WHOLE SYSTEM IMPACTS OF ELECTRICITY GENERATION TECHNOLOGIES

Peer review for impartiality

A report for Frontier Economics and the Department of Energy and Climate Change

Dr Robert Gross

Imperial College

Imperial College London

Objective

Frontier Economics have asked for a peer review of a report that they have produced for the Department of Energy and Climate Change (DECC) on the system costs imposed by different types of electricity generation technology. Specifically, Frontier has requested the following:

"As the Whole System Impacts of Electricity Generation Technologies focuses on a wide variety of different technologies, DECC have asked us (Frontier) to undertake an impartiality peer review that scrutinises and assesses whether we have considered all technologies fairly and impartially, whether we have applied the same principles to all technologies and whether we have considered all available evidence from relevant and significant literature. This impartiality review is to ensure that we have provided an impartial and objective picture across all technologies of interest."

In responding to this request I have undertaken a full review of Frontier's report a made a number of detailed comments and observations on the report. This focuses primarily on any sources of bias between technologies. However I have made a few more general observations and these are also summarised below.

Main comments

Opening comments and the coverage of the literature

Frontier has produced a very thorough and well written discussion of the electricity system costs associated with a range of power generation options. The report focuses in particular on comparing the costs imposed by integrating wind and solar technologies with those associated with conventional power generation; gas, coal and nuclear power stations. Much of the literature is focused on delineating the differences between renewable energy and conventional generation, so Frontier's approach is consistent with the wider literature and describes the main issues very clearly.

The report provides a good review of existing literature and describes how the literature was found through a combination of recommended sources and searching various databases. The report is not based upon a systematic review and the search terms or Boolean search combinations used to reveal sources of evidence are not provided. Whilst a good range of studies are used to inform the report it is not possible to determine whether the literature review is exhaustive or whether important sources of evidence have been overlooked. This author is in the process of updating the systematic review he carried out for UKERC in 2006 on the costs and impacts of intermittency, and this update will be based upon a new systematic review. It is hoped that this activity will complement Frontier's report by ensuring as comprehensive as possible a review of the international literature. Frontier has also undertaken stakeholder consultation activities to complement the literature review and the findings from the consultations are used effectively within the report to enhance the discussion. Overall, prima facie it appears that the report makes good use of existing literature. It certainly covers all the main system impacts associated with variable renewables.

Being explicit about the focus of the report – the costs and impacts of integrating renewables

The report seeks to be even handed across technologies and achieves this reasonably well, subject to the detailed observations below. The report provides a sensible categorisation of system costs that tend to be different in particular when renewables are present on the system and discusses how technologies compare in each category. This is a very useful addition/update to the literature on these issues. Nevertheless, in providing in essence a discussion of how renewable generation (principally wind and solar) compares with conventional generation, the report does not strictly discuss system costs per se. Rather, it considers categories of cost (for example, providing capacity adequacy) that are generally discussed in the context of reports that review the cost of integrating renewables. This is because variable renewables such as wind and solar generally cannot provide the same level of system service as conventional generation and costs are imposed upon the wider system in order to maintain capacity adequacy, provide system balancing to cope with unanticipated changes in output and so on.

In some respects therefore the report would be improved if this comparison between renewables and conventional generation were made absolutely explicit at the outset. The danger of not making the need for this comparison, or this difference between variable renewables and conventional technologies, absolutely explicit at the outset is that the report reads as if it is reviewing a set of technology neutral categories of system cost and in so doing 'discovers' that renewables impose higher costs than conventional generation. Yet this is of course inevitable, since the many of the categories of system cost discussed are in most instances discussed in the literature order to elucidate the additional costs associated with integrating variable renewables.

An alternative way to frame the report and help achieve balance across technologies would be to set the scene with a brief discussion (in broad terms) of how whole system costs might differ for a range of decarbonisation scenarios compared to the incumbent system: A system dominated by nuclear power would have to find the means to cope with much more inflexible output and perhaps require transmission system upgrades to allow more nuclear power stations to be built in appropriate locations – usually remote from population centres (and with access to cooling water). System balancing would have to cope with large single in-feed loss. We might be concerned about overall system resilience in the event of a common mode failure, such as the enforced shut-down of all or many of the nuclear stations due a common safety issue. Alternatively, a system decarbonised largely through CCS would require the construction of an entirely new CCS pipeline system. The cost of this could be socialised in some way, and shared with non-power generating CCS on industry, or it could be borne by generators and hence show up in LCOE. Either way, overall system costs would be increased. Finally, we have the situation where the system is decarbonised through a mix of renewables and these impose the sorts of system costs that are the main focus of the report – distribution network costs, possible transmission upgrades, additional system balancing costs, impact on wider system load factors and the need to ensure that there is adequate firm capacity.

