CAPACITY VS ENERGY SUBSIDIES FOR RENEWABLES: BENEFITS AND COSTS FOR THE 2030 EU POWER MARKET

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Overview

It is widely agreed that renewable electricity policies, such as feed-in tariffs, that encourage siting of renewable developments irrespective of the marginal worth 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 profitability better reflecting the market value of power. 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 or transmission availability.

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, promoted by Newbery et al. (ibid.), would pay a per MWh subsidy, but only up to a maximum number of MWh per MW of capacity.

In this paper, 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. In particular, we ask the following question:

- How do the different policies impact the mix of renewable and non-renewable generation investment, electricity costs, renewable output, the amount of subsidies, and consumer prices? Specifically, do capacity-based policies result in significantly more investment and possibly learning?

Capacity versus energy subsidies may also have a strong effect on the economics of "system friendly" wind turbines, which have been recently promoted as having lower integration costs and more valuable power output profiles (Hirth and Müller, 2015; Nils 2017). But because such turbines have lower capacity per unit output (which may be achieved simply by using smaller electric power generators for a given tower size and rotor diameter), they may be disadvantaged by capacity subsidy programs. We investigate whether this is indeed the case.

Moreover, 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 COMPETES, a 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.

Methods

A market equilibrium has two characteristics. First, each market party pursues its own objective (its profit), and believes that it cannot increase its surplus by deviating from the equilibrium solution. The second characteristic is that the market clears: supply equals demand for energy 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 (out of 8760) hours to capture load and renewable output variability within a year, and a static (single year) equilibrium is calculated for the year 2030 rather than for a multiple year time horizon. 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 four policies (no renewable subsidies, which results in 46.8% renewable electricity production; a MWh feed-in premium that achieves at 55% renewable goal, and two MW investment subsidies policies that also achieve 55% renewable energy) is shown in the first four columns of the below table. 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 renewables in one country to satisfy requirements elsewhere. However, these simplifications allow us to to explore the general impact of energy versus capacity policies. (We note that our simulation of country-specific targets (i.e., a MWh-based policy with a minimum of 40% renewable electricity by country, in addition to the 55% EU-wide goal) indicates that country-specific targets would more than double the cost of renewable policies.)

Policy: Variable	Base: No Renewable Subsidy	MWh Feed-In Premium	MW Capacity Subsidy	Newbery et al. Capacity Subsidy	MWh Premium: Differentiated Wind/Solar
EU Renewable Electricity Share	46.8%	55%	55%	55%	55.6%
Wind share	20.8%	27%	24%	25%	27%
Central solar share	5.0%	8%	11%	10%	9%
Incremental generation cost	0 M€/yr	2198 M€/yr	2777 M€/yr	2404 M€/yr	2879 M€/yr
New investments onshore wind	86.3 GW	147.1 GW	120.5 GW	130.9 GW	120.5 GW
New investments central solar	17.8 GW	77.3 GW	134.5 GW	110.6 GW	134.5 GW
Renewable payments	0	13.3 €/MWh	32,662 €/MW/yr	30.7 €/MWh (for first 30,000 MWh/MW)	10 (Wind), 22.8 (Solar) €/MWh
Total renewable subsidy payments	0	8568 M€/yr	8329 M€/yr	8724 M€/yr	9314 M€/yr

Conclusions

Assuming that policy makers adjust capacity targets to meet a 55% energy target, the basic capacity-based policy must increase costs (by 27%), since directly constraining (and paying) the product that directly contributes to a desired target is the first-best way of meeting that target. But the capacity policy does have the benefit of increasing the GW of renewable investment (by 14%). In contrast, the Newbery et al. proposal's results fall in-between these cases, as it has charracteristics of both capacity and energy policies; compared to no policy, it increases GW capacity (by 9%) at about half the cost per unit (total cost increasing by 9%), while increasing GW investment by 9%. On the other hand, if separate wind and solar energy subsidies are used to achieve the same GW investments as the basic capacity policy (see last column of table), our initial solutions indicate there is the possibility of a slight increase in renewable generation and a 100 M€/yr increase in cost compared to the capacity-focussed policy.

Meanwhile, other results (not shown) indicate that "system friendly" wind turbines with half the generator capacity could be financially attractive under MWh subsidies because the generator cost savings might exceed foregone revenues and subsidies during the times of highest wind. However, foregone income is about three times larger if instead the capacity-based policy is in place, greatly decreasing the value of the system friendly design.

Overall, 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 realizing renewable energy production.

References

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