Review of Phase 1 report

Whole System Impacts of Electricity Generation Technologies by Frontier Economics

Andy Boston (Energy Research Partnership)
1/9/15

Overall Impressions

The report aims to be comprehensive, is written in clear English and is well structured and formatted. It provides a useful "Integration costs 101" to policy makers. However it is somewhat long and wordy, and a little repetitive at times, certainly exceeding the 30 page constraint by nearly 4 times. However the issues are complex so 25-30 is perhaps an unrealistic expectation by DECC, but 50-60 should've been achievable.

It is somewhat shallow in parts and leaves a lot of work for phase 2. The boundary between the phases is somewhat fuzzy, so this may be exactly as DECC intended but I would've expected a greater exploration of the costs and constraints that will need to find their way into the modelling, and at least an initial sifting of what should be included and what can be safely ignored. Where impacts are mentioned the distinction between costs, constraints and drivers is muddied. The report lacks essential background to the four key services identified by National Grid as needing attention (reserve, frequency response, inertia and reactive power).

Similarly a policy maker reading this would be left with a number of questions about what needs to be done, how best to incentivise flexibility or what has worked well in other electricity markets when faced with the same issues.

Missing

The following should have been included

1. A clear explanation of all the services needed to run an electricity system, commenting on which ones are paid for, which come for free and which are mandated. This would include a view on their likely change in importance going forward. A brief commentary on extra (low priority or plant specific) services would help even if they are dismissed in terms of importance.
2. A clear map of which technologies can provide these services (or create additional demand) with comments on their applicability for that role and whether it can be combined with other roles. It is noted that Table 18 contains some of this information and is a good starting point.
3. The focus on just generation technologies was unhelpful although may not be entirely the choice of the consultants but a steer from DECC. It is important that any modelling (or policy development) treats non-generation

technologies on an equal footing. Storage, interconnectors and DSR are going to play a vital role in reducing integration costs, therefore they should have been included in all technology tables.

4. The explanation of technology characteristics did not include some of the most important dynamic constraints. This will need broadening anyway if storage or DSR are included.

Fitness for Purpose

The report does not really address all the issues in the depth required. It could be made acceptable by including the missing elements highlighted above. In addition a shorter punchier summary is required (the ITT asks for 3-4 pages, there are currently 13). It should summarise the key points that a modeller should take forward, the issues that a policy maker should address and other important issues and principles of general interest that have emerged (in the form of a bulleted list with a very basic explanation of each).

Detailed comments on the text

Executive Summary

Figure 2 (p4) provides a useful breakdown of whole system impacts. However balancing costs are not only driven up by greater uncertainty (as described), but also by the displacement of flexibility service providers by a less flexible incremental technology. Conversely they can be reduced if the incremental technology can provide these services more cost effectively.

Although taken directly from another source many of the values in Table 1 (p6) seem far too high to be credible. A more detailed explanation of the potential misleading values is given in the comments on section 4.3.3 below.

As more renewables are added to the system non-generating assets that provide grid services are likely to become increasingly important, if not dominant in some area. Therefore although DECC only listed pump storage in this category the report authors should've realised the importance of storage in general, as well as Demand Side Response and interconnectors and held them central to the thinking. Section 1.1.4 (p8) claims that the cost framework used is robust for non-generation technologies. Their exclusion means this has not been demonstrated.

Table 2 (p10) does not make clear that Balancing costs are only internalised for large generators, eg the owners of rooftop PV are not subject to imbalance charging (although offtakers are by aggregation with their accounts). Additionally the network costs and losses should mention the opportunity that constraints afford for gaming the system such as through £-999 bids when constrained off.

Introduction

The three bullet points of p15 should also be supplemented by one that points out that some technologies offer ancillary services which can reduce the system cost by replacing more expensive providers. In some cases these technologies deliver no energy to the system (or even consume energy in the case of storage).

Chapter 3, What are Whole System Impacts

Table 4 has fuel infrastructure requirements within scope. However it might be expected that some were out of scope (a new LNG terminal, or uranium enrichment facility) so a clearer distinction should be made.

