A European Supergrid

Evidence to the Energy and Climate Change Committee

31 March 2011

IET Ref: (S)896

This evidence has been prepared by The Institution of Engineering and Technology (IET) who will be pleased to provide further information on request.

In addition the following bodies have signed up to this evidence under the banner of Engineering the Future: The Royal Academy of Engineering, The Institution of Mechanical Engineers, and The Institution of Chemical Engineers.

Submitted by:

Paul Davies
Head of Policy
The Institution of Engineering and Technology
Michael Faraday House
Six Hills Way
Stevenage, SG1 2AY

Email pdavies@theiet.org
Telephone: 01438 76 56 87

A European Supergrid

Evidence to the Energy and Climate Change Committee

Evidence from the Institution of Engineering and Technology (IET) supported by The Royal Academy of Engineering (RAEng), The Institution of Mechanical Engineers, and the Institution of Chemical Engineers.

31 March 2011

Executive Summary

1. A European Supergrid is a fascinating concept that in the long term could provide some very interesting options for UK electricity, particularly in managing intermittent renewables.

2. The term "European Supergrid" is used rather loosely at the moment to describe a range of interconnection concepts, including:

- a North Sea supergrid, principally connecting countries with North Sea coasts and potentially large amounts of offshore generation;
- a North-South supergrid bringing power from North Africa into Europe;
- an East-West supergrid crossing several time zones and thus allowing advantage to be taken to different timings of demand peaks as well as uncorrelated renewables;
- various combinations of the above.

3. Each of these would have rather difference costs and benefits, could be scaled at different levels and could make different levels of use of existing infrastructure.

4. Technically a super-grid would be challenging on account of its large size but would not particularly stretch the knowledge we have today. However its deployment in a complex multi-jurisdictional environment, with massive construction of transmission infrastructure in countries each with their own challenges in planning, would be very challenging[1].

5. We would suggest that it is currently not possible to predict by what date a useful supergrid could be made sufficiently complete to provide large scale benefit to the UK, and the IET would therefore caution against placing too much reliance on its being available when planning UK policy.

6. However, we do need to start somewhere and these uncertainties should not be a reason for holding back on preparatory work, which the UK should fully support. As we move forward to decarbonise the UK and wider Europe's energy systems the challenge of greater interconnection will in time need to be addressed. The potential benefits may be substantial.

[1] Although it should be noted that large scale power transfers across mainland Europe using legacy networks are undertaken routinely

7. The IET would strongly support continuing scoping and other studies to allow functionality, costs and benefits to be quantified. Alongside this, the institutional, legal and other barriers should be explored. Deployment would then need to be planned, financed and delivered. Once deployment was well underway, and greater understanding of the challenges of delivery had been gained, the UK may be able to take a view on planning for the use of a Supergrid as a part of future energy policy.

8. In providing this response, we have addressed the potential for very much greater interconnection across Europe. We have not included in this evidence the smaller (but still substantial and important) issue of providing the best means to connect UK offshore wind generation to the UK power system. There are more integrated alternative possibilities than the point to point connections envisaged under the OFTO regime. Should the Committee wish to explore this issue further, we would be pleased to provide further evidence.

9. Our detailed comments below are necessarily generic, and it may be that the various concepts have radically different economics. Much more analysis of need, technical solutions, costs and risks is needed to understand these issues fully to inform decision making.

10. Our responses to questions 1, 2, 3, 4,5, 6 and 9 follow.

Question 1: What are the technical challenges for the development of a European Supergrid?

11. We assume here that a European supergrid would be a multi GW meshed electrical network connecting the power systems in numerous European countries. The technical challenges for such a European supergrid are significant but are not at all insuperable.

12. In conceptualising the supergrid, key early decisions would need to be taken about its architecture and the extent, if any, that conventional AC transmission would be used rather than high voltage direct current (HVDC). HVDC transmission would be needed for any links crossing significant bodies of water (such as the English Channel or the North Sea), and may be desirable for economic or aesthetic reasons for large overland power transfers.

