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Response to Ofgem Consultation on the benefits of the Low Carbon Network Fund and Governance of the Network Innovation Competition and the Network Innovation Allowance

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KEITH BELL

DAMIEN FRAME

GRAEME HAWKER

EMAIL ADDRESS FOR CORRESPONDENCE

GRAEME.HAWKER@STRATH.AC.UK

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ABOUT THE AUTHORS

Keith Bell is the ScottishPower Professor of Smart Grids in the Institute for Energy and Environment within the Department of Electronic and Electrical Engineering at the University of Strathclyde in Glasgow.

Damien Frame and **Graeme Hawker** are Research Associates also in the Institute for Energy and Environment.

The authors are providing this submission on behalf of UKERC but the views represent those of the authors alone.

Inquiry remit

In regulating energy networks and the system operator, Ofgem promotes innovation which brings benefits and value for money for consumers.

The inquiry[1] seeks to carry out a review of the governance arrangements for the Network Innovation Allowance (NIA) and the Network Innovation Competition (NIC) and the level of funding that should be available for the remainder of the electricity distribution price control period.

The review provides an opportunity to examine the criteria to evaluate NIC governance and to determine whether the process of awarding funding could be improved, including understanding whether the innovation funding is changing the distribution network operators' approach to managing their networks.

[1] Full details of the inquiry can be viewed at https://www.ofgem.gov.uk/publications-and-updates/reviewing-benefits-low-carbon-networks-fund-and-governance-network-innovation-competition-and-network-innovation-allowance

Our submission

The University of Strathclyde has had extensive involvement in LCNF-funded projects throughout the fund's inception, and this response is formed from both the experiences of working alongside network companies in the process of developing innovative projects, as well as observing the general progress of the sector in implementing new technologies and practices through the LCNF, NIA and NIC arrangements since their inception.

CONSULTATION QUESTIONS

1 Should we change the NIC and NIA criteria? If so, how and why?

1.1 What NIC and NIA seek to achieve

Our understanding is that the key criteria (in addition to other criteria relating to external funding, timing and methodology) in respect of eligibility for funding under the Network Innovation Competition (NIC) are that the proposed project[2]:

- accelerates the development of a low carbon energy sector and/or delivers environmental benefits whilst having the potential to deliver net financial benefits to future and/or existing customers;
- provides value for money to electricity customers;
- generates knowledge that can be shared amongst all relevant Network Licensees;
- is innovative (i.e. not business as usual) and has an unproven business case where the innovation risk warrants a limited Development and/or Demonstration Project to demonstrate its effectiveness.

A NIA project is supposed to have a 'direct impact' on a licensee's network and "involve the Research, Development, or Demonstration of at least one of the following:

- a specific piece of new (i.e. unproven in GB, or where a Method has been trialled outside GB the Network Licensee must justify repeating it as part of a Project) equipment (including control and communications systems and software);
- a specific novel arrangement or application of existing electricity transmission equipment (including control and/or communications systems and/or software);
- a specific novel operational practice directly related to the operation of the GB Transmission System; or
- a specific novel commercial arrangement."[3]

In addition, an NIA Project "must meet all of the following:

- has the potential to develop learning that can be applied by all Relevant Network Licensees;
- has the potential to deliver net financial benefits to electricity Customers;
- does not lead to unnecessary duplication."

With the exception of the omissions that we note below, we feel that the above criteria are appropriate.

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[2] https://www.ofgem.gov.uk/electricity/transmission-networks/network-innovation

[3] See https://www.ofgem.gov.uk/network-regulation-%E2%80%93-riio-model/network-innovation/electricity-network-innovation-allowance

1.2 Where use of customers' money is justified

As we discuss in our answer to Question 9, the existence of uncertainty is a fundamental requirement for allowing the use of customers' money. The aim is to reduce uncertainty through the generation of knowledge. It is our impression that at least some expenditure under the NIA and NIC has been more concerned with knowledge transfer – paying for a particular network licensee to acquire knowledge that already exists elsewhere – than with generation of knowledge. It might be contended that it is not reasonable for customers' money to be used simply for the transfer of knowledge that, arguably, a network licensee should already have or be working to acquire. Examples of this might include the installation of a particular item of network control equipment by a particular network licensee that has been used, apparently successfully, by another network utility for some years. If that other utility was in the UK, would the use of NIA or NIC money be reasonable? Would it make a difference if the other utility was outside the UK? The NIA criteria suggest that it would and that use of NIA money, at least, would be justified. How about the case of the other utility operating in a different sector, e.g. telecommunications?