A contextualisation of this form would greatly improve the sense of balance that the report conveys and help to set the scene for the detailed discussion of capacity adequacy, system balancing, balance of plant impacts and network costs that follows. The report should certainly pay more attention to the fact that *all* generation options have the potential to impose system costs.

As explained in more detail below it is also important to be clear that the system we have was not designed with renewables in mind. Rather, it was designed in the mid-twentieth century to minimise the overall costs of delivering electricity mainly from large coal stations. Power stations are expensive relative to transmission and subject to economies of scale and locational constraints. The system planners of the day therefore set about minimising overall costs by realising economies of scale in coal and building appropriate transmission. The system was also designed to incorporate nuclear power stations, with their own constraints. Whilst the system has evolved and changed since then it is important to be clear that despite the market environment we have had for 25 years, originally the system was planned on a least cost basis, but to suit the technologies of the day.

As an addendum to this I would also note that the report might pay rather more attention to the fact that because carbon emissions are not in adequately priced the system costs of the incumbent system are understated and the benefits of reducing fuel burn/emissions equally undervalued. It is completely appropriate that environmental externalities are out of scope for the report. However some more commentary around this in the Executive Summary and early in the main report would help to address the inherent bias in favour of conventional fossil generation that the absence of a carbon price imposes on any discussion of the system costs of low carbon options. In discussing the impact of non-fossil generation on wholesale prices I believe it would be worth reiterating in a few places that the wholesale price does not fully reflect the cost of carbon and if it did the value of non-fossil generation would be increased.

Overall therefore, in assessing whether the report *"considered all technologies fairly and impartially"* and *"applied the same principles to all technologies"* – the report treats technologies reasonably fairly. I recommend that the report goes further to make explicit that it is in large part discussing a set of issues that are associated with (and unique to) integrating renewables that have particular characteristics that distinguish them from conventional thermal generation. This does not detract from the quality of the analysis, and it is not a technology bias per se, rather it is an implicit assumption that underpins much of the discussion. Making this more explicit and doing more to explain that system costs differ by technology and are context specific would aid balance.

I also suggest that the report places a little more emphasis on the fact that depending on context, renewables can reduce system costs and thermal stations can add to system cost. In particular the potential for location constraints, large unit size and relative inflexibility to impact the potential system costs of new nuclear could be given more discussion, as could the potential system requirements and constraints on carbon capture and storage (CCS).

History matters – achieving system change requires co-ordination and planning

As mentioned above, another concern is that the report is focused upon costs that arise because of a desire to change the system – away from fossil and towards lower carbon. Yet in considering counterfactual systems that are largely based upon incumbent technologies it is important to remain mindful that *at some point in the past* investments were made in the system we have. Many of the initial investment costs of the gas and power networks made through the last six decades have been written down. It isn't surprising that replacing an old gas fired power station with a new gas fired power station doesn't impose much in the way of new network costs – since the gas and power networks have already been constructed to serve incumbent technologies. In other words, the incumbent system has a sunk-benefit associated with it. Consider for example the high voltage transmission lines that connect existing nuclear power stations. New nuclear power stations are planned or proposed that co-locate with existing nuclear power stations. They are therefore able to take advantage of investment decisions in high voltage transmission infrastructure made several decades ago. This is important because the report notes that nuclear has relatively low network costs associated with it. In reality, compared to distributed generation of whatever form, the transmission costs of new nuclear are rather high. This is important because it helps to inform the discussion the report provides of 'adaptation' (I prefer 're-optimising') the system over time. The transmission system we have was constructed to meet particular historical needs – to allow coal fired power stations to be built close to coal fields or nuclear power stations to be built remote from populations. The needs of a low carbon system infrastructure will be rather different and it would be surprising if new and rather different forms of generation could be plugged into a system designed for old forms of generation without imposing costs.

