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The Renewable Energy Policy Paradox

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Key Points

One major avenue for policymakers to meet climate targets is by decarbonizing the power sector, one component of which is raising the share of renewable energy sources (renewables) in electricity generation. However, promoting renewables in liberalized power markets creates a paradox:

Successful penetration of renewables could fall victim to its own success in liberalized electricity markets, increasing the cost of future deployment of renewables and reducing their scalability.

Full decarbonization of a power sector that relies on renewable technologies alone, given the current design of these markets, is not possible as conventional technologies provide important price signals. If all power had zero marginal cost, this would lead to the collapse of a liberalized electricity market.

Accommodating a small quantity of renewables in the electricity system can be achieved without distorting prices, profits or incentives for investments. However, to streamline a transition to low carbon sources, current power markets require restructuring – potentially even a reversal of liberalization. This is necessary to address the 'renewables blend wall', the point when sufficient renewables penetration materially reduces the market clearing price, or marginal cost of the most expensive facility required to meet demand, below the full cycle cost of new baseload generation.

The low initial costs and price impacts of renewables penetration should not blind policymakers to the costs associated with renewable energy transitions, including those affecting the viability of currently liberalized electricity markets.

Summary for Policymakers

Renewables with low or zero marginal costs of dispatch – such as solar, wind and hydro power – could fall victim to their own success after capturing large shares in liberalized power markets. Given existing liberalized market structures in most of the developed economies, future deployment of renewables could become more costly and less scalable because of their impact on electricity prices. Paradoxically, a too successful renewables policy could reduce the efficiency and effectiveness of future such policies.

Current liberalized market mechanisms are based on two assumptions: positive marginal costs and the dispatchability of power. Neither of these assumptions is applicable to renewable technologies, because renewables are intermittent and non-programmable and have almost zero marginal costs. These two characteristics explain why high market penetration of renewables leads to artificially depressed and more volatile electricity prices. In this scenario, renewables incentives become more expensive and lead to less deployment. In addition, based on existing market designs, 100 percent renewables penetration cannot be achieved because developers of renewable generation would be unable to earn a return on their investment without conventional technologies to provide a floor for electricity prices.

Two important implications of this finding are:

> This paradox applies only to liberalized markets and not to centrally planned systems.

> Penetration of renewables capacity in the current configuration of liberalized markets has limits.

Ignoring these findings can slow adoption and increase the costs of deploying new renewable technologies.

Liberalization Lays the Foundation for the Paradox

The liberalization of electricity markets in most advanced economies has profoundly changed the behavior of supply and demand (Joskow, 2008). On the supply side, liberalization engendered competition and unleashed new entrepreneurial forces. On the demand side, it empowered the consumer and aligned with customers' increased awareness of environmental and climate change issues. The electricity system was previously organized as vertically integrated companies, as natural monopolies, and in most cases these were in public hands (Joskow, 1998). Current liberalized electricity markets are the result of pro-market reforms that took place in the 1980s and 1990s to increase the competitiveness of the sector. The resulting decentralized market structure has made possible a formidable spread of renewables and enabled thousands of new producers – with embedded generation units including photovoltaic, mini hydro and mini wind – to become the fastest growing class of players in the electricity markets.

There are, however, two risks to the success of this liberalization program. First, based on existing designs of these markets, future deployment of renewable energy technologies will be more costly and less scalable. Second, renewables penetration disrupts the normal functioning of these markets (see, for example, De Vos, 2015). In fact, renewable technologies have (almost) zero marginal cost and this makes it difficult to integrate them into an electricity market based on marginal dispatch costs (Coase, 1946).

Existing power market designs operate on the assumption that electricity generation has a range of positive marginal costs that increase through some rank ordering, as is the case for thermal generators, based on technologies and fuel sources. This design is based on the construction of an efficient merit order through an implicit auction in the day-ahead market. However, when combined with the deployment of renewable technologies on a massive scale, this is leading to a decline in wholesale electricity prices and an increase in price volatility. This price drop does not reflect a true decline in the full cycle cost of producing electricity, though, but reflects the very low marginal cost of dispatch for renewables. Indeed, a state-owned monopoly would only be able to incorporate intermittent zero marginal cost output by distributing the costs within its overall rate structure. A liberalized market, on the other hand, makes this cost more transparent.

We use the term 'renewables blend wall' for the point when sufficient renewables penetration materially reduces the market clearing price, or marginal cost of the most expensive facility required to meet demand, below the full cycle cost of new baseload generation. Until this point the costs of integration are largely operational and of limited consequence to the overall price of delivered power. Beyond this point, the failure of the liberalized market structure to provide market players with a return on their investments requires the introduction of more costly adjustments. These can include capacity payments, investment support and even mandates to maintain plants that would otherwise be mothballed or decommissioned.