In addressing the above questions relating to knowledge transfer, a couple of things might be borne in mind:

a) The network licensees in Britain work within a quasi-competitive environment in that, particularly in a price control review, their performance, plans and rewards are judged relative to each other. Even if one licensee seeks knowledge from another, is it reasonable to expect the second one to give it up? If the latter's knowledge has been acquired with the support of Low Carbon Networks Fund (LCNF), NIA or NIC money, clearly it is reasonable as the LCNF, NIA and NIC conditions place a clear obligation to disseminate knowledge. On the other hand, if the company's investors have funded it, perhaps it is not.
b) Is it reasonable to expect each and every network licensee to "do what competent utilities do", as judged by reasonable international standards, and to deny them the use of customer's money to build up to such a level?

Arising from (a) is a further question: at what point do the penalties of competition outweigh the benefits? What benefits can come from collaboration and more knowledge sharing as 'business as usual'[4]?

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[4] There are some excellent examples of forums for the sharing of knowledge among network utilities, manufacturers, consultants and academics internationally, e.g. CIGRÉ. Our experience is that National Grid has, broadly, continued to engage with CIGRÉ but that SP Energy Networks' engagement has waxed and waned. The other GB electricity network licensees seem to have no engagement with it at all, though a number are regular attenders of CIRED conferences.

Arising from (b) is a further question: who would be qualified to judge the level of competence and how would they do it? It seems very unlikely that Ofgem could acquire the level of technical expertise to do so (although Ofgem should perhaps have a sufficient level to ask pertinent questions so as to reduce the chance of complacency on the part of the licensees); the personal experience of one of the authors of this response is that even professional engineering consultants engaged by Ofgem to review network licensees' capital expenditure plans are not fully qualified to do so. Perhaps an assessment of competence should be left in the category of "too difficult" and the principles of output performance measures that are a key component of the 'RIIO' arrangements are developed further as the only practical way of assessing (though only retrospectively and imperfectly) competence as indicated by outcomes. However, it may also be noted that what the network licensees are required to do is, to a large extent, determined by standards and codes (even if those standards and codes rarely say *how* to do it). In that light, the proposals put forward by The IET in respect of a 'system architect' – broadly, as we understand it, a body or individual with the responsibility to ensure coherence between different standards or codes – seem significant[5].

1.3 Management of NIA or NIC projects

We have some serious concerns about the 'Successful Delivery Reward'.

According to Ofgem, "Ten percent of the total NIC funds available each year will be set aside each year for the Successful Delivery Reward"[6]. Ofgem further states that the reward criteria will be project specific but that they are:

- "linked to meeting identified targets for the outputs that will be expected to be delivered through the Project;
- linked to meeting identified Project milestones on at least an annual basis;

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[5] The governance of standards and codes relating to electricity transmission is, in our view, quite open with, in general, clear opportunities to propose changes and clear processes for evaluating proposals (albeit the processes are arguably much too slow). Arrangements relating to standards and codes applying to electricity distribution are much less clear. They are largely left to the Energy Networks Association (ENA); given that the ENA is an industry association dominated on the electricity side by the Distribution Network Operators and spends much of its time lobbying on behalf of the network companies, we would question whether it is wise to leave the management of codes and standards to them.

[6] Electricity Network Innovation Competition Governance Document version 2.1, https://www.ofgem.gov.uk/publications-and-updates/version-2-1-network-innovation-competition-governance-documents

- linked to achieving the proposals it puts forward for the generation of new knowledge to be shared amongst all Network Licensees; and
- SMART – specific, measurable, achievable, relevant and time bound."