13. AC transmission is a highly mature technology, but HVDC networks (as distinct from point to point connections using HVDC) are as yet an immature technology. If the supergrid were to be substantially HVDC then the principal technical challenges would be:

a) At present HVDC networks would have to be designed without the use of DC circuit breakers at high voltages as they are not yet available. If the international industry were to develop them there would be significant cost savings and operational benefits.

b) To date, almost all successful HVDC schemes have been point to point connections, meaning that control practice for a meshed DC network is not yet established and would need to evolve.

c) There are limited suppliers of HVDC technology who would be able to overcome these challenges, leaving limited choice in the equipment market place.

d) Supply chains are not sized for this major expansion of HVDC technology and would take time to catch up, meaning that deployment would take some time.

e) Planning consent for converter stations, DC overhead lines and submarine cable landfalls would take time to obtain.

14. These issues have been looked at in some detail as part of the ongoing discussions in the UK regarding the best ways to connect offshore wind generation. We believe the

“missing” technologies can be developed by the industry provided there is perceived demand for them.

15. If the supergrid were to be substantially AC, the principal technical challenges would be:

a) The probable introduction of a higher voltage than the 500 kV maximum common across Europe currently. This should not be a major issue as 765 kV is in use in various parts of the world, and 1000 kV is under development in China. Higher voltages allow higher power transfers.

b) Care would need to be taken to develop and manage the network to avoid stability risks and cascade failure risks across Europe. HVDC tends to avoid this issue by avoiding synchronous connection of multiple power systems and thus effectively creating “firewalls” between national systems. This issue should be manageable but will require careful attention to system operation and governance.

c) AC overhead lines are generally more visually intrusive than DC overhead lines, which may create additional planning consent issues. Other planning consent issues would be similar to DC, though fewer building structures at substation sites would be required.

16. The more important challenge in relation to technology is to ensure that the necessary research and development takes place in a timely fashion. This requires timely signals to manufacturers to ensure they commence investment in technology and in the scaling up of the supply chain to be able to deliver at the right time. There will also be a need to drive standardisation as an important contributor to timely and efficient delivery.

Question 2: What risks and uncertainties would a supergrid entail?

17. The main risks and uncertainties are:

a) during the creation of an EU Supergrid, uncertainty as to when it could be brought to full fruition, given the range of jurisdictions involved and the consequent complexities of consenting and funding;

b) resilience during operation;

c) geo-political risks during operation;

d) uncertainty as to whether market rules and systems will be sufficient to allow a truly transparent process of sale across multiple boundaries at times of energy shortage in Europe.

<u>During creation of a EU Supergrid</u>

18. The main risk in bringing a European supergrid to full fruition is ensuring timely completion given the range of jurisdictions involved and the consequent complexities of consenting and funding. Persuading countries with nothing much to gain from a grid to accept the infrastructure through their territory would be challenging. It would therefore be unwise to rely on the supergrid to deliver significant amounts of energy to or from the UK until its deployment was quite well advanced. We would caution against it being used as a convenient assumption in policy making when considering the long term requirements for generation, for example.

19. The legal challenges involved in creating a cross-jurisdictional network should not be underestimated, particularly for those portions of it that might be developed offshore. There are significant differences in the ways EU member states apply laws relating to electricity in their coastal waters, and their legal frameworks are at different stages of development.

20. Another legal/regulatory issue is that the EU is currently organised into various regional electricity markets already (for example the GB market and the All-Island market in Ireland), and the commercial drivers (and legal frameworks) for creating increased linkage between these markets are very specific to the local context. There is also an economic fact that, if interconnectors between markets are financed privately, a large element of their market value consists in being a trading path for generators in a market area with low prices to sell electricity into a more expensive area. As more and more connection is built between markets these price differentials tend to zero, so the commercial incentive to build incremental capacity decreases. This challenges some of the market and financial models in place today, and might require different approaches to remuneration for owners of network assets.

21. The time taken to gain consents for new transmission lines is significant and projects can be subject to significant local opposition. The same is true however for potential alternatives, such as building more conventional generation plant.

<u>Resilience and technical risks</u>

22. The design criteria for the supergrid would need to include adequate redundancy against maintenance and breakdown downtime of individual components to ensure resilience was adequate.

23. Elements of the supergrid would be potential targets for terrorism, and appropriate measures would need to be taken to guard against this, which might include both redundancy in design and also physical protection at key node points.

