SUBMISSISSION TO THE HOUSE OF LORDS

by

SCIENTIFIC ALLIANCE

RESILIENCE OF ELECTRICITY INFRASTRUCTURE

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1. INTRODUCTION

The severity of the problems facing electricity supply in the coming years cannot be examined without reference to the pattern of electricity demand as well as the quantities and types of the different types of generating plant connected to the system. Therefore we consider it important to first assess the probable characteristics of the system in the relevant years.
Government targets for reducing CO2 emissions from the electricity system require that some 35% of electrical energy be generated from renewable sources by the year 2020. Some of this will be from other renewable sources, but the majority will be from wind.
However, there is a strong possibility that these targets will not be achieved in their entirety and we think it will be helpful to examine the Committee's questions against the background of the most likely out-turns. National Grid, in their studies of future energy scenarios, examine four different balances and compositions of load and generation, dependent on factors such as economic growth, progress with renewables and energy savings as well as the adoption of new types of load such as electric cars, heat pumps etc. However, they do not ascribe probabilities to any of these scenarios so we have taken the simple average of the four to arrive at a scenario for the purpose of this submission. For comparison also shown in the table (see Appendix) are the comparable figures if Government targets for 2020 were fully met as also are the figures for year 2015/16 in view of the expected critical risk to electricity supplies in that year. The government target for installed wind capacity in 2020 is around 30GW.

COMMENTS ON EXISTING AND EMERGING TECHNOLOGIES
(PARAGRAPH 9 OF CALL FOR EVIDENCE)

1. Electricity Storage - The benefits of an efficient and economic system of electricity storage, especially one that could be sited near to load centres, has long been recognized, especially for meeting peak demands in densely built up urban areas such as Downtown Manhattan. Trials have been made using storage batteries for this purpose but these have not so far proved economic, and in any case are unlikely to be adopted on a wide enough scale to have a significant effect on the electricity system as a whole. Compressed air storage has also been considered and would be capable of storing significant quantities of energy but, for reasons of fundamental thermodynamics, the efficiency of this will always be low, probably less than 50%, making its widespread application extremely unlikely. Pumped storage, using reversible pump/turbines first pioneered at Cruachan, has proved attractive and, at approaching 80%, is reasonably efficient, but because of the demanding site requirements (high head and suitable locations for large upper and lower reservoirs) cannot be expected to make more than a limited contribution.

2. Interconnection with Overseas Networks - While interconnection to neighbouring networks may sometimes allow the import of power in emergency conditions, it would seem unwise to place any reliance on this to meet system maximum demands, unless it were backed by firm contracts with consequential loss provisions. While this is we understand the case for mainland UK exports to Northern Ireland, this is for relatively small quantities of power and was agreed by Scottish Power when it had surplus output. It is difficult to envisage circumstances when an overseas generator other than a hydro utility or one with unique access to sources of cheap energy would construct plant for this purpose. In the light of this we would see Norway and possibly Iceland as the only possible sources, although the costs of transmission and the reliability of supply would be significant factors.

3. While it is sometimes claimed by proponents of renewable generation that widespread interconnection of electricity systems across Europe will effectively guarantee firm output from intermittent sources of generation, this is not supported by detailed analysis. In fact, as a forthcoming paper by Dr Capell Aris shows, the frequency of large anticyclonic weather systems covering the whole of Europe are such that low wind outputs in the UK are frequently coincident with similar low outputs throughout Europe, so that even large scale interconnection would make a minimal contribution to security of supply. We note that National Grid in their Ten Year Statement do not take credit for continental interconnections for meeting system maximum demand.

4. Management of Demand - The costs to commercial and industrial firms of an interruption of supply and the consequent cessation of their activities is with few exceptions far in excess of any savings made from the lower prices for an interruptible supply. The exceptions to this are generally heavy user process plants such as some chemical plants with moderate labour costs and the ability to store their product, but we would expect that nearly all of these which can accommodate an interruptible supply already do so. In the domestic market dual-rate tariffs to encourage consumers to move load to off-peak times (storage heaters, washing machines etc) were widely used, but with electric storage heating now in decline and with noise transmission in modern housing these are not expected to result in a significant degree of demand management, as a result of the wider deployment of smart meters.