This new aspect to price formation is reducing the effectiveness and efficiency of renewables policies in liberalized markets. It is a conundrum that a successful existing renewables policy should lead to a more expensive renewables policy in the future. Although increases in penetration of renewable technologies have been massive in recent years, with renewable generation growing by about 8 percent for six consecutive years, according to the

International Energy Agency (IEA 2015), this same success could lead to its downfall.

Although this policy paradox is only now being recognized, the impact of renewable policies on markets and investor behavior has been explored in literature, by Winkler et al. (2016), Nelson et al. (2016) and Bigerna and Bollino (2016), among others. The conclusion of these studies is that distorted market signals endanger competition and the opaqueness of subsidy pass-through weakens consumer confidence. Whether the present market designs are appropriate in the transition to a low-carbon power sector has become a critical question.

The early stages of renewables deployment were characterized by very uncertain returns, as it was difficult to price the risk of these new untested technologies. State-owned monopolists were buying the output of renewable energy installations at an administered price. Subsequently, more mature renewables entered the liberalized market and started to compete at zero marginal cost, with a relatively small and well-assessed risk, which investors found attractive. The recent rapid renewables penetration creates new systemic risks in the market, such as security of supply, excess costs and, ironically, the need to incentivize retention and even additions of fossil-fuel technologies as backup capacity.

This paper pinpoints the renewable energy policy paradox and explores the need for a rethink of the foundations of market liberalization. The crucial questions are:

> Where in the value chain is the free market still best placed to ensure economic efficiency in the deployment of massive amounts of renewable power?

> Should there be competition for dispatch rather than centrally planned systems?

> Is it a question of redesigning the market completely or just strengthening the rules of price transparency?

> Is there an endogenous feed-back from market rules to renewables growth? In other words, is there a risk of over investment in renewables, beyond the optimal level for societal welfare?

The Impact of Renewables on Wholesale Electricity Markets

Deployment of renewables tends to decrease spot electricity prices and, at the same time, increase their volatility, as pointed out by Browne et al. (2015), Clò et al. (2015), Würzburg et al. (2013), Paraschiv et al. (2014) and Dillig et al. (2016), among others. This is due to the interplay between the electricity market design and the cost structure and specific features of renewable technologies. This outcome makes it impossible for renewables policy to reach success, defined as achieving a specified level of deployment at the lowest possible cost. With low and even negative electricity prices, investors would be discouraged from entering the market and they would require more incentives to continue to operate.

Liberalized spot electricity markets are designed using a marginalist approach. This means that the market clearing price is set at the marginal cost of production of the last unit sold, which is the most expensive. In practice, power generators offer different quantities of electricity at various prices, which are ranked from cheapest to most expensive. Then, and for a given demand, the cheapest power plants supply electricity while the more expensive ones do not operate. Plants with marginal production costs that are lower than the market clearing price will be able to earn incremental revenues, which contribute to their fixed costs. The marginal plant will only be able to cover its variable operating and maintenance cost.

Renewable technologies do not follow the above structure. They have cost structures and technological features that make them difficult to integrate into, and ultimately incompatible with, current liberalized electricity market designs. The first feature is that their marginal cost is (almost) zero. The second is that renewable technologies are intermittent and unpredictable in the time frames for medium term supply planning. They cannot be used at will. Therefore, such technologies are unable to contribute to the construction of the standard textbook supply curves.

The first feature above explains why renewables have priority of dispatch. The structure of renewable technologies, which have a high levelized cost of electricity but zero marginal cost of production, gives renewable energy priority in the order of dispatch. However, renewable technologies are often not the cheapest. In some countries, a simultaneous increase in the total cost of electricity production has been observed, as more expensive renewables were added to the aggregate market, alongside a decrease in spot prices, driven by market rules favoring technologies with low marginal cost. For example, in Germany the feed-in tariff program supporting renewable energy has more than doubled residential electricity prices, ranging from 18 cents per kilowatt-hour in 2000 to more than 37 c/kWhr in 2013. The feed-in tariff subsidy program has already cost more than $468 billion, and its total cost could exceed $1.3 trillion by the time it expires, according to 2015 estimates. German consumers paid an 18 percent surcharge on their monthly power bills in 2014 to finance renewables. This is more than a fivefold increase since 2009 (Lang and Lang, 2015). In consequence, there has been a divergence between the average cost of the electricity system and the market price of electricity as renewables penetration in the generation mix increased. This could be considered analogous to a blending wall.

Furthermore, the impact of renewables is not limited to the level of prices alone. There is an interesting interplay between price volatility and renewables penetration. Price volatility is an inherent characteristic in electricity markets due to the lack of reliable and meaningful storage, which is exaggerated by the presence of unpredictable and intermittent technology. Any non-dispatchable generator, such as intermittent technology, will force conventional thermal power producers to make sudden adjustments to their production. This leads to sharp changes in electricity prices.

The renewable energy policy paradox results from the interaction between several factors, including:

- The (almost) zero marginal costs of renewables.
- The intermittent nature of renewables.
- The interplay between price volatility and renewable technologies.

