The Institution of Engineering and Technology

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A Robust Grid for 21st Century Scotland
IET evidence to the House of Commons Scottish Affairs Committee

2 February 2012

1. The Institution of Engineering and Technology (IET) welcomes the opportunity to contribute to the call for evidence on "A Robust Grid for 21st Century Scotland".

2. The IET is one the world's leading professional bodies for the engineering and technology community. The IET has over 150,000 members in 127 countries and has offices in Europe, North America and Asia-Pacific. The Institution provides a global knowledge network to facilitate the exchange of knowledge and to promote the positive role of science, engineering and technology in the world.

3. The IET aims always to provide unbiased, independent, evidence based policy advice, free from commercial or political influence. This response has been prepared on behalf of the Board of Trustees by the Policy Department drawing on the expertise of the IET's Energy Policy Panel and the Scotland Policy Panel.

Executive Summary

4. The IET's key points are:

- Electricity is essential to modern day life and our dependence has grown to the point whereby any disruption can have a severe impact on our lives. This dependence is set to increase as we decarbonise our energy supplies.

- Experts expect that climate change is likely to result in more volatile weather conditions, and it is possible that these may result in more severe storm and ice loading conditions than networks are presently designed to cope with.

- It is therefore possible that a level of network resilience that was appropriate in the past will no longer be considered appropriate by consumers in the future, and we believe a debate informed by appropriate analysis of costs and benefits is timely.

- The severe disruption recently experienced by Scotland provides an excellent opportunity to evaluate whether the economic and social cost of the disruption justifies the cost of an increase in the security standards

- The IET is keen to be part of this debate and to support the Select Committee's deliberations in this area.

Introduction

5. Before we address the specific questions, we offer the following as context and background to this inquiry.

Clarification of terms

6. We believe a distinction should be drawn between transmission and distribution e.g. in Question 6. This is an important distinction as it indicates whether the responsibilities are those of the System Operator, the Transmission Owners (TOs) or the Distribution Network Operators (DNOs). Their responsibilities and service levels are regulated under different licences.

7. In England and Wales the transmission system refers only to 400kV and 275kV assets. However, in Scotland the 132kV network is also regarded as transmission, partly in order to transmit power to remoter regions and partly for legacy historical reasons.

8. This means the Scottish 400kV, 275kV and 132kV network is owned and maintained by Scottish Power (SP) and Scottish and Southern (SSE)[1] under their Transmission Owner licences and form part of their TO regulated asset base.

9. The low voltage distribution network in Scotland (33kV, 11kV and 230V) is owned and operated by SP and SSE under their Distribution Network Operator Licences.

10. National Grid Electricity Transmission plc is the System Operator for the Scottish transmission assets owned by SP and SSE. (Whereas in England and Wales National Grid both owns and operates the transmission assets.)

The causes of severe weather related failure

11. The two main causes of severe weather related failure are falling trees (or boughs) and (exceptionally) ice loading. The latter occurs during snow storms when the conductor temperature is at a critical point which encourages ice build-up (accretion) which has a 'snowball' type effect and can lead to massive mechanical overloading of structures and fittings.

12. Lower voltage grids are more likely to suffer damage due to severe storm or blizzard conditions and falling trees. In England and Wales these are the **distribution** grid, while in Scotland, as described above, they include the lower voltage parts of what is operated as the **transmission** grid. Therefore in Scotland, transmission operators encounter problems not experienced by transmission operators in England and Wales.

The impact of disruption to electricity supplies

13. Electricity has become essential to modern day life and our dependence has grown to the point whereby any disruption can have a severe impact on our lives. This **dependence is set to increase as we decarbonise our energy supplies** with the potential electrification of heat and transport and also due to a growing dependence on smart systems that will impact on many aspects of our everyday lives.

14. Experts expect that climate change is likely to result in **more volatile weather conditions**, and it is possible that these may result in more severe storm and ice loading conditions than networks are presently designed to cope with.

