Displaced carbon and the Sizewell C Development Consent Order

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Introduction

In order to meet a new requirement for Development Consent Order (DCO) applications the Sizewell C (SZC) DCO includes

(a) a calculation of the carbon emitted during the construction of the project and

(b) an estimate of the amount of time it would take to 'displace' this carbon once SZC starts operating.

The assumption used in the calculation of (b) is that once operating, SZC's output will displace the 'grid average' carbon intensity of a future forecast UK grid (the calculation uses a combination of BEIS UEP to 2035 and National Grid FES 2019 to 2050) for the future grid counterfactual. This note is directed at the logic or otherwise of the method of calculating the carbon displaced.

Carbon displaced by Sizewell B

In an earlier note (Newbery, 2020) the author calculated the carbon displaced by Sizewell B (SZB, he only PWR operating in GB) as part of an exercise to compute the cost of that carbon displaced. In the counterfactual in which SZB is not built, other forms of generation would be needed to replace its output, with its associated emissions. Fig. 1 shows the fuel mix from well before commissioning SZB.

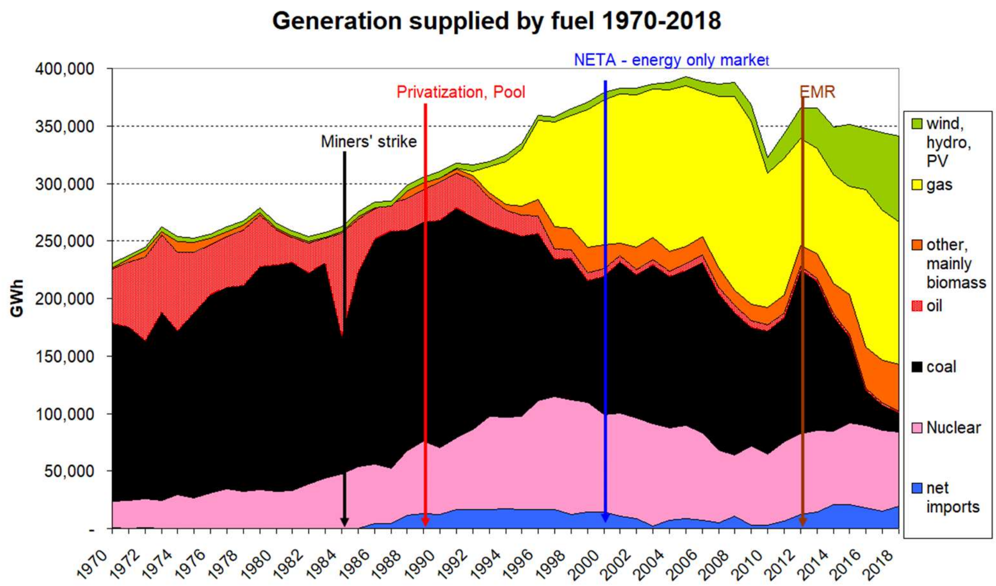

Figure 1 Generation by fuel, 1970-2018
Source: DUKES 5.1

[1] EPRG was commissioned by EdF to prepare a paper on RAB financing on Sizewell C (Newbery et al., 2019). The author is writing in his own capacity and any views expressed here should not be attributed either to EPRG, nor the University of Cambridge, nor to EdF.

From 1995, gas-fired CCGTs started to enter the liberalized electricity market, mostly on the back of favourable long-term contracts with the newly privatized Public Electricity Suppliers (PESs). It seems likely that the CCGTs would have entered at least as quickly without SZB, in response to the very favourable contracts they were able to sign with the PESs, so the counterfactual would likely have had more coal generation, which was clearly declining in response to increased nuclear output, higher imports (enjoying a non-fossil fuel benefit) and possibly even more CCGT output.

In the period before retail prices were liberalised (1998-2000) the avoidable gas cost was slightly above the avoidable coal cost, but the contract position with the PESs probably meant they were dispatched before coal. Oil prices were consistently above coal prices and so oil is primarily used for peaking plant, and would likely continue in that role until displaced by gas. Thus from 1995 to 2000 each MWh generated by SZB would displace the carbon content of 1 MWh of coal generation, which gradually rose from 0.82t CO2/MWh to 0.87t CO_2/MWh.

The carbon involved in building SZC 5,738,084 tonnes CO_2 for a capacity of 3,340MW, or 1,718t CO_2/MW capacity.[2] If SZB had the same construction carbon intensity, its impact would be nominal rated capacity of 1,198 MW times 1,718 CO_2/MW = 2,058,151 tonnes CO_2. In its first full year of operation SZB displaced 6.94 MT CO_2 so the it would have paid back its construction emissions in just over 3½ months of operation.