5. There remains the possibility that developments in types of electrical load, such as charging for electric cars or widespread adoption of heat pumps for heating, would be more amenable to management of demand. However we would expect that if electric cars become a significant load, the supply companies would introduce appropriate tariffs making it more economic to recharge them during night-time or low load periods and we would be surprised if National Grid have not already taken that into account in their scenarios. Equally with escalating electricity costs and the continued availability of reasonably priced gas it is difficult to see a major shift in heating systems from gas to electric heat pumps – added to which there is the fundamental limitation of heat pumps to supply heat at economic costs at the higher temperatures required for existing radiator systems. We would expect that heat pumps will find a market in new build using low temperature under floor heating systems rather than in conversion of existing properties, where the absence of heat storage in the structure would mean that heat pumps could not be switched off at times of maximum demands.

6. More Flexible Nuclear Technology - Nuclear generation in the UK has traditionally been used only for base load provision. However, this is not because of any inherent limitation of the technology, but more an optimisation of the costs of generation. In France, the high proportion of nuclear generation on their grid system has required a flexible response to demand changes in order to contribute to system stability. Nevertheless some existing nuclear plants in the UK can provide some flexibility, being able to reduce load by a limited amount over a prescribed period. Five out of eight UK stations already offer this for grid system faults during grid outages and one can also provide automatic frequency response as a contribution to grid stability.

7. Developments in new nuclear reactors will include greater flexibility to respond to demand changes and to contribute to grid system stability, although it should be recognised that because of the low marginal cost of nuclear this will be a costly exercise compared with using fossil fuel generators in this role and is likely to be a last resort in the face of increasing penetration of wind and solar generation. The flexibility and grid stability contribution from nuclear generators will depend to some extent on design choice but there is no reason to limit the amount of new nuclear generation on this account.

8. Carbon Capture - This is still an unproven technology: severe doubts exist whether it will make a significant contribution to the system as whole, not least because of the high costs and reduction in efficiency of the generating plant (of the order of 25%). Because of the escalating costs of electricity to the consumer and the implications of high energy costs for the economy it will become increasingly important to concentrate on technologies which have good prospects of delivering supplies at lowest possible costs. For these reasons it would seem unwise at this stage to place any great reliance on this technology making a significant contribution.

9. Flexible Hydro Generation - Conventional Hydro is certainly able to respond to system demands in times varying from a minute or so to several minutes. However the total capacity of hydro generation connected to the grid system is some 1400 MW and the available potential is virtually all already developed. There remains perhaps some 200 MW in very small run of river installations (or with limited storage) and which would be connected to the distribution networks. These are presently being developed because of the attractions of the ROC system of subsidies, but at significant cost to the consumer. Because of the lack of seasonal water storage, only a small proportion of these can be expected to make a reliable contribution to meeting peak demands.

10. Increasing the Diversity of the Renewables Portfolio - We are not aware of possible renewable sources which meet the twin objectives of affordability and reliability. It is sometimes suggested that the widespread adoption of marine energy (tidal flows and wave) would reduce the problems of intermittency from wind power but this effect, if it exists at all, is not seen as significant. It should be remembered that wave energy is also a function of wind and that, as winds fall, low wave energy follows with only a small time delay. Tidal flows, while largely independent of wind, experience four periods of low output per day even at springs and will generally have rather low outputs at neaps with generation unrelated to times of maximum demand. Therefore, far from ameliorating the problems of intermittency, they will add to them.

11. As we shall show later in this submission the most severe problems in the resilience or reliability of the electricity supply system stem from the large amounts of intermittent and non despatchable renewables already being connected to the system under the ROC and Capacity Credit regimes.

SHORT TERM (to 2020)

12. Under the Electricity Acts the supply authorities (CEGB, SSEB and the Hydroboard) had an obligation to supply, and to meet this obligation provided a generating capacity margin above winter MD of some 20-24% with a higher figure for seven years ahead of 28%. This was equivalent to a loss of load probability of four winters in 100 years. In order to fulfil this obligation at the lowest practicable costs to the consumer, the Boards carried out regular ‘whole system cost’ studies of a wide range of strategies to determine the most attractive option.

13. At privatization, the responsibility for providing adequate supplies was left to the market with neither the generators nor Ofgem being required to take positive action to meet any shortcomings. National Grid’s responsibility is limited to making the best use of plant offered to it to meet demands. Likewise the use of whole system cost studies was abandoned, with DECC, amongst others, resorting to quoting the less meaningful ‘discounted energy costs’ for specific types of generating plant. This approach ignored the well-known interaction of different types of generating plant on an integrated electricity supply system and failed to distinguish between the requirements and costs of meeting system maximum demands as distinct from energy requirements.