15. **It is therefore possible that a level of network resilience that was appropriate in the past will no longer be considered appropriate by consumers in the future, and we believe a debate informed by appropriate analysis of costs and benefits is timely. The IET is keen to be part of this debate and to support the Select Committee's deliberations in this area.**

[1] Scottish and Southern Energy plc was named in December 1998 after the merger of Scottish Hydro-Electric with Southern Electric plc. The brand name "Scottish Hydro-Electric" continues to be used for the company's Scottish business.

Network Design and Specification

16. The electricity grid was designed and built for the 20th century. Fundamental to its design is its resilience to adverse weather conditions, both to provide reliable supplies and to minimise the risks to public safety that could arise from physical failures.

17. It is possible to design a grid which is almost 100% reliable. However, the economic cost would be unacceptable and as a consequence the grid is designed, built, operated and maintained to a prescribed level of performance which is itself regulated.

18. Increasing resilience further will incur a cost and if this can be justified by the benefits then it should be considered. Ultimately this is a 'willingness to pay' issue which should be decided by consumers and other stakeholders. If accepted this would then need to be followed through in investment planning and the expenditures allowed by the regulator.

19. Overhead lines across Great Britain are now built to broadly common standards dictated by the required factors of safety and clearances specified under the Electricity Safety Quality and Continuity Regulations (ESQCR).

20. Network Operators are additionally incentivised (through rewards and penalties) to deliver acceptable levels of performance in terms of customer minutes lost and numbers of customer interruptions against specified targets (albeit severe storm conditions are regarded as 'exceptional events' and excluded from the incentive mechanism).

21. Resilience of individual overhead lines to extreme weather can be improved by building or rebuilding them to be more robust, but to apply this across a whole network would be very costly and take many years. Targeted upgrading and improved automation is usually deployed on lines known to have poorer performance.

22. **The severe disruption recently experienced by Scotland provides an excellent opportunity to evaluate whether the economic and social cost of the disruption justifies the cost of an increase in the security standards**, i.e. Grid and Distribution Code standards (SQSS and ER P2/6 respectively). Such an evaluation should take account of how these costs, and the long term willingness of customers to pay, might change as our dependence on electricity increases. With the potential benefits identified it should then be possible to determine whether or not the costs of increasing the regulated standards of performance can be justified.

Review of network performance

23. The severe disruption also presents an opportunity to evaluate how the grid performed in the context of the current regulatory incentives for performance. These reward/penalise grid companies according to customer interruption and duration performance against prescribed by targets set by Ofgem.

24. We would expect that the grid companies, in conjunction with the regulator, should have conducted a comprehensive review and identified areas of good performance, areas of poor performance and lessons learnt.

25. We would then expect the grid companies to have identified a number of actions to raise their performance. These might range from low cost actions, e.g. changes to operating procedures, through to higher cost actions which may require substantial infrastructure investment.

26. Thus the first step is to ascertain how well the grid companies are performing under the existing regulatory incentives for performance. Only once this is ascertained does it make sense to move on to consideration of whether to raise security standards.

QUESTIONS POSED BY THE COMMITTEE

Questions 1 and 3
1. The frequency and severity of weather-related power cuts in Scotland.
3. The current condition and technological state of Scotland's electricity transmission network, and what conditions they are built to withstand.

27. These deal with present aspects of network performance and the extent to which the network has been designed and maintained to respond to prevailing weather conditions. We believe that the network companies owning the assets and the regulator are best placed to respond to questions 1 and 3.

Question 2: The consequences of such power cuts to individuals, businesses and public sector services.

28. This is a crucial question that will probably require considerable investigation to evaluate robustly and comprehensively. It would be helpful if some assessment could also be made of how these consequences might change given likely increasing dependence on electricity in the future.

29. Electricity has become essential to modern day life and our dependence has grown to the point whereby any disruption can have a severe impact on our lives. The list of services affected in a prolonged power cut includes: communications, water pumping (for drinking, washing and water for heating systems), internet, business systems, electronic equipment, industry, commercial applications such as electronic doors and electronic funds transfer, healthcare monitoring, and safety systems such as lighthouses etc.

