewable electricity

Sebastian Busch¹, Gustav Resch²

¹Vienna University of Technology, +43-1-58801370354, busch@eeg.tuwien.ac.at
²Vienna University of Technology, +43-1-58801370354, resch@eeg.tuwien.ac.at

Introduction

Three trends have been characteristic for (western) electricity markets. The liberalization process leading to the separation of network and generation assets. The integration of formerly separated market / network zones. And the increasing penetration of renewable energy sources for electricity production. The latter is motivated by the objective to transform the way electricity is produced, mostly due to (in some cases perceived) benefits that are external to the power system, such as reduced air pollution [1]. In Europe the renewable energy sources directive provides opportunities for cooperation through the so called cooperation mechanisms. In this respect policy makers who are in charge to evaluate and implement such regional, cross border support instruments will be interested to be informed about the potential benefits and distributional effects across countries.

Methodology

Modelling Framework

Figure 1: Modelling Framework

In order to gain a better understanding of the effects of integrating support schemes across countries a dynamic equilibrium model of the electricity market is developed. The model jointly considers the Karush-Kuhn-Tucker conditions of several electricity market actors’ interrelated optimization problems. In the model renewable energy policy can be cooperatively or non-cooperatively. In the non-cooperative case each country achieves its own technology-specific target by domestic renewable electricity production. In the cooperative case two or more countries achieve a combined target and renewable electricity is produced where it is most valuable.

Renewable electricity producer’s optimization problem

\[ \max_{\ell_t} \sum_{t=0}^{T} \left( \sum_{n=1}^{N} \left( c_{i,n} \cdot \ell_t + \text{transmission costs} \cdot \ell_t \right) \right) \]

\[ \text{s.t.} \]

\[ \ell_t - \sum_{n=1}^{N} c_{i,n} \cdot \ell_t - \sum_{n=1}^{N} \left( \text{transmission costs} \cdot \ell_t \right) \leq 0 \text{ for } \forall t, i, n. \]

\[ \ell_t \geq 0 \text{ for } \forall t, i, n. \]

The fulfillment of the targets is achieved through the market clearing conditions of the renewable support scheme as shown in the equations above. The dual variable of the equation can be seen as the green certificate price, it can also be interpreted as premium in a renewable electricity premium support system (assuming the policy maker has full information on the costs / market value of renewable electricity production and aims to reach a certain RES-E share).

Results

For the initial application the model has been calibrated with data for France and Germany. Information of technology-specific trajectories and targets for renewable electricity production have been derived from the National Renewable Energy Action Plans. Results indicate that cooperation can lead to cost savings of roughly up to one billion annually. However the reallocation of renewable electricity production may make some compensatory approach necessary due to the shifting of rents.

Conclusions

Equilibrium models for the electricity market of similar type have for instance been developed by [2], [3] and [4]. Compared to models where all investment decisions are taken by a benevolent central planner equilibrium models are better capable to capture the changes in incentives structures of different actors induced by changes in the renewable support scheme. They also allow to have prices such as the renewable premium (dual variables) endogenously in the model formulation. In future work it is planned to also include the optimization problem of the policy maker(s), i.e. to minimize support costs or to maximize welfare for example. Then the model would become a two level problem and would need to be solved as MPEC or EPEC.

References


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