14. Later, in the year 2000, the NETA trading arrangements were introduced in an attempt to prevent generators gaining the market by manipulating the availability of generating capacity and receiving high payments from the Pool for offered capacity. NETA allowed generators to supply their contracted loads directly instead of selling into a national pool. The appropriate pattern of demand for domestic and commercial consumers was not metered but was based on assumed shapes of load curves for the average consumer. More recently, under the Electricity Reform Act, DECC have assumed some responsibility for meeting future system maximum demands and costs to consumers by the introduction of Capacity Auctions for different types of new generating plant. The basis on which these auctions are decided is not clear, as DECC have made no mention of whole system studies or costs to consumers.

15. We hope that this potted history of relevant factors in the UK electricity Supply System over recent years will be helpful and assist in putting our answers below to the Committee’s specific questions in a more meaningful context.

16. Ofgem has recently made the point that the plant margin for winter 2015/16 is at an all-time low of some 2% after using reliefs of load management. Expressed in these terms this may not sound too alarming but in practical effect it could mean that load shedding would be required for two hours over the periods of peak demand for more than a month for several years in succession before the situation can be remedied. This is far below the standard to which we have been accustomed and it would be surprising if it did not have political implications. It has been reported that National Grid are taking emergency measures to increase these margins by contracting with owners of small private standby generators for emergency supplies. It is not known to what extent this will be helpful, but the costs per KWhr are likely to be high.

17. As the figures in the Appendix show, based on an average of the National Grid’s four scenarios, the supply position in 2020, at only 18% margin as compared with a target of 28%, is still likely to be critical. This is largely a consequence of the withdrawal of some 8 GW of conventional generating capacity between 2013 and 2015, which is not compensated in terms of firm capacity by the increase in renewables, principally wind. Another way of looking at this situation using probability theory results in a requirement for an additional 15,500 MW of gas turbine capacity to be commissioned by 2020 to achieve a risk level of 8% (as in the 2013/14 winter), equivalent to a failure of supply in eight years in one hundred. It should be remembered that these margins are against the background of no growth in demand and, even so, are likely to result in extended periods of loss of supply over periods of high winter demand.

18. In view of the short time scale it seems unlikely that significant capacity of new conventional generation could be constructed and commissioned in time to improve the supply position by 2020 so that the most effective course would be to defer the withdrawal of some existing capacity, as presently planned. Further measures would be to encourage the installation of some open cycle gas turbine generating capacity and increase, where practicable, incentives for more widespread load management for consumers with large commercial and industrial loads. Both of these measures are likely to prove costly for the consumer.

19. We have thought it would be useful to the Committee if we also assessed the costs of the present policy concentrating on renewables with those of an equivalent investment programme with conventional generation. In both programmes we have kept the nuclear and conventional capacities the same as in the average of the four National Grid FES scenarios and in order to make the programmes comparable, have varied the amounts of new gas turbine capacity installed to achieve an 8% risk. This means the renewables programme would require an additional 15,500 MW of gas turbine generation above the average FES figures as against 19,300MW for the conventional alternative. We estimate the additional cost in 2020 with the renewable programme would amount to some £12.3 billion, equivalent to £165 or 25% on the average domestic consumer's bill. Commercial and industrial consumers each face similar costs, but in their case augmented by the higher VAT rate, and these too will eventually fall to the domestic householder in the higher costs of goods and services. To all these have to be added the costs of carbon taxes which, based on the prices in the 2014 budget, would add a further £50 to the average domestic consumer's bill by 2020. Adding these various elements of the energy programme results in the astonishing increase of some 90% by 2020, expressed as a proportion of the average household electricity bill.

20. There is no effective means of evaluating the costs and benefits of alternative investment and planning strategies other than carrying out 'whole system cost' studies. If DECC are now to assume responsibility for deciding planning strategy in the electricity industry (as would seem to be the case under the Capacity Auction Scheme) we consider it vital that such studies should be carried out as a matter of urgency and the results made generally available. It is our understanding that Government's intention is to invite tenders for new plant without first carrying out such studies. If so they can have really no idea of the different types and quantities of generating plant required in the consumers' interest **and this in our view would be a clear dereliction of their responsibilities.**

21. We believe that the next few years could be crucial in bringing home to Government the limitations of present policies, entailing as they do an over-concentration on renewable and intermittent sources of generation. **To date there has been little or no recognition of the fact that electricity is of value only if it is available as and when required and that generation at other times has no value and is in fact an embarrassment.** In short, the concentration on energy and the failure of the various market mechanisms to recognize the equal importance of capacity (the ability to meet demand at all times) results from lack of appreciation of the implications of the fact that unlike other commodities, electricity cannot be stored, or at least not in quantities sufficient to allow normal market mechanisms to apply. It is because of this failure that DECC, under their 'Electricity Reform Proposals' have decided to enter the market by inviting proposals for new generating capacity. Whether or not this will prove effective in attracting bids to provide the required types and quantities of new generating capacity is too early to say, but it clearly represents an unprecedented executive role for Government (even compared with that of the nationalised industry) rather than the regulatory function which is usually seen as appropriate in relation to private industry.