More generally the report confuses “costs” and “constraints”. The distinction is somewhat subtle because meeting a constraint (like a minimum level of inertia) often leads to a cost (such as an increased fuel burn somewhere on the system) compared to not having a constraint. However they are treated very differently by a modeller and so the distinction should be made here. As well as constraints and costs Table 4 also contains a mixture of inputs (Carbon prices), outputs (electricity prices) and statements (system cycling) and therefore it is unclear what this table demonstrates.

Although technology own costs are not a focus for this report it is important to understand them as the vast majority of grid level costs are actually the sum of plant level costs for the rest of the system. This should be made clear to the reader. The components of these costs (e.g. start up, no load, incremental, fixed, non fuel variable, capital, interest) should be listed and explained. The way these contribute to grid level costs through the need to meet constraints should be made clear. For example increasing wind penetration increases the need for fast reserve (a constraint) which in turn means more plant running part load thus increasing fuel consumption (a cost). Other non generation costs (grid reinforcement , losses etc) should be explained in similar detail.

To understand these issues there needs somewhere to be a good explanation of all the demands and constraints that must be met. The report states that there are over 20 services tendered by National Grid and there are probably others that are essential but not contracted. The list should include for E.g.

- Energy
- Reserve (broken down suitably)
- Frequency Response
- Inertia
- Capacity
- … Black start

For each the importance should be demonstrated and the most important should be recommended as needing to be dealt with in the model. Those that are to be rejected for inclusion in the modelling should be included on the list with the reasons for rejection made clear. The description of each should also help policy makers understand any shortcomings in the way they are currently dealt with including suggestions, perhaps based on international experience, of dealing with them.

4.1

It is not clear what Table 7 in section 4.1.1 is trying to show. For example why is marginal generation cost a technology characteristic but neither capex nor fixed costs are? Why is inertia important but not its ability to provide frequency response? Tables 8-9 are not particularly helpful either, disconnected from explanatory text of how to use them. “Cycling Efficiency” I think is an unhelpful concept as it mixes a number of service provisions (load following, reserve, response).

4.2.2

Table 11 (p54) does not seem to have any purpose. It is not even clear what the data means, it seems to say that as tidal is built it becomes more variable as a proportion of its output. It must also be dependent on a particular build programme. It should be removed or a more careful explanation given of the data it contains and its relevance to whole system impacts.

Table 12 (p57) lists some of the important dynamic constraints for power plant operation. For some plant though the minimum on time and minimum shutdown time can be the most critical. These should be included. The text around the table should explain what is meant by ramp rate – units can have a very different ramp rate when starting up compared to the ability to change load once the unit is thermally stable. Ramping down rates are different again. The amount of positive and negative reserve that can be provided is important. The report should pick the most critical of these to the flexibility of the technology. Perhaps a diagram of a unit operation cycle would help, e.g.

4.3.1

Sinden’s work (2007) on correlation of wind (p61) and demand is somewhat dated now having been done before much data was gathered. It downplays the anticyclone effect where cold still periods produce coincident high demand, low wind periods significantly reducing the capacity credit of wind.

4.3.3

Table 14 (p62) seems to have very high and somewhat misleading estimates of capacity credit. Anticyclone events mean peak demand and low wind are correlated, a fact some authors have not accounted for so 10GW of offshore wind may not mean 3GW of conventional plant can be retired with no consequences for LOLE. For nuclear the large unit size means that 10% penetration can be delivered by just 3 EPRs. There is a very significant probability that one is unavailable so 97% credit would seem inappropriate to maintain the very low target level of LOLE. The report should explain how a convolution of probability distributions from demand side and generation can be used to determine appropriate values, as implied by the first paragraph on p58, not the naïve OECD definition of 1-unplanned outage rate.

In section 4.3.3 (p63) the report uses the term reserve to describe capacity margin – this is potentially confusing for an unfamiliar reader. It is best to only use the term reserve in the context of National Grid's requirement to have in place generation that can provide extra power within minutes or a few hours.