In our view, the view the way the above criteria appear in black and white fails to acknowledge the nature of R&D[7]. This is, fundamentally, that things are uncertain. This has the consequence that, whatever tests are planned or findings are anticipated, unexpected things will arise that must be assessed and are very likely to either delay subsequent work or even to change the direction completely. If it were not the case – if things were very certain – there would be no justification for an innovation funding allowance. In addition, as far as we are aware, it has often been the case that LCNF, NIA or NIC projects have been managed by individuals within the network licensees who have experience of project management but no experience of managing research or development. This contributes to a lack of recognition of uncertainty.

It may well be argued by Ofgem that they recognise that the process of innovation is uncertain and that plans can change or activities can slip. However, in our experience in at least some cases, the network licensees lack confidence that their explanations and arguments for changes to a plan or the schedule of expenditure and deliverables will be understood and accepted by Ofgem.

As a consequence of the above, in many cases the licensees have interpreted 'success' of an innovation project as only arising if the idea being investigated is adopted as business as usual. In some cases, this has the result, firstly, that projects are commissioned only if they are judged to have a high chance of 'success', in which case there would seem to be relatively little doubt about the outcome and one wonders why innovation allowance money – designed to account for risk and uncertainty – was needed; and, secondly, negative or inconclusive results can tend to be hidden even when they are quite understandable and contain important learning[8].

In our view, 'success' should concern the *quality of the evidence gained* either that an innovation should be adopted (and how) or that it should not (if certain conditions are

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[7] Ofgem notes that "The Expert Panel and Ofgem may suggest changes to the Successful Delivery Reward Criteria proposed within the Full Submission as part of their consideration of the Full Submissions". It might be speculated that the seeming relative lack of experience of R&D on Ofgem's 'expert panel' does not help in this regard.

[8] To be fair, we see this tendency as reducing. In recent times, our impression is that many of the network licensees are becoming more open in respect of sharing lessons on difficulties encountered, and this is much to be welcomed. For further discussion on how the DNOs, in particular, have reported project outcomes, see our answer to Question 8.

not met). This implies that a robust, informed judgement regarding the proposed innovation can now be made. This, in turn, implies that one of the criteria for assessing whether a given project proposal should be funded is whether there is a clear articulation of relevant research questions and a clear plan for how to gain answers to the questions supported by the collection and evaluation of evidence. It may well be that the answers obtained are not what was expected at the outset; however, if the evidence is strong (including evidence that the question is harder to answer than first thought), that would be a success.

In what might be an over-generalisation, our feeling is that the network licensees had, over the last 25 years, broadly forgotten how to undertake, manage or report R&D with the result that experiments – necessary to test ideas or gain knowledge – are not always well designed and reports sometimes fail to follow good scientific practice in providing the means by which others might test the results and conclusions. Having said that, we believe there is now evidence that at least some network licensees are becoming much better at managing and reporting R&D. The quality of published outputs has improved through the lifespan of the LCNF. (See further discussion of LCNF outcomes in our response to Question 8).

The expertise necessary to support not only innovation projects but also best engineering practice in an evolving 'business as usual' is discussed in our answer to Question 10.

1.4 Omissions from the NIA and NIC objectives: addressing threats

In our view, there is a significant failure in the NIA and NIC criteria to recognise that uncertainty is not just something that prevents exploitation of an opportunity but might instead concern a threat that is not well understood.

An example of the former might be real-time thermal ratings: how do we do it, what does it cost, and what are the risks and benefits? An example of the latter is the public's perception of electromagnetic fields. There is no clear, consistent evidence of a detrimental effect on health but some people believe there is, nonetheless, a detrimental effect. There is clearly a need to keep investigating, but who pays for it? Other examples are:

- the possibility that a power system with too little inertia will be inoperable – we do not yet know if that is true or how little inertia is too little;
- what would be the impact of SF_6 gas use being banned[9]?

[9] Sulphur hexafluoride – SF_6 – is an excellent electrical insulator widely used in power system switchgear to aid the extinction of arcs created by the isolation of short circuit faults, and increasingly used in compact high voltage substations. It is also an extremely potent greenhouse gas.