The paradox is that the same renewables policies that led to current success become increasingly less successful in the future as the share of renewables in the energy mix grows.

The Renewable Energy Policy Paradox

Depressed and more volatile electricity prices arising from high penetration of renewables are not ingredients for long term growth, unless costs are declining more quickly than the combination of market price drops and financing costs hikes. Renewables policy objectives are criticized by some as “often inexplicit, unclear, not quantified and temporally unstable,” (Knoepfel, 2008). For simplicity, we assume that the objective of renewables policy is to deploy renewable capacity at the lowest cost possible as a proxy for reducing carbon emissions at the lowest cost. We acknowledge this is a restrictive assumption as, of course, there are alternatives, such as enhancing energy efficiency or other technologies including carbon capture and storage. The point is that considering renewables in isolation may prove to be self-defeating.

In the new framework of liberalized markets, policymakers have three types of generic financial instruments to promote renewables. These are:

1. Guarantee a fixed price for renewables production regardless of the market price. Examples include a feed-in tariff or a bilateral power purchase agreement.

2. Support renewables by paying a fixed amount on top of the market price, such as a feed-in premium or a production tax credit.

3. Provide a direct subsidy for initial investment.

For simplicity, let’s also assume that there already exists a critical mass of renewable energy in place. Our contention is that when these instruments are implemented in the markets with decreasing, but more volatile, prices – as is the case in electricity markets with high penetration of renewable technologies – the outcome will be either less deployment than expected initially, or more expensive policy support (Blazquez et al., 2016).

Investing in new renewables capacity is less attractive at a time of lower electricity prices, as they reduce expected profits. Also, private investors will likely demand higher rates of return as volatility raises the uncertainties over the projects. Lower expected profits and higher profit requirements inevitably reduce the number of projects commissioned in the absence of additional policy support. The level of a feed-in premium, for example, or of an investment credit, would need to be higher than otherwise in order to maintain a given level of investment.

Feed-in tariffs or bilateral agreements could be a potential way to manage this impact, since both guarantee a stable flow of revenues by fixing prices. However, such instruments would lead to increasing levels of support as wholesale prices decline due to the penetration of new renewables capacity. Guarantors of the payments – either taxpayers through government, or consumers through surcharges on their bills – would need to compensate generators better to cover the difference between fixed and spot prices in these liberalized markets. In the short term, consumers may benefit from the decline in electricity prices, while the equity value of incumbent generators may deteriorate. In the longer term, investors will not reinvest or recapitalize electricity markets without sufficient guarantees on returns. These additional costs will eventually be borne by taxpayers or consumers.

In the extreme (theoretical) case of 100 percent renewables, the market price would effectively be zero and therefore the compensation would be equal to the full cost of renewables. In other words, the result would be a purely administered subsidy, i.e., a non market outcome.

Liberalized Electricity Markets in Transition

In practical terms, a transition toward a 100 percent renewable electricity sector is unattainable, given the existing power market structure. In most liberalized markets, electricity prices are set by short-term marginal costs, assuming that the short-term marginal costs are always positive. This metric does not capture the system's costs when there is a high penetration of renewables technologies, because they have marginal costs that are close to zero. Non-dispatchable technologies, as such, need to coexist with fossil fuel technologies in order to continue growing their market share. In an extreme scenario, markets would collapse if the last unit of fossil fuel technologies were to be phased out. In this scenario, prices would be at the renewables marginal cost, equal to zero or even negative for long periods. This is already occurring in Germany (Praktiknjo and Erdmann, 2016) and is clearly an unstable outcome.The failure of the liberalized market to capture the full cycle cost structure is artificially lowering electricity prices.

Alternative price setting mechanisms have been tried in liberalized electricity markets. One, known as a pay-as-bid auction, is where each market generator receives its actual bid, again up to the highest market clearing bid. However, pay-as-bid auctions are not the standard way to organize liberalized markets since they promote strategic bidding, often not reflecting marginal costs. The reason is that generators behave strategically in order to make a profit maximizing competitive bid, avoiding rejection (Newbery and McDaniel, 2002; Wolfram 1999; Joskow, 2006). In addition, pay-as-bid can lead to inefficient dispatching as lower or less aggressive bids from more costly plants are accepted. The liberalization of U.K. power markets in the 1990s used a variant of pay-as-bid where all bidders received the clearing price. This was also dropped, for the same reasons.

In short, current power market designs cannot satisfactorily accommodate renewable policy mandates without distorting electricity prices. Alternative approaches will be required.

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About the project

The goal of this project is to understand how policy can expedite renewable energy transitions in a cost-effective way, while allowing competitive national industries to develop. In line with this objective, a wide range of policy instruments, designed and implemented to promote renewable energy, are being assessed. Furthermore, the project takes a holistic approach by analyzing how the competitive dynamics between renewable technologies and incumbent technologies evolve.

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