ROYAL ACADEMY OF ENGINEERING

Energy revolution

Response to the Energy and Climate Change Committee

May 2016

Which innovations have the greatest potential to revolutionise energy markets, and why?

1. The Royal Academy of Engineering is pleased to respond to the Committee's inquiry on potentially revolutionary innovations. This response has been compiled through contributions from Fellows with expertise in the sector as well as being informed by recent studies by the Academy on energy policy.

2. The energy market will need to undergo dramatic changes over the coming years if it is to fulfil the legally binding decarbonisation targets while remaining secure and affordable. Changes will occur not just in the electricity sector but in heat and transport as well, and in both domestic and business markets.

3. Although system integration is not a single innovation, it was the strong view of Fellows that this is *the* critical factor that will determine the success or failure of the future energy system. Repeated studies by the Academy have concluded that sufficient technologies already exist that would enable the energy system to be decarbonised. Understanding how these technologies can be integrated remains a challenge, particularly in terms of how they will operate in real-world situations. The challenges and criticality of understanding the issues inherent in real-world interconnectivity and system integration was exemplified in last year's flood induced four-day power cut in Lancaster, the subject of a recent reported by the Academy, the IET and Lancaster University[1]. The loss of power affected many other critical services: communication, transport, utilities and the food chain.

4. It is true that disruptive innovations can occur that can dramatically affect the system – such as the way that hydraulic fracturing for gas and oil have had such an impact on global markets in recent years. However, any technology that is still only in the early stage of development would take many years to mature to the point that it could make a significant contribution to the system. There is a risk that looking for such 'silver bullet' would unnecessarily delay the roll-out of existing technologies and delivery of the optimal energy system for the UK is already at serious risk.

5. The Academy's most recent report on energy *A Critical time for UK energy policy*[2] made this point clear and stated that, as a matter of urgency, the government should undertake local or regional whole-system, large-scale pilot projects to establish real-world examples of how the future system will work. These must move beyond current single technology demonstrations and incorporate all aspects of the energy system - electricity, heat, transport and industry - along with consumer behaviour and financial mechanisms.

6. Turning to more focused innovations, grid-scale electricity storage is seen by many as the technology that could make the most difference in the electricity market. At present, the only significant form of electricity storage is from pumped storage hydro-electric stations and these are only suitable for relatively short-term peak load balancing. In the past, the power system developed to cope with a lack of storage through a combination of baseload and flexible thermal plant, but the increase in variable renewable technologies such as wind and solar has gradually altered this arrangement and led to potential difficulties within the system in terms of balancing

[1] http://www.raeng.org.uk/publications/reports/living-without-electricity
[2] http://www.raeng.org.uk/publications/reports/a-critical-time-for-uk-energy-policy

services and other auxiliary services such as inertia and frequency control. In turn, this has led to market reforms such the capacity mechanism.

7. Considerable work is being done to develop grid-scale electricity storage and, although there are some interesting developments such as compressed air energy storage and flow batteries, deployment at a scale that would make a significant difference is still some way off.

8. What is more likely to make a difference is what might be described as virtual energy storage. This would incorporate multiple technologies and processes including existing batteries that are either aggregated or distributed, demand side management, heat storage, and coordinated integration of different vectors such as gas, electricity or heat.

9. Combining the relevant technologies and processes in an efficient and functional system will be a complex task. It will rely on digital systems and increased use of data flows but, equally, it will rely on new markets that will work for consumers, utilities and system operators, allowing the additional costs and benefits to be shared equitably between the different parties.

10. Progress in this area would form a major part of the pilot schemes noted in paragraph 5 above. These would provide an opportunity for the digital or 'smart' systems to be tested in practice as well as the major retrofitting that would be necessary to install the new systems and trialling of the various novel pathways for integrating the different parts of the system together.

11. Considering the power generation sector, nuclear power is seen by the Academy as a vital component of any future electricity system. It remains one of the few proven sources of large-scale, low-carbon, baseload electricity, which it has now been delivering for over 60 years. However, recent new build programmes have seen many problems in terms of cost overruns and delays. In the UK, Hinkley C is still to be given the final go-ahead despite originally being due to be completed before the end of this decade.

12. Small modular reactors have the potential to overcome some of the issues that their larger counterparts face. Most significantly, they will require much lower initial capital outlay and would allow greater levels of modularisation. This should mean they do not face the same hurdle in finding sufficient financing.

13. There are still engineering issues with developing a viable, civil SMR design, despite the fact that small reactors have been used in submarines for many years. Much work has already been done in this field and the UK government has already show interest through NIRAB[3] and the announcement of the £250m competition in the last budget. However, if successful, SMRs have great potential to have a positive impact on the electricity market and efforts should be made to establish a leading position in for the UK in this technology.

14. It is also worth noting that this relates to the recommendations made in the Academy report *A Critical time for UK energy policy,* noted above. This recommended that the government should, *inter alia*, 'Drive forward new capacity in the three main low carbon electricity generating, technologies — nuclear, carbon capture and storage (CCS) and offshore wind.' Offshore wind shows the greatest potential to continue to delivering on expectations which is encouraging, but there still remain challenges as industry moves to developing the next round of deep water arrays. CCS, however, continues to stall

[3] See, for example the latest NIRAB annual report http://www.nirab.org.uk/our-work/annual-reports/

following the removal of the government funds set aside for the CCS competition despite the fact that most future scenarios see it as a critical component in any decarbonised energy system.

15. Finally, some consideration could also be given to innovations in the transport sector. With the transport sector almost exclusively reliant on oil, electrification has been seen as the most likely means of decarbonisation. Progress is being made through both hybrid and fully electric vehicles, and understanding how these will integrate effectively into the future transport and energy systems will be a significant part of the pilot schemes mentioned above. However, electrification will not be the only solution and thought also needs to be given to reducing the need the need to travel either through telecommunications, mode shifting or better planning of high density, mixed developments.

16. Some modes of transport will struggle to find an electric solution, including aviation and the heavy duty vehicles that dominate the freight industry. For freight vehicles, increasing the volumetric capacity can have considerable impact on their carbon emissions. Possible innovations that achieve this include longer semitrailers, double decker trailers or platooning. Trials of each of these approaches have already been carried out in Europe and should be considered in the UK.