4.3.4

Two ways to value capacity are given on p64. It would be worth exploring a model that was required to meet a minimum capacity constraint (or maximum LOLE), at minimum cost. The shadow price of that constraint should be the marginal cost of capacity, hence the value attributable to any technology reducing that requirement. It would save any manual determination of the marginal capacity provider (which is not always clear), or the cost saving involved. Other constraints could be added (meeting reserve, demand or inertia) to make the model holistic.

4.4.1

The last paragraph on p65 says that intermittent sources exhibit great uncertainty of short-term output than dispatchable technologies. This statement needs qualifying, the certainty that a windfarm will be within 50% of where it was 1 minute ago may be higher than a conventional generator which can fail instantaneously to zero.

Figure 16 shows "The increase in the reserve requirement is expressed as a share of wind capacity." (p66). It should be clarified whether these are annual averages or instantaneous values.

4.4.3

The statement about 1 in 365 chance of being unable to maintain security needs expanding and referencing with a tighter mathematic definition (p68). I presume this means that some level of disruption is acceptable on one day a year, if so the level of disruption need defining - Is brown-out acceptable? How many hours in the day can be disrupted? Can the equivalent hours be spread over a number of days?

Understanding the need for reserve is essential to understanding grid integration costs. Reserve is complex and multifaceted and therefore needs careful explanation. A modeller or policy maker will at least need a basic understanding of generically what reserve is, how it is procured, who are current providers, how it is broken down by timescale and direction, the relationship to frequency response, the relative size and importance of the different markets, etc. The ITT asks "whether we need a more precise consideration of the different types of reserves which provide back-up adequacy, head/foot room, spinning reserve etc."

None of this was really tackled in the required depth. Where it was referred to (eg Figure 20) terms like STOR and ROCOF were used without any preceding explanation of the importance of these or the recent history of changes to these that have affected the market for reserve, response and inertia. There was no confidence given that the authors understood these complexities even if they chose not to describe them, but this is at the heart of understanding the origin of a significant part of the whole system impacts. Where explanations are given they are brief and scattered in different boxes such as those on pages 68 and 72.

4.6.2

There are a number of comments on Table 18 (pp83-84).

- A number of those in the CCS field say that it can be designed to be as flexible as CCGT. In fact the inherent storage within the CCS cycle could enhance certain aspects of its flexibility if designed to do so.
- A key nuclear constraint is distance from population centres/local acceptance, which pretty much limits it to existing sites.
- The "Cooling" location constraint against nuclear needs clarification. All thermal power stations need cooling. This can be provided directly, or via wet or dry towers.
- The correlation of wind with demand is complex – by season it is weakly positive, but in very high demand periods there is some evidence that it is negative (anti-cyclone effect).
- Solar has no real energy storage to contribute to inertia in any meaningful way. It could only be achieved through curtailment and connection to storage.
- Interconnectors have a huge potential to share inertia across systems but are currently not run that way.

5 Summary

Balancing costs are in some cases ignored (inertia) or reduced by enforcing mandatory participation (frequency response). Hence there is not price signal to drive market corrections or support new providers.

5.1

The discussion about the generator with awkwardly shaped output (p87 bottom-p88) misses the point that the end-buyer will be forced towards periods where prices are higher for two reasons: Lower merit plant will be setting the price and there will be a higher premium earned during these periods.

5.4

Table 19 (p92) should perhaps mention the ability of generators within a constrained zone have a much greater (local) market power to set prices, which can be highly negative in times of excess generation. This distortion is not cost reflective.

6.1

Table 22 (p99) should state the basis of these comparisons. For example are the balancing costs at the same level of penetration? If not can they be corrected for that? In some cases the variation is so wild (Wind from 0.04 to 9.43) so as to make the results very questionable. In other cases (Nuclear at 1.49) it looks like there is only one value in the data set giving a false sense of precision. Perhaps interquartile ranges would be more representative?

Figures 24-26 would be better displayed as box and whisker plots, with a slight displacement between the technologies so they do not overlap.

9 Annex 2

The annex should list the part of the business that the experts consulted were from. The report reads as if it were lacking some input from plant operators, traders and modellers from industry. There were no nuclear operators in the stakeholder list. It would've also been useful to involve someone from UCL's (or ETI's) modelling team. The academics' institutions should also be listed.