Capacity vs Energy Subsidies for Renewables: Benefits and Costs for the 2030 EU Power Market

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Introduction

It is widely agreed that renewable electricity policies, such as feed-in tariffs, that encourage siting of renewable developments irrespective of the marginal value of their output, promote inefficient investment in terms of maximizing the net economic and environmental value. Instead, the EU and its member states are moving towards feed-in premiums, curtailment requirements, and other policies that result in profits better reflecting the market value of electric energy. Development may therefore be encouraged where resources produce fewer annual MWh, but where the increased market value more than makes up for that decrease due to timing and availability of transmission and dispatchable generation capacity.

However, although such policies might decrease the net economic cost of achieving renewable energy targets, it has been argued that they are still inefficient in achieving the goal of promoting technology improvement. In particular, if learning-by-doing occurs through cumulative MW investment rather than through cumulative MWh production, then policies that are tied to investment rather than output might be more effective in reducing technology costs (Newbery et al., 2017). These policies may take the form of straight-forward per MW investment subsidies. A more sophisticated variant, as described by Newbery et al. (ibid.), would pay a per MWh subsidy, but only up to a maximum number of MWh per MW of capacity.

Here we compare the impact of energy-focused (feed-in premium) and capacity-focussed (investment subsidies) renewable policies upon the EU-wide electric power market in 2030 using a market equilibrium model. Specifically, do capacity-based policies result in significantly more investment (and possibly learning)? We explore how different policies impact the mix of renewable and non-renewable generation investment, electricity costs, renewable output, the amount of subsidies, and consumer prices. In addition, we also evaluate the efficiency of national policy targets for renewable electricity production (as a whole or per technology) and compare these with a cost-effective allocation of renewable enegy production, given resource quality, network constraints and the structure of the electricity system in the various EU countries.

To address these issues, we use COMPETES, an EU-wide transmission-constrained power market model, which we enhanced to simulate both generation investment and operations decisions (Özdemir et al., 2013, 2016). In contrast, other analyses of renewable electric energy policies in Europe have often identified best locations and technologies based on levelized costs or other metrics that disregard the space- and timing-specific value of their electricity output. COMPETES uses linear programming to simulate the equilibrium in a market in which generation decisions simultaneously consider the effect of development costs, subsidies, and energy market revenues on profitability.

Method

A market equilibrium assuming a perfectly competitive market has two characteristics. First, each market party pursues its own objective (its profit) under the assumption that it cannot increase its surplus by deviating from the equilibrium solution. The second characteristic is that the market clears such that supply equals demand for electricity at each node in the network. One approach to modeling market equilibria is to concatenate the first-order conditions for each market party's problem with market clearing equalities, yielding a complementarity problem. Complementarity problems can be solved either by specialized algorithms or, in special cases, by instead formulating and solving an equivalent single optimization model.

The version of COMPETES applied here adopts the latter approach. It uses a single linear program that is equivalent to a market with profit maximizing generators who invest and operate to maximize profits and a transmission operator who minimizes dispatch costs, all subject to policy constraints such as renewable energy or capacity targets and carbon prices. For practicality, this version of COMPETES uses a sample of 1200 hours (sampled from eight years of data from Gorm et al., 2015) to capture load and renewable output variability within a year, and a static (single year) equilibrium is calculated for the year 2030. Also, this version represents the EU 28 country market with 22 nodes, considering net transmission capability constraints between countries or regions.

Results

An initial comparison of our baseline scenario of no renewable policies versus three EU-wide policies achieving a 65% renewable electricity target is shown in the first four scenarios in Figure 1. The renewable policies we simulated assume a single EU-wide target without country-specific mandates, and furthermore assume that the same level of subsidy applies to all renewable sources. Of course, the reality of EU policy is that there are distinct programs for wind, solar, biomass, and hydropower, and each country has their own targets, with relatively limited opportunities for countries to satisfy their renewable requirements elsewhere. However, these simplifications allow us to explore the general impact of energy versus capacity policies.

Assuming that policy makers adjust capacity targets to meet a 65% energy target, the basic capacity-based policy would increase the incremental generation cost[1] of achieving that target (by 58%, from 11B€/yr for a feed-in premium policy to 18B€/yr). Using MWh feed-in premiums rather than capacity payments is cheaper because paying for the product that contributes directly to a desired target (MWh rather thn MW) is the first-best way of meeting that target.

On the other hand, the capacity policy does result in higher renewable investments compared to the no-policy case (446 additional GW, which is 63% higher than the 273 GW additional capacity in the energy target case). In contrast, the Newbery et al. proposal's results fall in-between these cases, as it has characteristics of both capacity and energy policies; compared to no policy, it increases the incremental GW capacity investment (by 36%, 372 GW vs. 273 GW) at a somewhat lower cost per incremental GW unit (incremental cost of achieving the target of 14B€/yr).

But if the target is instead capacity (MW) instead of MWh, then the capacity mechanism is cheaper. In other runs (not shown), we have found that the 377.3 GW of new renewables that results from the 65% feed-in premium policy could also be achieved directly by capacity policy at an incremental cost that is 26% lower than the 11B€/yr cost of the feed-in premium policy. On the other hand, the cheaper capacity policy achieves only 59,9% (rather than 65%) renewable penetration.

We also explored the impact of country-specific targets (last scenario in Figure 1). This is a MW-based policy with a minimum amount of renewable solar, wind onshore and offshore capacity by country based on targets reported in theENTSO-E (2018) Sustainable Transition (ST) scenario. The incremental cost of achieving a 52.7% EU-wide renewable energy goal using the specific country goals was 8,5 B€/yr. This is about seven times higher than than the incremental cost of achieving the same 52.7% level by using the most cost-effective locations and technologies in the EU, and almost as high as the cost of achieving a much more ambitious 65% target by the most cost-efficient means. Moreover, our simulations show that the choice of technologies and locations are equally to blame for the cost increase resulting from country targets, accounting for the 53% and 47%, respectively, of the generation cost increase.

Conclusions

Our findings show that the efficiency of energy vs capacity-focussed renewable policies depends on the EU's renewable energy goals. If the goal is to reach a certain share of renewable energy in total consumption, it is more efficient to use an energy subsidy to achieve a given MWh target than to use capacity-based (MW) mechanisms. But if the objective is to promote technology improvement through capacity installation, then it can be significantly less expensive to use capacity subsidy mechanisms to achieve a given renewable capacity goal than to use renewable energy subsidies.

Moreover, the country-specific targets without renewable energy credit trading greatly increase the cost of renewable policies. Our analysis shows that there is considerable room for coordinating and improving renewable energy policies within Europe which will help reduce the total costs of promoting renewable power.

Footnote

[1] Includes investment and variable generation costs of conventional units, storage and renewables, as well as costs of load shedding. NB: no load shedding was observed in any of the cases. Furthermore, net import costs from non-EU countries are included as well, with import prices adjusted for border congestion, assuming that congestion revenues are equally shared between neighboring countries.

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