<u>Geo-political risks</u>

24. Once operational, a supergrid would carry a number of political risks to UK electricity supply, including the possibility of switching off supply from source countries, such as those in North Africa, for political reasons, and sharing power amongst European states in time of shortage.

<u>Market uncertainties and risks</u>

25. Once operational, the supergrid would need to be governed by clear trading rules such that there could be no question of transit countries acting in their national interests in circumstances where power was short.

26. Existing markets have a number of mismatches in their operating rules which act as a barrier to otherwise rational trades across borders. These are being addressed in part by legislative change at EU level but there are various changes to market rules and systems required to allow a truly transparent process of sale across multiple boundaries.

Question 3: How much would it cost to create a supergrid and who would pay for it?

27. This question can only be answered meaningfully after defining the extent, capacity and boundaries of a supergrid, which would then be the starting point for a cost study. To make a major long term difference to moving renewable energy across Europe, power transfers might be greater than 100-200 GW – which is 50 to 100 times the capacity of the current England-France link. However, other concepts for a European supergrid are rather more modest, seeking instead the more limited objective of flexing output from offshore generation to countries best able to accept the output. The difference in costs between these two could be a factor of 10 or more, illustrating the uncertainties involved.

28. Costs for individual transmission connections can be calculated but this does tend to depend very much on individual circumstances. The cost varies greatly depending on whether links are sub-sea, over mountains, through densely populated areas etc. The

costing of conventional AC transmission is well understood and various projects are underway to build better knowledge of capital costs for HVDC projects. We can point the Committee to this work on request, but this only addresses the cost of individual connections that might form part of a supergrid rather than a complete supergrid.

29. One option to reduce costs and increase the chances of gaining planning consents would be to convert existing AC line routes across Europe to HVDC operation, which would substantially increase their transfer capacity. Extensive technical studies would be needed to determine the feasibility of such an option, which could of course also have an impact on the networks of which these lines are currently a part.

30. To deploy a supergrid of sufficient capacity across Europe to make a significant difference to managing the intermittency of renewables is likely to cost in the tens of £billion at 2011 prices.

31. The question of who would pay for it will be highly influenced by the existing mechanisms for remuneration of transmission networks in different member states. There are significant differences in approach (for example, in the UK currently generators pay a charge for use of the transmission network; in some member states they do not).

32. In addition, most major renewable energy projects are financed by subsidies such as feed-in tariffs or Renewables Obligation Certificates. As subsidies are not generally transferable between member states, as all have their own systems and targets, this means that a generator in one country will be subsidised by the customers of that country, regardless of where the energy is finally used. This has potential to unfairly penalise customers in small states with high amounts of renewable generation. Legal mechanisms exist at EU level for member states to trade surplus renewable energy but they are not fully defined beyond 2020. Further work is required in this area to come up with a workable approach to subsidies which recognise different countries' individual targets whilst creating capability to move subsidy funds transparently around the EU as a whole.

Question 4: Will a supergrid help to balance intermittency of electricity supply?

33. A supergrid has the potential to contribute significantly to balancing intermittency of renewable energy production, provided:

- it is connected to countries with uncorrelated renewable supply and/or demand;
- they are willing to trade
- the supergrid is of sufficient capacity.

34. It is noteworthy that the electricity system has to be balanced on an ongoing minute by minute basis, so any analysis of its benefits would need to take account of scenarios such as low UK wind and high local demand for Scandinavian hydro, as well as the reverse, more favourable, cases, since investment in additional back-up plant would be largely governed by worst case combinations.

35. If major benefits are to be achieved in smoothing intermittent renewable generation sources, this would imply the supergrid would need to cover a wide geographic area, possibly extending beyond Europe into North Africa and Russia, and be of sufficient capacity to transport very large (100 GW scale or larger) amounts of power. Staying within the relatively limited geographical confines of northern Europe will limit the amount of uncorrelated renewables accessible, and also the opportunity to exploit time differences in times of maximum demand, other than at the margins.

36. The extent to which using a supergrid to back up intermittency is cheaper than other options for coping with intermittency (such as demand management, storage, low cost back-

up generating capacity, etc) can only be determined by detailed study, at least in part using highly complex hourly models.