After 1999 CCGTs had a less secure place with the PES's, with the end of the domestic franchise and with it their guaranteed market, and coal would likely run on baseload while CCGTs moved to mid-merit and peaking. Nevertheless, the pressure to retire coal plant might have been lower had SZB not been commissioned, so while some of the time SZB replaced gas, it may also have displaced some baseload coal. During this period is it reasonable to assume that SZB displaced 50:50 coal and gas.

From 2006 with the introduction of first the EU Emissions Trading System (for CO_2) ETS and later the GB Carbon Price Support (an additional carbon tax on generation fuels), the carbon-inclusive cost of coal was almost always above that of gas, making coal the marginal fuel unless constrained by its capacity (often the case for hours of higher demand). If these occur half the time, then again the generation displaced is 50:50 coal and gas. Thus from 2006 to 2019 the displacement is roughly 0.63 tonnes CO_2/MWh (the falling efficiency of coal generation is almost exactly offset by the rising efficiency of gas). (Chyong et al. 2019, sets out a more sophisticated method used for measuring the displacement factor of wind but that would require calibrating a counterfactual plant mix back to 1996.)

Constructing the counterfactual

In the example of SZB, the counterfactual was fairly straightforward as the UK had not at the time of commissioning (let alone reviewing the case for construction) locked itself into legally binding carbon targets, and the analysis was retrospective, so what happened is observable. The arguments above, while not decisive, bound the range of carbon displaced between the coal and gas emissions factors. The requirement to compute the future displaced CO_2 over the life of the prospective plant is far more difficult, not least as the future is

[2] EdF (2020, Table 26.9)

unknown. To resolve that difficulty, it is necessary to take some view of a possible future evolution of the electricity sector, of the kind set out in National Grid's *Future Energy Scenarios*. However, that does not completely solve the problem as one needs a counterfactual with and without the proposed plant.

The suggestion is to take the *average* future power sector carbon intensity, but that makes no logical sense, as the generation displaced depends on its operating characteristics (base-load, intermittent, peaking, etc.). It also has the perverse implication that the more successfully the investment in new plant deliver carbon reductions, the less they are valued, effectively penalising that which is desired. The situation is even worse if we assume that the future transition to a zero-carbon future is a binding commitment, for in that case any portfolio of choices of plant to reach that goal will have to release about the same amount of CO_2 over this future (and it is the cumulative carbon budget that is the constraint, not the instantaneous emissions rate). On that basis no plant can claim any CO_2 reduction as if it does not go ahead then some alternative zero-carbon plant will have to replace it.

There would seem to be two alternatives to this absurdity. The first is to set an appropriate trajectory of carbon prices (as HMG already does for its social cost benefit analysis) and then judge infrastructure on whether it is least cost (counting the costs of emissions and any system impacts). The second, less satisfactory alternative, it to take the counterfactual as an evolution without a legal carbon target, possibly also without a carbon price but perhaps with the projected ETS carbon price, much like the SZB example above, and then assess the carbon displaced given a scenario in which fuel choices are guided by fuel prices and plant costs. A defensible short cut would be to assume that the displaced plant would be CCGT, for the following reason. If CCGTs have lower variable costs than coal, coal is likely to be at least partly displaced at the margin, and so CCGTs' emission factor would understate the saving. Conversely if coal runs baseload and CCGTs at mid merit then CCGT output would be displaced except for peak periods, when again higher emission factor plant will be at the margin.

At full operation SZC would generate (at a conservative 84% load factor) 24,577 GWh/yr. and, displacing CCGTs at 0.34 tonnes CO_2/MWh, would offset the construction emissions in just over eight months.

Conclusion

The requirement to assess the carbon impact of infrastructure investment or policies more widely makes sense when their prime aim is not to reduce emissions – for example in the case of road building. There is also a case for looking quite carefully at induced effects, for example when looking at producing bio-fuels, where the land allocated to their source crops will induce land use changes that will have emissions impacts. However, when evaluating low or zero carbon electricity generation, the main factors to take into account are the emissions involved in construction and operation/maintenance and those directly induced by their operation. Thus if intermittent generation requires running part-loaded fossil plant for N-1 and inertia reasons, then the extra emissions resulting from part-loading, and the loss of output from curtailment, need to be factored in. Calculating the emissions displaced, however, is at best fraught, and at worst self-negating. Better instead to properly price carbon and include it in life-cycle costs, as is standard practice in many social cost-benefit calculations.

References

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