Over the last decades, various policies have been adopted to reduce carbon emissions and promote the development of renewable energy sources. In the European Union, carbon emissions have been priced through a cap & trade mechanism – the European Union Emissions Trading Scheme (EU ETS); at the same time, various countries have launched national schemes to support renewable energy sources, in particular in the electricity sector. The overlapping of carbon mitigation policies and direct support schemes to Renewable Energy Sources for electricity (RES-E) affects technology adoption patterns in a way that depends on the details of the specific type of policies in place. As a result, changes in the carbon mitigation policy, such as the prospected reform of the EU ETS, require to reconsider the RES-E support schemes adopted by national governments.

Motivations underlying the research

The ongoing EU ETS reform establishes the introduction of the Market Stability Reserve (MSR), which will allow the European Commission to manage the supply of allowances in order to stabilize the price of EU carbon allowances. The MSR, which will become operational in 2019, will shift the European carbon mitigation policy away from a pure quantity - based towards a hybrid price/quantity - based tool.

Overlapping tools and changes in carbon policy are likely to affect uncertainty borne by electricity producers, and this in turn may have an impact on incentives to invest in RES-E technologies by regulated firms. It is therefore crucial to assess such impacts, along with the changes in RES-E policies design required in response to the carbon policy reform.

A short account of the research performed

We develop a theoretical model featuring two risk neutral generators initially sharing the same, carbon intensive, technology. Our aim is to analyze how different combinations of carbon mitigation and RES-E support policies affect the generators' incentives to switch to a RES-E technology, when investments are undertaken under uncertainty.

In particular, we compare four possible policy combinations, where a carbon tax (intended as an extreme case of a MSR) or a cap and trade are, in turn, combined either with a feed-in tariff (FIT) or with a feed-in premium (FIP). The various combinations affect differently generators' exposure to market uncertainty and, therefore, the incentives to technological adoption. More specifically, FITs insure the RES-E adopting firm

against uncertainty on power prices (as electricity is sold at a fixed regulated price, not depending on market conditions). Conversely, under the FIP, generators adopting RES-E receive a fixed monetary premium on top of the electricity price; therefore, they are subject to uncertainty on power prices.

The main conclusions

The European carbon policy and national RES-E support schemes need to be coordinated, by explicitly considering how their design allocates market risk and affects generators' returns from RES-E adoption. We show that the switch from pure cap and trade to the new hybrid system established by MSR modifies significantly the effect of the direct RES-E support schemes on investment. Under pure cap and trade, that is, the "pre-reform" EU ETS scheme, which of the two policies (FIT or FIP) triggers more adoption ultimately depends on parameter values, as well as on the policy-maker goals. In a nutshell, if the goal is to incentivize large-scale adoption of RES-E (i.e., having the vast bulk of generation capacity produced using RES-E), then FIT may be the best option; if, instead, the objective is to incentivize only partial adoption of RES-E, possibly due to limited resource availability, then FIP may be the correct choice.

The above recommendation changes substantially as a result of the ETS reform. We show that maximization of incentives to invest in RES-E, when the MSR will be effective, will require moving away from FIT towards FIP. This conclusion clearly holds under our assumption of risk neutrality, which is valid for large enough power generators with a sufficient ability to self-insure. It may instead not be appropriate for small producers or self-producers of electricity. For small producers with a risk-averse profile, an increase in uncertainty is likely to reduce, rather than increase, the expected returns from RES-E adoption, working as a countervailing force with respect to those identified in our paper. For those producers, adoption may be maximized by a FIT which does not expose RES to market uncertainty.

Potential benefits, applications and policy implications of the work

Since the MSR will shift EU-ETS towards a hybrid price/quantity instrument, EU Member States will have to adapt their national RES-E supporting schemes. Our model shows that, within the context of feed-in support schemes, maximization of RES-E adoption will require EU Member States to move away from FITs and switch to FIPs. More specifically, our results suggest that the schemes currently adopted in Germany and in Italy, broadly based on FIP (or in any event on monetary premia – possibly resulting from tender processes - on

top of the electricity price) for large generators, could well fit also the post-MSR EU carbon mitigation policy. To the contrary, other countries where FITs are in place (e.g. France and the U.K.) may have to modify their support schemes as the MSR will become operational.