The report, rightly, discusses the need to ensure that new forms of generation are exposed to the system costs that they impose. However it is also important to ensure that active decisions are taken to incentivise investments that will *create* a low cost, low carbon system for the future. Examples might include enhanced incentives for flexible generation, allowing DNOs to invest in storage or to encourage demand response. Much of this discussion goes beyond the terms of reference for the report. However it is important to note that internalising the system costs imposed by low carbon generators are only part of the story – the other part being to actively plan and incentivise system change to ensure that system costs are minimised in a future low carbon system. Failing to recognise this risks a form of lock-in, a self-fulfilling prophecy where the system costs of many low carbon options remain high, because the system into which they are integrated is not fit for purpose. The report mentions this. However it might be helpful to make it even more explicit that changing the mix and nature of generation technologies *requires* that the system is changed over time - because the current system was designed for an entirely different technology paradigm in a previous era.

Capacity adequacy and wider system resilience

The report discusses capacity credit system margin and LOLE. These are extremely important determinants of system reliability. However the historical evidence suggests that widespread power shortages affecting consumers or industry are seldom an outcome of capacity shortfalls in the form of inadequate system margin, at least in developed countries. Instead, such events have resulted from the following: transmission system failures due to extreme weather or 'cascading' events where sequential tripping of circuits occur; fuel shortages due to international events or industrial action (miners strikes); low rain fall in hydro dominated systems and/or lack of cooling water for river-fed thermal stations due to droughts; common mode faults, notably when a significant number of nuclear power stations have to be shut down due to a common safety concerns. In addition, there is a concern that over reliance on a particular fuel may expose consumers to high levels of price volatility. For this reason there is a literature on power system diversity and resilience that goes beyond the purely technical power sector issues discussed in the report.

I understand that these wider issues are partially out of scope. However I think that the report would be more balanced if there were a box-out perhaps that provided a short discussion or the section on the scope of the report were extended to mention these issues. This is important because it helps to balance the discussion of capacity adequacy and capacity credit across technologies. In very general terms a power system that combines a diversity of sources/fuels/technologies is likely to be more resilient than one that relies very heavily on a single source of energy. Some of this is not captured in purely technical measures of LOLE or plant level capacity credit/availability. For example, whilst it is perfectly true that an individual nuclear power station has a high capacity credit compared to wind there have also been a significant number of historical incidences internationally (most recently in Japan) where significant numbers of nuclear power stations have had to be shut simultaneously, usually for safety reasons, with significant impacts for consumers. This impact is not captured in capacity credit.

There is a purely technical dimension to this as well that could be made more explicit. Maintaining reliable supplies is all about balancing probabilities. The report does not mention for example that measures such as LOLE, LOLP and criteria for assessing system balancing requirements derive from statistical measures and distributions around likely events. In simple terms the capacity credit of wind is not zero because there is a non-zero probability that it will be windy when the system is under stress and a large thermal power station falls over. And a system with lots of small generators will be more resilient than one with a small number of larger generators, all other factors being equal. Some additional discussion around this would aid balance.

Detailed comments

<u>Executive summary comments</u>

P2 Discussion of wider effects. The text refers to macroeconomic effects but Figure 1 refers to environmental externalities. The text should also mention externalities to be consistent. This would also be an opportunity to explicitly state that the benefit of reducing CO2 emissions is not priced properly. Therefore a significant system benefit associated with low carbon technology is not priced and this distorts the relative whole system costs/benefits in favour of fossil fuels. Saying a bit more about this would aid balance.

P3 A longer term perspective. It would be better to refer to system 're-optimisation' here (not 'adaptation'). The system may be redesigned to minimise cost and maximise renewables just as the current system has been constructed to minimise costs using conventional technologies.

P4 Figure 2. Include a mention of carbon as well as fuel.

P5 'Any technology which is added to the power system should lead to generation cost savings'. This is a rather strange statement and a bit misleading. Suppose we are in a world where gas is not available and N/SOx emissions tighten. New (compliant) coal plant could then be more expensive to run than old plant. I think this section needs to be reworded to explain more clearly what is meant.

