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Policies for decarbonizing a liberalized power sector

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It is widely accepted that an efficient climate change mitigation strategy requires the rapid decarbonization of the electricity supply industry (ESI). Most advanced economies have competitive privately-owned generation companies trading on wholesale fuel and electricity markets, unbundled from transmission, distribution and retailing. As such they take short-run operating decisions on the basis of spot fuel and carbon prices and make commercial investment decisions on the basis of forecast fuel and electricity prices, announced taxes and subsidies and a view about the future time path of CO_2 prices.

The UK Government along with the European Commission recognize and intend to address the energy policy trilemma: to deliver reliability, sustainability (decarbonization) and affordability/competitiveness. Of these three, the hardest is how best to incentivise the decarbonization of the ESI. There is considerable dispute as to whether renewables targets, e.g. as specified in the EC *Renewables Directive*, a carbon price, an emissions performance standard (EPS), or some mix of these policies embodied in long-term contracts, would be most cost effective.

Setting a carbon price seems the natural approach for a liberalized ESI, as standards fail to equilibrate marginal damage costs across sectors or technologies. For setting the carbon price to be effective in delivering the objective of rapid decarbonization of the ESI, its resulting value should not be too sensitive to fuel price and other uncertainties. Unfortunately, this is not the case, as this paper demonstrates, which strengthens the case for supplementary policies. This paper introduces the concept of a break-even carbon price - the carbon price at which a zero or low-carbon technology (e.g. an on-shore wind turbine) has the same cost as a competing more carbon-intensive alternative (e.g. a combined cycle gas turbine, CCGT) and develops a methodology to explore the sensitivity of this carbon price to key uncertain parameters, such as future fossil fuel prices, the discount rate and capital costs. This methodology can be readily applied to a wide range of technology comparisons, illustrated with on-shore wind competing with a CCGT and a nuclear plant competing with an advanced combustion coal plant. It can also be fruitfully applied to Marginal Abatement Cost Curves.

A liberalized ESI has important characteristics that require a specific approach to designing emissions and related policies. Efficient energy and climate change policies needs to ensure efficient operation of existing capacity, efficient choices of new capacity, efficient demand responses, including energy efficiency, and an efficient innovation strategy.

If ESI investment decisions are to be left to the market, then a number of market failures will need to be addressed. The most obvious is that CO_2 emissions should be properly priced, but that is not the only externality, as innovation creates valuable public knowledge that is not reflected in the returns to developers. In addition to the difficulty of determining the right carbon price, the problem is amplified by a number of missing markets. ESI investments are highly durable and futures markets for more than a few years ahead are lacking. That might not matter if the policy environment were predictable, but that is far from the case. Perhaps more important, suitable risk markets are lacking. Fossil generators enjoy a natural hedge as they set the electricity price, and shift the volatility in fuel, carbon and electricity prices on to consumers and on to zero-carbon generators, whose variable costs are close to zero. Consumers are further denied the option of insuring through future climate change mitigation options in existing markets.

Decarbonizing electricity is an attractive insurance policy against an increasingly likely high cost of future climate change damage but not one consumers can purchase, except via public policy. This is recognized both in international climate change negotiations and within the EU in the ETS. While cap-and-trade solutions are politically attractive as coordination mechanisms, they fail the test of resilience to shocks that underlies the literature on addressing persistent global stock externalities like GHGs. They need to be reformed to give credible, durable and adequate price signals. The social cost of carbon is highly uncertain, and as there is widespread agreement that the ESI should lead in decarbonizing, it appears operational and therefore attractive to set the carbon price at the break-even level at which zero-carbon options become commercially viable. Unfortunately, this break-even price is highly sensitive to fuel price and other uncertainties. If, for example, gas generation is to be outcompeted by wind, then a fall of \$10/MWh_{th} (\$2.93/mmBTU) in the price of gas requires an increase of \$53/tonne CO_2 to restore parity.

Given the volatility in the forecast price of gas (and other risks), it would be difficult to set a carbon price now that would give credible signals over the life of new investment. Setting an EPS has the merits of ruling out some obviously unattractive choices like coal-fired generation, but is unlikely by itself to signal the kinds of investment needed for a low-carbon ESI with growing intermittent renewable power and (commercially) inflexible nuclear power. A carbon price floor is valuable in guiding short-run operating decisions (raising the cost of higher carbon plant and reducing its capacity factor), but long-term contracts have the advantage of addressing missing market problems (risk and futures markets) and can be designed to select enough zero-carbon capacity.