The Future of Electricity Markets: More questions than answers

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Among the readers of the EAERE Magazine, there is probably no need to stress the urgency of reducing carbon emissions. In the coming two decades, we must accelerate the transition towards a low carbon economy to limit the rise in world temperature within the dangerous 2C limit. As Nicholas Stern puts it, "the opportunity is now": delay is simply not an option.

However, whereas the objective is clear, the route we should follow is less so. Most of us agree on the need to support a least-cost energy transition but … do we agree on the set of policies that would allow us to succeed? Policy innovation – an area to which we have much to contribute as economists - is probably as key as technology innovation is for a successful energy transition.

With the focus on the power sector, the objective of my ERC project (ELECTRIC CHALLENGES, for which I have been honored to receive the EAERE award) is precisely to inform policy-making towards a least-cost energy transition. With only one summer apart from the start of the project, at this point I can only suggest questions - and very few answers - with the hope of inspiring much needed research in this exciting area. The future of electricity markets and the design of the policies that are best suited to meet the environmental targets are still open for debate.

Renewables, a game changer that opens several design questions

Renewables are called to play a major role in the process of decarbonizing our economies. Complying with the recently set EU climate and energy objectives means that, by 2030, around two thirds of total electricity generation should come from renewables.[1]

Renewables are a game changer in electricity markets for two reasons: first, they allow to producing electricity at almost zero marginal costs, and second, they are not always available. This poses several questions for market and regulatory design, which I group within three broad categories: (i) the design of electricity markets, (ii) the design of auctions and contracts for renewables, and (iii) the design of dynamic pricing incentives.

Regarding the design of electricity markets:

In most electricity markets, generation technologies (e.g. nuclear, coal, gas, hydro, etc) are paid at the market-clearing price, typically reflecting the marginal cost of the most expensive technology needed to meet demand. Greater reliance on renewables will push market prices down, eventually driving market revenues below the average costs of most, if not all, generation technologies. Is this market design well suited for renewables-dominated electricity systems?

In order to address this question, we would first need to understand competition among renewables. The so-called *merit-order effect* (namely, the role of renewables in depressing market prices) is based on the premise that renewables bid at zero marginal costs, thus shifting the market supply curve out and the market prices down. However, just as conventional energy producers do not always bid at marginal costs, renewable producers need not always bid at zero.

The question of *How do renewables compete among them?* is still – as far as I am aware of – not fully answered.[2] In particular, at which prices will renewable producers offer their power? How will this depend on the pricing rule in place? Will ownership of renewables matter? Will the various renewable technologies bid differently? What will be the resulting market price patterns (i.e., the price level and its volatility)? Understanding these questions is key to assessing the future performance of electricity markets under a business-as-usual market design, or alternatively, for assessing the need to re-design it.

There are certainly many other questions related to market design issues that will become increasingly relevant. For instance, if renewable generation exceeds total demand, which units should be called to produce first? Should we allow producers to bid down negative prices, or should we rather rely on rationing rules that introduce efficiency considerations (e.g. minimizing network congestion)? How do the various rationing rules impact producers' uncertainty, and what are the effects on their investment incentives?

Regarding the design of the auctions and contracts for renewables:

One option for mitigating strategic bidding is to avoid renewables from facing the fluctuation of wholesale market prices. Ultimately, there are no major compelling efficiency reasons to do so given that their marginal costs are essentially constant, their fixed cost are unrelated to changes in the marginal costs of producing electricity in coal or gas plants, and their availability is mostly subject to exogenous weather shocks. The so-called Contracts for Differences (or CfDs, as in the UK) or the contracts with floating premia (as those used in Germany) reduce the price exposure of renewable producers, thus mitigating the investors' risk premia and reducing their costs of capital.[3] Whether such lower costs are passed on to consumers critically depends on the design of the auctions and contracts for renewables. This poses several unsettled issues: How long should the contracts for renewables be? Should several renewable technologies compete among them or should we rather rely on technology-specific auctions? Should we ask bidders to invest in renewable capacity only, or should we ask them to provide firm energy, e.g. to combine their investment in renewables with back up capacity, batteries, or demand response? The list of issues regarding the design of renewables auctions is long… not least because the costs and benefits of deploying renewables will largely depend on whether we get such design issues right.

Regarding the design of dynamic pricing incentives:

An alternative – or rather, a complement - to building back-up capacity to cope with the intermittency of renewables is to encourage demand to be more active. Dynamic pricing offers one option to induce changes in consumers' behavior: if consumers face price incentives to shift load from high-price periods (i.e., those with high demand/low renewables) to low-price periods (low demand/high renewables), there is scope to reduce the peaks of demand and thus mitigate the need to maintain excess capacity. But, do we know whether consumers would indeed respond to such pricing incentives? Prior work has taught us that consumers indeed respond to such price signals, and that information and automation enhance demand response. However, such analyses rely on data from field experiments with voluntary participation of a small, and thus potentially unrepresentative, set of consumers. The possibility to assess the external validity of such experimental evidence is limited as dynamic pricing has not been broadly implemented in practice (an exception is Spain, where the default option for all households is to pay electricity prices that change on an hourly basis, RTP).

If we face consumers with dynamic prices, would they respond to the hourly price changes? In particular, would they have the incentives to do so and would they gather then necessary price and consumption information? What would be the distributional impacts of such a pricing policy as consumers with different consumption profiles face different price patterns over time? Do consumers dislike hourly price volatility? In particular, if given the option to opt out to flat tariffs, which consumers would be most likely to abandon dynamic prices? Shedding light on these issues is key to designing consumers' pricing schemes, and to ultimately quantify the role that demand response can provide in balancing renewables-dominated electricity systems where the extent of price variation can be large and where, absent demand response, the need to keep excess capacity would be greater.[4]

To conclude….

This is just a sample of the issues that we should understand in order to inform good policy making towards an efficient energy transition. They are certainly not the only ones. Other major issues regard the economics of energy storage, the potential for energy efficiency improvements, the economics of distributed generation, the impacts of a broader adoption of electric vehicles….And, as the state of technology evolves in this rapidly changing field, further policy issues will become relevant – new technologies for producing or storing electricity might arise; or the costs of the existing ones might fall; the involvement of consumers might become cheaper and quicker; or new forms of transportation might appear….Our role as economists is to make sure that society benefits from such technology breakthroughs through a set of good policies. And, as economists working in the area of Energy and Environmental Economics, we should feel reassured that our contribution will be key to achieving a least-cost energy transition. The stakes are high. We should work hard to get it right!

Endnotes

1 The objective is that 32% of total energy consumption will come from renewables. Since other sectors find it more difficult and more costly to rely on renewables, a big share of such effort will come from the power sector as electricity will increasingly provide clean energy for other sectors.

2 Together with Gerard Llobet, we shed light on this matter in the on-going paper "Competition among Renewables".

3 Indeed, as reported by David Newbery (2017), the switch to CfDs in the UK reduced cost of capital from 6% to 3%, saving GBP 2.25B per year.

4 Together with Mar Reguant and David Rapson, we are analysing these issues, in the context of the Spanish market, through the lens of a big data set made of the hourly consumption of more than 4M households over two years.