The central issue here is that adding zero marginal cost generation will tend to lower wholesale prices and push higher marginal cost plant off the system. Of course this only actually happens in the context we are considering because renewables plant is subsidised so this new plant is added because of drivers 'outside the market'. In a purely market environment the expectation would be that a new plant would only be built because it would be profitable, able to generate at lower cost than incumbents or to meet unmet demand (somewhere in the merit order). The discussion of displaced generation is specifically about plants with zero marginal costs impacting wholesale prices and it is slightly confusing as currently worded. I think this is partly because the report is specifically discussing zero marginal cost plant and indeed particularly variable renewables yet the wording seeks to be 'technology neutral'. Yet these are not technology neutral considerations.

P6 table 1. On page 62 you cite National Grid and a range of capacity credit of 81% to 94% for new nuclear. We don't know for sure what the availability of new nuclear will be as none have been built in the UK (or in much of the rest of the OECD) for 21 years. Whilst the capacity credit of new coal and gas can legitimately be single numbers for the rest I think you should cite a range. As the text makes clear, this is context specific for renewables. It is uncertain for new nuclear as we do not yet know how reliable the new plant will be and I would also note that older plant will tend to be less reliable than new plant, even for fossil generation. There is a false certainty in the table.

P6/7 Balancing. I was surprised that this discussion didn't mention N-1 criteria (largest single in-feed loss). When we did the UKERC work back in 2006 it was clear that at that time this dwarfed any additional STOR needed to balance wind at low penetrations. I appreciate that balancing requirements increase as the wind penetration rises however I think that the discussion of balancing in the ES is less thorough than in the main text. Also single in-feed is a balancing issue, not a capacity adequacy issue. This is because if a large plant falls over unexpectedly, rapid provision must be made to compensate in the short term, irrespective of whether demand is high or low.

I would also mention that research into power electronics and possibilities for synthetic inertia may be able overcome the inertia issue. Maybe a trivial point - but aren't some windfarms synchronous?

P7. Network infrastructure and losses

‘constraints for thermal generators are typically lower than for wind and tidal plants for example, though they still exist’. This is an overstatement (certainly for wind). Considerable locational constraints effect nuclear (population density, cooling water) and indeed coal and even gas (rather obviously, you need access to the high pressure gas grid or coal delivery, and you still need cooling water for both).

P9. Who bears the system impacts?

The discussion of internalising system costs is valid and doing so would help minimise system costs. However this is only a partial answer. Ideally, the market and incentives would work in cohort to build an optimised, least cost, low carbon system. This means minimising system costs *and* minimising generation costs. If the system is to be re-optimised (for example more flexible, more DSR, storage, etc.) then it is likely that in addition to ensuring generators bear appropriate system costs then the desirable system attributes will need to be incentivised directly. In some cases it is an open question as to whether the costs of this should be socialised or directly allocated to renewable generators. As discussed above, the system we have was built in a different era and built under centrally planned conditions. The market/regulatory system we have was designed to optimise the use of a system already built (though it also largely accidentally led to the dash for gas). If we accept the objective is to redesign the system to be lower carbon then I think that the question of how to allocate costs and what to attribute to particular players and what to socialise becomes rather more moot. There’s also a set of questions around first mover disadvantage and network externalities. It is legitimate to consider whether some strategic investments that bring multiple benefits are better socialised than attributed solely to particular technologies. In this way the system costs associated with new RE come down over time.

This is a complicated discussion and not appropriate to go into at length here. However I think it would be appropriate to state that there needs to be an appropriate mix of measures to incentivise a re-optimised system that lowers system cost, and of ensuring system costs are fairly allocated to RE.

P10 Table 2

‘least cost dispatch will generally be incentivised… etc.’ this is a very opaque statement that you might want to reword.

Footnote 5. This isn’t a footnote point it is an additional bullet.

P12 Table 3 and associated bullets

As the first bullet notes this table has the potential to be pretty misleading since the fossil fuel plants provide the counterfactual against which RE is judged. It is particularly inaccurate to represent the capacity cost of gas and nuclear as zero (and I do not know why they are not zero for coal), since the whole point of the estimates of the cost of capacity with variable RE is to work out what the cost would be of providing equivalent energy with a form of firm capacity. So zero is in effect definitional – compared to gas the cost of gas is zero. This is circular and spurious. It is less spurious for balancing and network but I don’t see how balancing costs for anything can be zero. The non-zero risk that any plant will fail (or demand prediction be wrong) feeds into the overall calculation of probabilities that lead to the need for STOR and other balancing services. However I completely accept that for an individual thermal plant (unless it is the single largest in-feed) the marginal impact will be very small. Network costs are context specific. Surely for all technologies we'd expect a range? I note the caveat on the table notes but I think the caveat should be stronger, and that some of the zeros (in the capacity column at least) replaced with 'NA'.