22. Whether or not Government is equipped to fulfil this role, there must be concern that, when inviting bids for new plant, they appear to be in a weak negotiating position. This became apparent in the contract negotiations for new nuclear capacity at Hinckley. While the price agreed was similar to the published expected out-turn cost for the first plant being built at Flamanville in France, we would have expected a significant reduction for a second plant of virtually the same design provided from essentially the same supply chain. Certainly these costs are high compared with those published by the USA Energy Administration for equivalent nuclear capacity now under construction there.

23. In particular the next few years should provide firmer information in areas such as:-

i. The high costs to consumers of present policies concentrating on renewables. This is a consequence of the ROC subsidies, the high costs of transmitting wind output from remote locations to the load centres in the SE, as well as the costs of running back-up plant at lower efficiencies at part load.

ii. The effectiveness of present policies in terms of reducing CO2 emissions. Studies of actual system performance for the Republic of Ireland and in the Western US indicate that the savings in CO2 emissions for the system as a whole are significantly less than would be assumed from a simple substitution of wind for thermal energy, principally due to the less efficient performance of back up thermal generation which has to be run at part load. In fact these studies indicate that, with coal plant as back up, there are no savings, and CO2 emissions can even be increased in some circumstances. No detailed information has been made available of UK system operations to allow a proper assessment of this.

iii. The extent to which renewable generation will need to be constrained off the system with high compensatory payments which will be charged to consumers bills. Taking the Appendix for year 2020 there would be some 21,239 MW of wind as well as 6,600 MW of solar installed. National Grid estimate this will require some 7,000 MW of short term response to compensate for rapid variations in renewables output in addition to the 5,000 MW required for system regulation and sudden loss of the largest infeed. Because of the need to run fossil fuelled plant at part load to provide this response, there will simply be insufficient demand to absorb the wind output even at moderate wind levels, so necessitating that wind output will need to be constrained off the system and requiring high compensatory payments to the generators. National Grid has estimated that it will be necessary to constrain off wind generators in some 40 days by 2020. In fact because of the need to run back up generating plant and the implications of constraining off wind, the Government's target of meeting 35% of electricity requirements from renewables would seem to be a practical impossibility.

iv. The ability of the system to maintain its integrity following an electrical fault is a function of the inertia of the generating plant. For this purpose it is usual practice to increase the inertia of generators, such as hydro, which are remote from the load centres. However wind generators, being non-synchronous, do not add inertia to the system and are therefore more likely to lead to loss of supply following a fault. We think it probable that this was a contributory factor in the widespread and extended loss of supply in the Highland Region earlier this year. Furthermore AC systems naturally increase the forces holding the system together following a fault whereas DC connections, which are increasingly being employed to transport wind power from the North of Scotland to load centres in the south of England, have no such ability. These factors will set a limit to the amounts of conventional generation which can be displaced at any time by intermittent generation if serious degradation in the reliability of supply is to be avoided.

v. As the preferred option of additional nuclear capacity will be insufficient to meet requirements until later in the 2020's, it will be necessary to meet the shortfall in thermal generating capacity by concentrating on CCGTs, possibly with the addition of some OCGTs. While the availability of piped gas supplies is likely to be augmented with imports of liquefied gas, its distribution to new generating stations will make heavy demands on the gas network. This will need to be assessed and planned accordingly.

MEDIUM TERM (to 2030)

24. The resilience and reliability of the electricity system will be placed under ever greater strain with the installation of large amounts of intermittent generating capacity – some three times the present capacity by 2030 in the median scenario in the Appendix. We estimate the additional costs of meeting the demand of this scenario compared with a mix of new nuclear and CCGTs would be some £26bn pa**, equivalent to a 53% increase in the average domestic consumer's bill**. This is before adding the costs to commerce and industry (which eventually fall to the householder), or the costs of carbon taxes.

25. If present policies are continued we see no escape from the increasingly severe and costly implications for operating the system together with a reduction in reliability of supplies even more severe than is now being reported from Germany because of the very large installed capacity of intermittent generators there. We see no relief from this in terms of local generation; the economies of scale are nowhere greater than in electricity supply and it was to achieve these that the CEB was introduced in the 1920's, to secure the benefits of an integrated system with large central power stations. In fact, because of the 1939-45 war, it was not until the late 1960's that the UK was able to substitute large central stations producing at low costs for the uneconomic smaller municipality- built electricity stations.