37. Extensive commercial modelling will also be required to understand the commercial incentives acting on generators and consumers to trade power across such long distances. Even if this is technically possible and desirable it might not represent a credible market response.

38. The technical capability to balance intermittency will only be realised in practice if various countries' market rules are sufficiently aligned.

Question 5: Will a supergrid reduce energy prices for consumers and businesses?

39. Without the analysis referred to above, and a more detailed knowledge of the capacity and topology of the supergrid it is not possible to comment on its impact on UK domestic energy prices.

40. If capacity were sufficient it would tend to produce more uniform prices across Europe. Whether these benefits are sufficient to offset the price impacts of building the Supergrid is unclear at the moment.

41. We would caution that, in any case, energy and electricity prices are likely to rise substantially over the next ten years, and the debate about supergrid economics should be more in terms of whether it limits increases more or less than other options rather than whether it reduces prices.

42. Building a supergrid entails addressing a series of complex institutional issues which are only worth tackling if it is demonstrably cheaper than the alternative of building large amounts of backup generation or demand-side measures to match demand to generation from intermittent renewables. The problem could be that, for individual countries, the balance of costs and benefits might be significantly different: arguably there could be net winners and net losers. For example, a small country could conceive of being a net exporter of wind power into neighbouring states, but unless subsidies are apportioned fairly, the consumers in that country could end up paying more to subsidise exports of green electricity. For those states for whom offshore network build is contemplated, the construction costs are significantly higher than onshore and have to be borne by the market somehow, so the benefit derived in terms of access to cheaper generation would need to outweigh this cost.

Question 6: What are the implications for UK energy policy of greater interconnection with other power markets?

43. Assuming interconnection with Europe was of rather higher capacity than today, the UK market would become in effect a part of the wider European market. Electricity would be traded across Europe for the best price, and the UK would need to consider safeguards to ensure supplies needed domestically were not sold into the rest of Europe in times of shortage.

44. Greater interconnection than at present should reduce to a degree the need for reserve generation capacity as, in principal, reserve plant could be shared. However the issues around backup plant for intermittent renewables would need careful analysis, taking account of the correlations in renewable outputs and national electricity demands in worst case hours.

45. The issues around subsidies for renewable energy mentioned above would need to be tackled, however for UK, with a high population density and the corresponding challenges of planning and environmental barriers to building enough renewable projects to meet its own

targets, greater interconnection could allow the country to import green energy from any neighbouring countries with a surplus. The GB market is one of the largest and most open electricity markets in the EU and therefore potentially attractive in this respect.

46. In summary, more work is needed to evaluate the benefits. The supergrid could potentially leverage significant economic benefits as outlined above, but at the same time could leverage risks, both technical and in governance terms.

Questions 7 and 8
Not answered.

Question 9: Would new institutions be needed to operate and regulate a supergrid?

47. The option of letting a supergrid evolve through the gradual development of component links between pairs of countries is worthy of consideration. However certain countries are likely to fulfil more of a transit role with less obvious benefits to themselves. At the very least, regulatory arrangements would seem to be needed to incentivise the construction and to govern the operation of the supergrid. This whole area needs further investigation as part of the overall studies needed for the supergrid.

48. In areas where interconnection is not well developed already, such as around the North Sea, or between the UK and mainland Europe, a supergrid is unlikely to evolve[2] without groups of affected countries agreeing to coordinate network planning and also coordinating regulatory development to remove barriers to implementation. Such coordination could occur at a working (zonal) level without a need for over-arching institutions. There are existing regulatory bodies at EU level already considering some of these issues and they can also play a useful role. However there is still work to do to improve and coordinate overall governance across Europe.

49. The UK does not at present have to engage significantly with European Transmission System Operators (TSOs). With a supergrid this would change, and the UK would need to guard against governance decisions that were not in its favour.

About the IET

50. The Institution of Engineering and Technology (IET) is one of the world's leading professional bodies for the engineering and technology community and, as a charity, is technically informed but independent of network company, equipment supplier or service provider interests.

51. This submission has been prepared on behalf of the Board of Trustees by the IET's Energy Policy Panel and takes into account inputs from experts within the IET's wider membership who responded to a request for input.

IET
March 2011

[2] Individual interconnectors may be provided by the market, but not an integrated grid