30. Our dependence on electricity **is set to increase as we decarbonise our energy supplies** due to the potential electrification of heat and transport and also a growing dependence on smart systems that will impact on many aspects of our everyday lives.

31. "Willingness to pay" surveys are undertaken already to understand the views of consumers, but we believe there may be some merit in reviewing this process to ensure responses from consumers are being made in the light of expected changes to how electricity will be used in homes and businesses, for example the overnight charging of electric vehicles.

32. Climate change is likely to result in **more volatile weather conditions**, and it is possible that these may result in more severe storm and ice loading conditions than networks are presently designed to cope with.

33. The **increasing inter-dependence of infrastructure** also needs to be taken into account. Other parts of the National Infrastructure, particularly communications, IT, and water supplies are dependent on electricity for their resilience. This is discussed in more detail in the report "Infrastructure, Engineering and Climate Change Adaptation – ensuring services in an uncertain future" published by Engineering the Future in February 2011.[2]

34. **It is therefore possible that a level of network resilience that was appropriate in the past will no longer be considered appropriate by consumers in the future, and we believe a debate informed by appropriate analysis of costs and benefits is timely. The IET is keen to be part of this debate and to support the Select Committee's deliberations in this area.**

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[2] "Infrastructure, Engineering and Climate Change Adaptation – ensuring services in an uncertain future" published by Engineering the Future in February 2011.
http://www.raeng.org.uk/news/releases/shownews.htm?NewsID=623

Question 4: The advantages and disadvantages of using an alternative electricity transmission infrastructure, particularly regarding its vulnerability to weather-related damage, but including all significant consequences.

35. We are concerned that question 4 is potentially restrictive as there are a number of courses of action in addition to "alternative electricity transmission infrastructure". As noted earlier we would expect that the grid companies will have conducted a comprehensive review of their performance along with lessons learnt. From this we would expect to see a number of recommended actions which might include, but certainly not be limited to, alternative electricity infrastructure. Our response to this question is therefore in four parts:

Designing for Resilience

36. Considerable investments are being made by transmission owners and especially distribution network operators (as distribution lines are generally less resilient) to improve the resilience of overhead line networks. These include:

- Rebuilding light construction (BS1320) HV lines to a heavier standard (essentially stouter wood poles, heavier steelwork and larger cross-section conductors);

- At low voltage (400/230 volts), extensive rebuilding using 'aerial bundled conductor' (ABC) in areas surrounded by trees, which is a fully insulated cable and far less likely to fail due to tree contact than the traditional un-insulated 'open-wire' lines.

Operational Issues

37. Ways in which the energy companies can improve operational performance include:

- Greater attention to tree cutting and managing clearances (though since most distribution lines on private land are held on terminable wayleaves, the degree of cutting has to be agreed with the landowner, and there can also be issues of local opposition to tree cutting);

- Improved inspection and diagnostic techniques; for example:

    - extensive use of high definition aerial 'fly-past' photography (using helicopters) which records 'tower top' photos in great detail enabling any damage or corrosion issues with insulators, fittings, conductors and steelwork to be visually identified;

    - Ultrasonic mapping of wood poles to detect internal rot and ascertain residual strength (ie whether the required FoS is still satisfied);

    - Specialist testing of high voltage steel-cored aluminium alloy conductors using an electrical technique that determines whether the inner (hidden) steel core (which is responsible for the mechanical strength of the conductor) is exhibiting any signs of loss of galvanising / corrosion and hence loss of tensile strength.

- Robust communications systems for maintenance staff, bearing in mind that in emergency situations where there is no power, mobile phone base stations will not work after a few hours.

Enabling technologies including "self-healing networks"

38. These technical improvements will be assisted by increasing "smartness" in the Distribution Grid. For example, if the eventual agreed specification for **Smart Meters** in homes includes "Last Gasp" functionality, the network company could have automatic and immediate notification of a power supply failure during the night rather than needing to wait for

householders to wake up and report it. Moreover, the ability for network operators to selectively poll meters would alleviate the problem which can occur today when large areas are returned to power but network companies have no way of telling that a few houses remain without power due to a secondary reason.