Main text comments

Introduction

P16 'Supporting technologies purely on the basis of their LCOE risks the technology mix deviating from that which minimises overall cost…'

At the risk of labouring a point this is of course true but it does fail to capture a really fundamental difficulty – system costs are not static. As you note in the ES, over time the system can be adapted (re-optimised) to incorporate RE at lower costs. There is a danger that if the model simply internalises contemporary system costs and allocates these to RE this will merely dis-incentivise RE and not actively incentivise system change and re-optimisation.

P23 As noted in the comments on the ES it would be worth stressing that until there is an appropriate means to properly price carbon the whole system costs of fossil generation will be understated and benefits of low carbon undervalued.

P26 'These two won't always marry up…' I found this paragraph hard to understand. I am not sure what would make a marginal generator less efficient. Is this a consequence of installing low carbon generation? Perhaps because the utilisation of the marginal plant would be so low that the economics of OCGT would be favoured over CCGT? It would be easier to understand this point if it were reworded.

P27. Figure 5. The figure could suggest to the lay reader that the new technology scenario is always going to be more expensive, yet as you explain in Figure 6 there will be costs and cost savings. You state in the text that 'system impacts could also reduce costs' but it would be better if the figure could capture the fact that 'own costs' and 'system costs' could be positive and negative.

P31 'these adaptation costs'. I am not clear what this means or how these costs could be accounted for.

P32. Figure 7. This figure is sourced to the Nuclear Energy Agency. This is a complicated figure and rather hard to interpret. It shows a remarkable increase in the capacity of OCGT. I'd note that the data are from France and hence show the impact on a system already unusually dominated by nuclear. In addition, one assumes; a system with unusually flat demand that has already been optimised to the characteristics of nuclear power, and extensive export through interconnectors. Therefore the figure may represent a system where adding variable RE has the effect of disproportionately affecting the role of gas/OCGT relative to a system which already copes with wider demand variation and is more diverse.

P33. (LCOE) is 'flawed'. I would prefer 'limited in scope'.

P34. The Hirth and Ueckerdt approach works *in principle* –provided that prices are fully cost reflective. It might be worth pointing out that markets often do not fully price balance/imbalance in this way and that renewables may or may not be receiving some sort of wholesale price discount.

P35. Figure 8. In discussing balancing costs it may also be appropriate to mention that there may be a need to schedule and pay for more system balancing services (STOR) and this imposes an additional cost.

P38. Balancing impacts. 'these efforts are costly' – suggest replacing with 'impose a cost'. This discussion would be better if it started with an explanation that system operators must always make provision for demand prediction errors or the unexpected loss of a generator (including the single largest in-feed). It would help to explain that this is undertaken probabilistically and that the implications of new renewables are assessed by considering their impact on this balance of probabilities. When the penetration of renewables is modest, the impact on this balance of probabilities is also modest and may in fact be marginal compared to the N-1 criteria. However at large penetrations the impacts become much more significant.

P40. Comments about DNOs. DNOs will have a commercial interest in emphasising costs and the need for network reinforcement as this allows them to increase their asset base. This is not to suggest that the concerns are not valid.

P45 '(location constraints) are greatest amongst the renewable technologies'. For the reasons explained above I am not sure that this is entirely correct. There are considerable location constraints on thermal stations, particularly nuclear and possibly CCS. All thermal stations need fuel and cooling water. Offshore wind is obviously location constrained but can be widely distributed around parts of the coast with appropriate seabed. I am not sure how true it is to say that rooftop solar faces location constraints (imposing distribution network impacts is a separate topic).

P46. 'However, as part of this project we want to go further and help develop the understanding of all the generating technologies that DECC considers in its policy making'. This is indeed an important aspiration for the work. However it might be worth being slightly more direct about the fact that because much of the literature focuses on the costs variable renewables impose it is inevitable that much of the discussion in the report also focuses on these costs. This is perfectly legitimate since variable renewables impose costs that thermal stations do not impose (particularly relatively flexible stations that are not remote and are not the largest in-feed).

P48. Footnote. It might also be worth mentioning that other factors such as unit size and diversity of technology/fuel are relevant here.

