Tax or turn off: that is the question

Some insights in power sector emissions reduction measures' effectiveness in a small, open economy

D. Devogelaer, BAEE Board Member, Federal Planning Bureau, +3225077438, dd@plan.be

Overview

In times when, in Belgium as well as in the rest of the world, climate marchers are protesting loudly against the apparent lack of strong and decisive policy measures taken by different authorities to reverse the trend of growing global greenhouse gas emissions, we look into the effects regulatory measures like decommissioning certain highly emitting technologies in future power systems might engender. The focal point of the impact analysis is Belgium which is a peculiar country because of its current strong dependency on both interconnections and low carbon nuclear energy, but has a nuclear phase-out planned in the timeframe 2022-2025.

In this paper, a combination of methodologies is used to provide insights in the main feedbacks and causal mechanisms of electricity systems. A soft link between an overall energy system model and a dedicated electricity sector dispatch model is created in which scenarios compatible with both the 2030 EU Energy/Climate Framework and the 2050 Low Carbon Economy are scrutinized in order to discern the difference in means to generate similar emission reductions in the European power sector.

Methods

PRIMES (E3MLab, 2018) is a partial equilibrium energy system model that delivers outcomes that are fully consistent across the entire energy system (both supply and demand). Within the energy model, the power and steam module applies an optimisation algorithm to handle the long-term simulation of power system operation, power plant dispatching, investment in new or refurbished power plants, supply/distribution, trading and pricing of electricity between countries and towards consumers. To keep computation time within a reasonably acceptable timeframe, its functioning is based on time slices. These time slices are of course judiciously chosen to at best represent the future power system.

However, in order to expand our understanding of the power system of the future and to take certain sector peculiarities (e.g. the need for flexibility) which are deemed to grow in importance into account, a more fine-grained analysis with an extended (hourly) time resolution is indispensable. Therefore, a second modelling framework is used, being a dedicated unit commitment optimal dispatch model. Crystal Super Grid (Artelys, 2016) is a dispatch model that minimizes total system production costs whilst aligning demand with supply. It contains an extensive library of both physical and financial assets (thermal power plants, renewable energy sources, power lines, etc.) which allows for a meticulous level of detail for analyses.

For this exercise, Crystal Super Grid is soft linked to PRIMES, meaning that the installed capacities calculated by the capacity expansion power module from PRIMES for the EU28 are integrated in Crystal Super Grid. Scenarios are run with three test cases each to take account of different meteorological years and hence the influence of the weather during a specific year on both demand and solar and wind production. It is important to specify that in the construction of future demand and variable renewable production profiles, a coherence between the two is taken into consideration.

Results

A first scenario based on the *EUCO30* scenario of the European Commission (EC, 2016) is constructed in which the announced coal phase outs by a couple of countries were put in practice. It is called *Coal Phaseout*. More specifically, the Netherlands announced in its 'Regeerakkoord' made public on October 10, 2017 that by 2030, it would phase out all its coal-fired units, including the most recent ones commissioned in 2015. The UK, France and Italy made similar commitments. A such scenario generates a decrease in the European power sector CO_2 emissions compared to the original *EUCO30* scenario of 32.4 Mt in 2030.

In a next phase, we tried to end up with a similar amount of CO_2 reductions in the European power sector by modelling a higher price on carbon. This scenario was named *Higher carbon price*. Through trial and error, different carbon prices were integrated in the European power system until a price was found that matched the requested amount of CO_2 reductions. This carbon price ended up being twice as high as the original carbon price (in *EUCO30*). Although the decrease in power sector CO_2 emissions is similar, other indicators are quite different. A selection is depicted in Table 1 in which the impact on the Belgian electricity system is being sketched.

Table 1 Differences wrt EUCO30 between scenario with the announced national coal phase-outs and scenario with substantial rise in carbon price, year 2030

	Coal Phase-out	Higher carbon price
EU CO_2 emissions ($MtCO_2eq.$)	-32.4	-34.5
BE SMC (EUR/MWh)	+5.8	+21.5
BE CCGT production (TWh)	+2.2	+1.4

Source: Crystal Super Grid.
Note: BE stands for Belgium; SMC stands for System Marginal Cost; CCGT stands for Combined Cycle Gas Turbine.

The delta in the Belgian system marginal cost is dramatically different, meaning that opting for a coal phase-out instead of experiencing a rise in carbon price causes a spectacularly lower impact on the average system marginal cost, hence on the price of the commodity. Phasing out coal through regulatory measures hence seems to be cheaper for the customer, but there is a sting: lower carbon prices might not give the proper incentive to boost future wholesale power prices through which investments in the system of the future are remunerated. This means that specifically capital-intensive (e.g. wind or sun) and marginal (e.g. gas-fired power plants) production capacities might not be enticed to invest unless capacity remuneration mechanisms or long-term contracts are on the table.

Conclusions

A coordinated coal phase-out throughout Europe results in a significantly lower average system marginal cost than would prevail if the carbon price rises to a level that engenders a similar level of emission reductions. Nonetheless, if the carbon price does not increase, this might have some less wanted side-effects in stalling investments in low-carbon or flexible units.