39. Network operators are now able to access advanced work/resource scheduling systems, coupled with vehicle tracking systems, to more effectively deploy repair crews. Used in conjunction with smart meter data to identify residual faults on the distribution networks (as mentioned above) it should be possible in future to better prioritise storm damage rectification work and restore supplies to consumers more rapidly.

40. Network remote monitoring, control and automation will increasingly help network operators to isolate damaged sections of the network and restore supplies to the majority of consumers initially affected by network protection systems (circuit breakers) tripping to clear storm related faults. Advanced automation systems coupled with distributed (decentralised) network management systems are now being developed which will enable networks to reconfigure automatically under a wide range of scenarios. This would make it possible not only to restore supplies following a fault, but also to ensure that the network is optimally configured to deal with network loading conditions in real time, including for example to maximise the availability of connected generation.

41. Using with advanced diagnostics, networks in future will be able to 'predict' certain incipient fault conditions and self-reconfigure in order to isolate sections of network at risk of failure before a fault occurs. These so-called **'self-healing' network technologies** are not yet mature, but are under development as part of network operators' R&D portfolios - including using incentives such as Ofgem's Innovation Funding Incentive.

42. Other emerging technologies aimed at improving network resilience include **active network management** using a wider range of monitoring, state estimation and diagnostic techniques in order to minimise network constraints and enable network components to be operated at a higher level of utilisation. An example is the use of “active dynamic ratings” of overhead lines in which sensors monitor ambient temperatures, wind speeds, and duty cycles of a line to permit higher network loadings under favourable conditions whilst eliminating the risk of network overloads under extreme ambient conditions and abnormal network loadings.

Undergrounding

43. In urban areas a large proportion of the low voltage **Distribution** Network is already buried underground, mostly for reasons of aesthetics. However, undergrounding of distribution circuits is one of the options that might be considered in rural areas for particular sections of line that are subject to particularly high risk of disruption from weather. For low voltage overhead lines, a more practical and cost-effective alternative is often to re-conductor lines using insulated Aerial Bundled Conductor which is more resilient to damage from falling tree branches and which overcomes the common problem with traditional 'open wire' lines of electrical failure due to conductor clashing as a result of falling branches.

44. There has been considerable discussion recently about the pros and cons and costs of undergrounding high voltage **Transmission** circuits. However, this is of less relevance to resilience as it is the **Distribution** grid which is more likely to suffer damage due to severe storm or blizzard conditions and falling trees. The high voltage transmission grid is largely unaffected by wind.

45. The IET has provided independent quality control for the report “Electricity Transmission Costing Study”[3] by Parsons Brinckerhoff in association with Cable Consulting International.

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[3] “Electricity Transmission Costing Study” by Parsons Brinckerhoff in association with Cable Consulting International, January 2012. http://www.theiet.org/factfiles/transmission-rep.cfm

This report sets out to provide authoritative independent information on the costs of the seven available options for Transmission lines. It was published on the IET website on 31 January 2012. Though it's terms of reference are limited to England and Wales, the study is also of interest in Scotland and many other countries. Its headline conclusions are:

- No one technology can cover, or is appropriate in, every circumstance and thus financial cost cannot be used as the only factor in the choice of one technology over another in a given application,

- Costs per kilometre, for all technologies, tend to fall with increasing route length, and tend to rise with circuit capacity,

- For typical National Grid system circuit loadings, the inclusion of operating costs in the technology comparisons does not significantly affect the overall differences in cost between the technologies. However, they do affect the cost ratios considerably, rendering the latter a misleading measure when making investment decisions.