P 62. Table 14. As noted above, the use of single figures for many technologies is misleading and there should be a range. The figures for thermal plant appear very high and are not consistent with the range cited from National Grid for new nuclear.

Capacity credit does not decline 'over time' it declines with increasing volumes of capacity installed, particularly where there is not much geographical diversity.

P64 Discussion of LOLE target and capacity market. This would be clearer if it explained that the benefit for system margin (meeting peak demand reliably) is not independent of the impact on system balancing (making provision for unpredictable events at all times of the day and year). As worded the paragraph could be read as *conflating* capacity credit and providing for single in-feed loss.

P65 'intermittent renewables…. require larger, more rapid and more costly…' This should be caveated more carefully. This is true at large penetrations, at low penetrations renewables are largely lost in the noise of demand variation. Also, 'larger' balancing actions needs to be considered carefully since the need to manage largest in-feed loss can still have a significant impact on scheduled STOR etc.

P73, 'All technologies face location constraints'. This is an extremely good, clear and balanced statement. It should be made more prominent in this chapter, the ES and in Ch. 3.

P74. For reasons already explained I am dubious about the statement that 'constraints for non-renewable generation are typically lower'. The constraints are different. There may be a better correlation between location constraints and existing infrastructure (particularly for gas stations). However I think this point needs to be made carefully, with considerable nuance and caveats. The best case for conventional generation is clearly better than the worse-case for renewables, but between the extremes there is a lot of overlap and I think it is fair to say that the constraints on new nuclear and CCS are non-trivial, whilst the constraints on some renewables are not substantial.

As noted in the comments above, at some point in this chapter it would add balance to insert a short discussion or box on the wider concept of system resilience. We know that historically widespread power outages are seldom due to capacity adequacy per se, rather they have been caused by industrial action or international politics, common mode faults/safety concerns, network failure or drought. This would allow a discussion of the benefits of diversity that would help to balance the focus on the technical constraints on integrating variable renewables.

P 83. Table 18 (and perhaps elsewhere). In the flexibility column on transmission connected wind the note says 'curtailment only'. This is true but my understanding is that in Spain, the TSO has direct control over some wind farms. This has been used to adjust *ramp rates* of wind farms and smooth variations. This is of course curtailment, but it is interesting to consider that if wind is rising rapidly just as demand is falling then for a modest overall energy penalty in terms of wind output foregone it is possible to control wind output to minimise system costs and reduce the strain on other plants by reducing their ramp rates. This smoothing of outputs through TSO contracts and control is one example of a smarter approach to integrating variable renewables, and therefore worth some discussion.

P96. There is an important discussion here of what the literature focuses on and how this has shaped the report. It would be useful to include some mention of this in the introduction and ES because for the reasons outlined above it would add balance if the report were more explicit about the focus on 'problem' technologies.

P98. This figure and similar figures would be much more informative if a key were provided with the sources from which the various dots were derived. Where there are more dots is this because there is a wider range within studies or because there are more studies of this impact?

P101. There is a conflation in the discussion around nuclear and single in-feed. Wouldn't single in-feed show up in balancing costs? Again, on P103: It is hard to understand how any plant can strictly have zero balancing costs (though a new unit may not have much impact on the aggregate balancing need) and if the plant is the largest in-feed it has to have a balancing impact.

P105. Network. Given earlier discussion in the report that costs can range from negative to highly positive depending on context as much as technology is it worth stating that this category of impact is least appropriate to draw generic conclusions about? More generally it would be extremely helpful to reiterate strongly in the ES and conclusions that a technology might be strongly positive in one context or strongly negative in another. Your Greek/UK comparison on solar is a good example.

Table 25. Because the range largely reflects context rather than uncertainty or difference of approach isn't presenting the mean rather meaningless?

P108. The points made on the range of findings and the reasons for the range are extremely important and it would aid balance to feature this in the ES.

Conclusions – A very good and sensible set of conclusions overall.

This concludes my comments. I would like to reiterate that the report is well written provides a very thorough and detailed review of system integration impacts. Whilst I have made quite a large number of comments, there are a rather smaller number of themes which I return to in a number instances. If it is possible to make a number of relatively modest, but important, modifications to the report then it will provide a technologically balanced review of system impacts and provide a valuable addition to the literature.

Robert Gross

16 August 2015.