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

Özge Özdemir, PBL Netherlands Environmental Assessment Agency, +31 6 14380938, ozge.ozdemir@pbl.nl
Benjamin F. Hobbs, The Johns Hopkins University, Baltimore, MD 21218 USA, +1 410 516 4681, bhobbs@jhu.edu
Marit van Hout, PBL Netherlands Environmental Assessment Agency, +31 615252993, marit.vanhout@pbl.nl
Paul Koutstaal, PBL Netherlands Environmental Assessment Agency, +31 6 12111627, paul.koutstaal@pbl.nl

Overview

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 profitability 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 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; May, 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 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.

Methods

A market equilibrium assuming a perfectly competitive market 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 where 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 (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 production share in annual EU demand; a MWh feed-in premium that achieves a 65% renewable goal, and two MW investment subsidies policies that also achieve 65% renewable energy) is shown in the first four columns of the table below. 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 to explore the general impact of energy versus capacity policies.

Policy: Variable	Base: No Renewable Subsidy	MWh Feed-In Premium	MW Capacity Subsidy	Newbery et al. (2017) Capacity Subsidy	RES targets per country (ENTSO-E ST scenario)
EU Renewable Electricity Share	46.8%	65,0%	65,0%	65,0%	52,7%
Wind share	23,6%	38,9%	28,6%	32,6%	26,2%
Solar share	5,1%	10,5%	20,0%	16,4%	8,7%
Generation cost[1] (delta)	0 M€/yr	11062,7 M€/yr	17446,6 M€/yr	14108,1 M€/yr	8482,8 M€/yr
New investments wind onshore	86,3 GW	242,4 GW	147,1 GW	188,6 GW	76,7 GW
New investments wind offshore	0 GW	3,4 GW	0 GW	0 GW	34,7 GW
New investments solar[2]	17,8 GW	131,5 GW	402,9 GW	287,5 GW	113,6 GW
Renewable payments	0	33,2 €/MWh	57.345,0 €/MW/yr	56,1 €/MWh (for first 20,000 MWh/MW)	Various (depends on country)
Total renewable subsidy payments (new RES units only)	0 M€/yr	33724,7 M€/yr	31539,7 M€/yr	29844,4 M€/yr	10292 M€/yr

Our simulations also explored the impact of country-specific targets (last column). This is a MW-based policy with a minimum amount of renewable solar, wind onshore and offshore capacity by country based on targets reported by ENTSO-E's Sustainable Transition (ST) scenario (ENTSO-E, 2018). The cost of achieving a 52.7% EU-wide renewable energy goal using the specific country goals was 8,5 Billion Euro per year. This is about six times higher than than the incremental cost of achieving the same 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. Thus, country-specific targets without renewable energy credit trading greatly increase the cost of renewable policies.

Conclusions

Assuming that policy makers adjust capacity targets to meet a 65% *energy* target, the basic capacity-based policy must increase costs of achieving that target (by 58%), 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 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 28%).

On the other hand, we note Newbery et al. (2017)'s observation that 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 capacity installation goal than to use an approach based on renewable *energy subsidy*. In particular, 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 (second column of table) could also be achieved directly by a 47614€/MW/yr subsidy,

[1] Includes investment costs (as well as savings from retirements) 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, 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.

[2] Centralized solar capacity only.

at an incremental cost that is 26% lower than the cost of the feed-in premium policy. On the other hand, the capacity policy also achieves only 59,9% renewable penetration, and has higher carbon emissions.

Meanwhile, other results (not shown) indicate that “system friendly” wind turbines with half the generator capacity might be financially attractive under MWh subsidies because the generator cost savings might exceed foregone revenues and subsidies during the times of highest wind. Whether this is the case or not depends on the assumptions made concerning the cost savings from reduced electric generator and associated machinery expenses. However, foregone revenue is several 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.

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