COUNCIL FOR SCIENCE AND TECHNOLOGY

26 July 2012

Text of a letter to the Prime Minister

SMART GRIDS

Energy is fundamental to the UK's future economic, social and technological success. It will have enormous strategic importance in the coming decades and it is a topic on which the Council for Science and Technology (CST) will want to offer ongoing advice to you and DECC Ministers.

Your Government already recognises that the development of a smarter electricity network (a "smart grid") will be essential in a successful transition to a low carbon system. But we wanted to write now to draw your attention to potential vulnerabilities in some of the developments currently in train. **We believe there is a short window of opportunity within which we can act to reduce these vulnerabilities** in a way that (i) reduces the need for further costly interventions at a later date and (ii) would better position the UK to reap longer–term commercial advantages as an early adopter.

Smart meters and smart grids

Smart meters in homes are critical to the operation of any future smart grid. The benefits that they can offer to control electricity demand in the home and therefore demands on the infrastructure (including advanced dynamic and time-of-use tariff models enabled via smart grid demand response techniques) may not be realised unless there is a timely roll-out of the supporting infrastructure.

Truly smart grids need to be based on a telecommunications architecture which will allow customer data to be gathered, processed and stored by those that manage the network. This data will show power flows within the network, enabling operators to make better asset management and service procurement decisions. The data will also help suppliers develop tariffs to reflect pricing signals from the market, encouraging customers to participate in load management. As take-up of heat pumps and electric vehicles becomes widespread, data on their use will be essential if we are to avoid vast new investment in the distribution network which would otherwise struggle to cope with the novel demands these will place on it. In the long run, smart meters in UK homes must provide the functionality to provide these capabilities.

We are concerned that the currently proposed consumer-led approach to the roll-out of smart meters is unlikely to create the density needed to realise these benefits on the right scale[1]. This could result in the UK network having only meters that solve the objectives of

remote reading and consumer awareness of energy cost missing an opportunity to control demand and thereby help avoid future system control problems. Limited smart meter functionality will inevitably lead to the requirement for a second round of meter installation at a later date: we believe that the roll-out of smart meters should include full functionality from the start.

Recommendations:

1. **DECC should keep the current consumer-led roll-out of smart meters under close review and, if the take up by consumers is slower than required, be prepared to revert to a mass roll-out plan. The details of such a contingency plan should be considered now, because we are unconvinced that there will be sufficient take up to provide an effective grid management capability by the target date of 2019. We would suggest that a formal review of progress should take place in 2016 (taking account of the dynamic models of the energy system set out in recommendations 3 and 4 below).**

2. **Smart meters must be connected to a smart grid infrastructure that allows a two-way flow of information to realise the full benefits of these new technologies and to ensure that customers contribute to the load management of the overall system.**

Future network requirements

The search for a low carbon solution to our energy needs has so far concentrated on the development of new renewable sources of generation, new nuclear build and carbon mitigation. We have made good progress in these endeavours but the variable nature of the power output of the wind and solar sources currently being deployed, together with their locations in the electricity transmission and distribution system, presents significant challenges for the electricity industry. In the past supply and demand was more predictable, and the system was easier to manage. Now, however, there will be many new complexities for which the grid needs to be prepared by the target date of 2019. (See Box 1 below). The key point is that there could be large fluctuations in frequency, with the ensuing automatic disconnection of current system equipment, leading to a cascade blackout. The future network needs to be capable of avoiding this.

Prompt action to disconnect load on parts of the system, known as load shedding, is possible. But this would be a drastic solution and would not be popular with those consumers experiencing the resulting blackouts. All supply would be lost, not just that which is less vital.

There is, however, an opportunity to manage the consumer demand on a controlled, voluntary basis provided we install sufficiently smart meters and incentivise people to accept this approach. For example, the charging of electric vehicles can be managed at consumer level to reduce the total load at any given point in time and yet still deliver the necessary battery charge over a period of time.

Box 1: System Frequency Control

The move away from centralised energy plants (e.g. power stations) to more geographically dispersed plants (such as wind farms) will require more sophisticated automated control of the network. Large wind farms are not, in the main, located near strong points on the existing network and will therefore require significant transmissions enhancement and enforcement. The recent IET report on the relative costs of the various options for those developments will help the planning decision process and lead to a stronger transmission and distribution system but will not remove the need for more sophisticated generation and load control mechanisms in the future[2]. New nuclear, as currently proposed, is largely close to existing or previous nuclear sites and so is easier to link to the network mostly with straightforward network enhancement. Solar and onshore wind are mostly integrated into the distribution system at voltages below, and mostly well below, 132 kV, meaning that National Grid does not have direct control of the plant and will require the DNO's to have real time systems, linked to the national control centre, that facilitate monitoring and control.

The technology employed allows the in-feed power to be frequency synchronised to the existing supply but usually does not have the capability to change its generation in response to frequency deviations from the nominal 50 Hz in the way that conventional generating plant is able to, through a governor control system. This is not a problem when the percentage of such variable renewable generation is small but becomes an increasingly significant issue as the proportion of renewable generation increases. It is difficult to arrange for co-ordinated control of the numerous embedded sources and indeed there may be no scope for control if the wind is not blowing or the sun is not shining.