26. Our comments on modelling, or rather the lack of it in relation to whole system studies under the present market arrangements, are set out in the preceding section. This constitutes a serious weakness which should be addressed as a matter of urgency.

27. We argue that present policies cannot deliver the three objectives of reliability, decarbonisation and affordability. Already the number of households in fuel poverty is not acceptable in a modern advanced society. The appropriate policies cannot be developed simply as a result of political debate; there is an overwhelming case for more **comprehensive engineering-led studies** on how to achieve the best balance between these conflicting objectives. It is only once this information is available that there can be a meaningful political debate to decide what is acceptable and practicable and to what extent the objectives need to be modified.

28. It seems likely that the outcome of such studies would be a greater emphasis on new nuclear (to the extent that it is practicable in this relatively short time scale) augmented by CCGTs, with some reduction in the emphasis on renewables. The most effective 'game changer' in this timescale is likely to be a thoroughly worked out and engineering-led nuclear strategy– for example just how many different types of nuclear reactors should the UK be considering in what is a relatively small economy, and should we be taking steps to re-establish a home-grown nuclear capability which was lost under an earlier Government when it sold off the then British-owned Westinghouse Nuclear to Japan.

29. At the present time UK industry is not in a position to take a lead in these developments and it would need far-sighted and determined Government intervention to re-establish a UK industry. In this context, it should be appreciated that nuclear, as the most economic and secure source of electrical energy, is expected to be increasingly important as fossil fuels become more costly and subject to political uncertainty. While UK governments seem prepared to spend large sums on blue sky science such as nuclear fusion, they seem unaware of other possibilities which are much closer to commercial application and which would truly be game-changing. One such promising development would be the development of the thorium-fuelled nuclear reactor and possibly also the thermodynamic cycle using CO_2 instead of steam.

30. The present structure of, and modus operandi of, the electricity industry in the UK is unique in world terms, and the number of major changes which have been introduced since privatization in the 1990's (and which are still continuing with the recent Electricity Reform Act) confirm that it has not been without its problems. The more usual pattern is for the electricity generators to be charged with total responsibility for supply in a defined area, with investment and tariffs subject to regulatory approval. Such a structure is quite compatible with competition to supply large industrial or commercial loads outside the concession area. In such a structure, responsibility is clearly defined, with no requirement for outside executive involvement. Nor is there any indication that this leads to a less satisfactory outcome for the consumer; indeed it was the pattern under which the two Scottish generators operated for the first two years under privatisation. There would clearly be difficulties for Government in introducing such a major restructuring at this stage, but it seems likely that something of this sort could yet prove more satisfactory than the present system with its high costs and periodic major overhauls in an attempt to address the continuing difficulties as they emerge**. In our view, the Electricity Reform Act, with its confusion of responsibilities and its weakening of financial disciplines, is unlikely to be successful in achieving satisfactory outcomes for the consumer.**

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APPENDIX

Installed capacity [MW]				**De-rating Factors**	**De-rated Values [MW]**		
	2015/16	**2020/21**	**2030/31**		**2015/16**	**2020/21**	**2030/31**
Nuclear	8,981	8,981	8,189	1.000	8,981	8,981	8,189
Coal	16,238	8,667	1,691	1.000	16,238	8,667	1,691
Gas	29,320	34,117	34,526	1.000	29,320	34,117	34,526
CHP	4,198	4,880	5,282	1.000	4,198	4,880	5,282
CCS	0	0	4,063	1.000	0	0	4,063
Interconnectors	4,000	5,500	8,650	0.000	0	0	0
Onshore Wind	7,903	12,537	16,185	0.096	759	1,204	1,554
Offshore Wind	5,041	8,703	21,378	0.096	484	835	2,052
Solar	4,129	6,624	12,630	0.050	206	331	632
Biomass	2,124	3,193	3,420	0.700	1,487	2,235	2,394
Hydro	1,672	1,857	2,452	1.000	1,672	1,857	2,452
Other Renewables	1,349	1,559	2,832	0.050	67	78	142
Other	3,572	3,499	4,095	0.700	2,500	2,449	2,867
Generation Equivalent thermal installed	88,529	100,115	125,392		65,913	65,635	65,843
ACS Peak Demand	60,741	60,091	60,335	0.925	56,185	55,584	55,810

Conventional Gen.		62,309		60,143		57,845	
Renewable Gen.	22,219	34,472	58,897	Plant Margin %	**17**	**18**	**18**
Demand Side Management	1,500	2,700	2,525	Standard	**24**	**28**	**28**