- Overhead line (OHL) is the cheapest transmission technology for any given route length or circuit capacity, with the Lifetime Cost estimates varying between £2.2m and £4.2m per kilometre, however OHL losses are the most sensitive to circuit loading

- Underground cable (UGC), direct buried, is the next cheapest technology after overhead line, for any given route length or circuit capacity. It thus also represents the least expensive underground technology, with the Lifetime Cost estimates varying between £10.2m and £24.1m per kilometre

- For the options using a deep tunnel, the largest single cost element is invariably the tunnel itself, with costs per kilometre ranging from £12.9m to £23.9m per kilometre, depending upon overall tunnel length.

- The 75 km high voltage direct current (HVDC) connections are estimated to cost between £13.4m and £31.8m per km, and are thus more expensive than the equivalent overhead or direct buried transmission options. However, long HVDC connections are proportionally more efficient than short connections.

- Undergrounded gas insulated line (GIL) technology is generally estimated to be higher cost (ranging between £13.1m and £16.2m per kilometre) than the lowest rating ("Lo") underground cable studied (£10.6m to £12.8m per kilometre), although the GIL equipment does have a somewhat higher rating than the compared UGC. This factor, along with any future experience of the technology in the UK, may change the effective costs per kilometre, and this situation should be kept under review.

46. The report also offers two notes of caution:

- Cost ratios are volatile, and no single cost ratio comparing overhead line costs with those of another technology adequately conveys the costs of the different technologies on a given project. Use of financial cost comparisons, rather than cost ratios, are thus recommended when making investment decisions.

- The transmission technologies may not all be able to use the same route as each other, so circuit lengths may vary between technologies for a given application. We therefore recommend that actual practicable routes be identified when comparing total lifetime costs of each technology for specific investment decisions.

Alternatives to national power network

47. Off grid solutions, essentially involving local means to generate electricity and potentially to store energy, have been the subject of considerable research in recent years, and deployment (mainly to remote sites) has been tested. Such systems may, for example, include wind turbines, some form of storage and a diesel engine backup. For particular applications consideration could be given to accepting weak network connections to remote areas but supplementing them with community energy schemes.

Question 5: Was the response provided by the energy companies satisfactory? (In terms of notification, restoration and compensation).

48. The IET does not have access to this information. However, we would expect that the grid companies would have conducted a review of their performance and this should have included customer facing activities. We would be pleased to assist in interpreting the responses received to this question. Consideration should be given both to whether the response was within today's acceptable limits, but also to whether consumers will come to expect a faster response and better information in the future.

Question 6: How the regulation of Transmission System Operators and Distribution Network Operators impacts upon investment in Scotland's electricity transmission network.

49. It is important to note that National Grid Electricity Transmission plc is the transmission System Operator for all of Great Britain but the Scottish transmission assets are owned and maintained by SSE plc and Scottish Power plc. Our assumption is that your question does not seek to draw any such distinctions but is intended to refer to the electricity grid network system in its entirety.

50. Investment in the electricity grid network is a regulated activity. Significant changes have recently been made to encourage innovation and promote longer term planning and investment. The new method for regulating energy networks is known as RIIO which stands for Revenue=Incentives+Innovation+Outputs. Ofgem's new performance-based RIIO model seeks to ensure that customers get the necessary investment in Britain's energy networks at a fair price. However, there is no or very limited experience of this new regime. Hence this is an important area that needs to be explored.

51. The two Scottish companies have submitted business plans for **transmission** activities to Ofgem under the new regulatory regime. The transmission company regulatory settlements include £7bn to upgrade the transmission system (including to permit connection of 11GW of wind farms). The Committee may wish to inquire whether their business plans incorporate lessons learnt from the recent severe weather. They are available here:
SPTL – http://www.spenergynetworks.co.uk/publicinformation/stakeholder_riio.asp
SHETL – http://www.ssepd.co.uk/Projects/TransmissionPriceControlReview/
Ofgem intends to publish a consultation on Initial Proposals for both SPTL and SHETL on 6 February, and will seek views from stakeholders at that point.

52. The **distribution** businesses will be submitting their plans to Ofgem for approval in 2013 (which will take effect from April 2015 through to March 2023).

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