On the demand side, large new intermittent loads such as heat pumps and electric vehicle charging will present massive network reinforcement challenges. This will incur inherently high costs unless the load can be managed dynamically, which would also help match the variable nature of the generation side. Any failure to instantaneously 'balance' the load with what is being generated means the system frequency is rising or falling, making control action on the timescale of seconds necessary, a process known as system frequency control.

CST is reassured that *economic* modelling of the way in which the energy system is balanced is already taking place, but this only provides one part of the picture. *Dynamic* modelling of the way in which the system will operate in practice, reflecting variations and shifting conditions from moment to moment is essential if we are to be fully prepared for future vulnerabilities, and to inform the review proposed in recommendation 1. Clarity of ownership is particularly important in the UK system where responsibility for a new smart grid will inevitably be shared between the National Grid and the Distribution Network Operator companies.

Modelling and analysis is required to examine how any future electricity network will function. This must model the impact on the system as a whole of the interaction of new sources of generation with a new geographical distribution and new sources of demand. For example if one area has lots of solar or embedded wind there could be voltage control problems that could lead to tripping of large parts of the network.

Recommendations:

3. **There needs to be effective *dynamic* modelling of how our changing electricity system will operate when large proportions of renewables are embedded. DECC and the regulator should work urgently to ensure this happens. This analysis should be as transparent as possible, opening it up for validation by the many external stakeholders.**

4. **DECC should clarify who will have lead responsibility for this modelling and ensure they are held to account to deliver on the required timescale. At the moment, there is little clarity as to who is addressing the issue and co-ordinating actions.**

European interconnectivity

New continental interconnections should help the UK meet its future electricity needs and help cope with peak demands. The European network is likely to require the UK to implement automatic generation control before it allows the increase to 9GW connection with the UK, thereby further complicating the control problem. A great deal more analysis is required to understand how this interconnectivity will work (another reason for the dynamic systems modelling recommended above).

Recommendation:

5. **Investment now in analysis of how the continental interconnections will work within the future UK electricity infrastructure is essential.**

Powering up the UK to lead on smart grid technologies

We have highlighted some specific potential vulnerabilities within the UK system; other countries are facing similar issues.

Decisive action to tackle these issues could therefore also generate significant export opportunities (particularly in the area of software and algorithms where the UK has specific expertise and on which CST will be offering separate advice)[3].

The development and deployment of smart grid technologies could create 9,000 new jobs and up to £9 billion in exports. It would also place the UK as a potential global leader in these technologies.

Recommendations:

6. **The UK should seek to be a major player in any European initiative that may happen given the strong interest in electricity system development being shown by France, Germany and others. This will need influence at the highest levels to ensure we are not excluded given the predominance of companies such as Siemens and ABB in the European research and development agenda.**

7. **Departments, notably DECC and BIS, should devise an integrated strategy that will not only address our own future issues but will put the UK in a technologically leading position from which we will be able to rebuild our export business.**

The skills challenge for universities and industry

The Grand Challenge in Energy (one of the six priority areas identified by the Research Councils and endorsed by Government as critical areas for research investment) should be enhanced to ensure that system aspects such as smart grid developments are added to the low carbon plans already underway.

Your personal advocacy would also help encourage the professional engineering institutions to engage with Government to identify road blocks, help devise strategies, and to engage industrial members in identifying opportunities. Electricity energy systems are inherently highly complex but the UK has a good track record in producing novel solutions that have been exploited on a worldwide basis. We have a well developed energy economics community but we lack the corresponding technology base that can respond to the opportunities, without the additional stimuli above. We note the recent initiative in smart grid technologies announced by the Chancellor during his visit to Beijing and involving EPSRC and the Chinese National Natural Science Foundation which is very welcome but is far too small (£3M) to have much real impact.

Recommendations:

8. **DECC, BIS and the Institutions should take action to encourage a sufficient supply of an appropriately qualified workforce, such as electrical power engineers at technician, graduate and importantly post-graduate level (building on initiatives for which you have already indicated your support).**

9. **The Government should set for itself the objective of making the UK a leading provider of smart grid technologies, building on our leading position in privatised electricity supply and on our history of leading technological innovations in electricity supply.**

We are copying this letter to the Deputy Prime Minister, Ed Davey, Charles Hendry, Vince Cable, David Willetts and Sir Jeremy Heywood.

[Signed]

SIR JOHN BEDDINGTON
PROFESSOR DAME NANCY ROTHWELL

Co-chairs

1 Experience elsewhere indicates that it might well be an order of magnitude more expensive to do the roll-out on a voluntary, individual home basis rather than by systematic roll-out ‘street by street, town by town’.
2 Electricity transmission costing study: an independent report endorsed by the Institution of Engineering and Technology. 31 January 2012.

3 Global energy trends suggest that world electricity demand may increase from 17217 TWh in 2009 to 31722 TWh in 2035. Electricity demand in the EU may increase from 2793 TWh in 2009 to 3530 TWh in 2035. (International Energy Agency World Outlook 2011).

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