2 Should we give more of an indication of where we consider innovation is required or is that inappropriate?

To date, it has depended on the network licensees to identify areas of work for which they seek innovation funding support. Although the LCNF budget has not been fully utilised, interesting and potentially useful areas for investigation have indeed been identified. However, on the other hand, it is our view that, welcome as this is, work on assessing the potential impacts of a significantly changed generation mix – in particular weather dependent, power electronic interfaced renewables and generation of any kind embedded within the distribution networks – has been slow to be addressed. (The studies published by the GB network licensees to date seem to be less mature than those commissioned by, for example, Eirgrid). Something similar might be said in respect of the potential contributions of flexible demand and how to enable it.

Even if there is agreement with the above opinion, it is not necessarily the case that stronger direction from, for example, Ofgem is needed now. For instance, the efforts now being invested by National Grid in the 'System Operability Framework' is very welcome and, in our view, much needed[10]. Nonetheless, to avoid the risk of delay in addressing future issues, perhaps there is a need for Ofgem or Government to be more proactive in highlighting areas in need of investigation. Whether they have or can be expected to have the level of technical expertise to do so in a useful way is another question. Academia could be envisaged as assisting; however, as we highlight in our response to Question 10, we feel that there are currently some issues relating to UK universities' capacity in relevant specialisms.

[10] We might add that, given the licence conditions pertaining to all the GB electricity transmission licensees and the role they play in facilitating connections and ensuring compliance with the Security and Quality of Supply Standard (SQSS), and the increasing significance of generation embedded within the distribution networks, the challenge of ensuring future system operability is not limited to National Grid. Moreover, there is significant engineering expertise sitting within the two Scottish transmission licensees that National Grid and GB electricity users could benefit from collaborating with.

3 Should the focus of the NIC and NIA be broader and cover the broader energy system?

Climate change is affected by carbon emissions largely associated with use of energy for any purpose, including heat and transport and not only electricity. Decarbonisation of the electricity system and substantial electrification of heat and transport currently seem very promising as a route to resolution of the tensions inherent between the goals of arresting climate change, providing a reliable supply of energy, ensuring affordability of energy and making the means of delivering energy supplies socially acceptable. However, there will inevitably be trade-offs between simple electrification and other options such as other energy vectors and technologies such as combined heat and power. These should not be neglected.

To address wider energy system issues would seem to require a wider set of participants in innovation projects than simply network licensees, including those that are more readily able to interact directly with energy users. The fragmented nature of the energy industry in Britain makes efficient collaboration a significant challenge.

4 Can we improve the process for deciding on which projects to approve and if so how?

As we noted in our response to Question 1, we believe consideration should be given to what questions a network licensee proposes to address and the ways in which it proposes to answer them. In our response to Question 8 we observe that in some cases LCNF projects have failed to produce meaningful evidence from technology trials due to factors including: choice of installation location, time period of the trial and inadequate data acquisition.

We would encourage greater attention to whether the pursuit of answers to particular questions requires the scale of trials proposed. For example:

- are trials of customer behaviour big enough to lend statistical significance to the results?
- do trials of control of batteries require such large and expensive batteries?

Much seems to depend on the assessment by Ofgem's 'expert panel' of, previously, LCNF Tier 2 and, now, NIC proposals. We note that, while many of the LCNF Tier 2 and NIC proposals submitted to date address engineering issues, there is only one member

of the panel at present that could be regarded as a currently practising engineer, albeit in academia[11]. Furthermore, on the face of it, there would appear to be a relative lack of direct experience of R&D. However, one difficulty with recruiting additional academics to the panel would be potential conflicts of interest if their institution is one of the partners in a bid for funding. This might be overcome by engaging one or more genuine experts from outside the UK which would also have the benefit of offering some insights into international best practice in the operation and planning of energy networks or the management of R&D.

We trust that the members of the 'expert panel' are able to improve their understanding of network innovation needs and the challenges involved in improving business practices and the delivery of benefits to customers by the network licensees. In principle, the network licensees' showcase event at which they present their innovation projects, the annual Low Carbon Networks and Innovation (LCNI) conference, represents an excellent opportunity for the panel members to gain knowledge and insights and help inform their future assessments.

5 How can we improve participation in the NIC?

We offer no particular contribution in response to this question.

6 Please comment on your experiences if you have worked with licensees when implementing NIC and NIA projects or when transferring innovation into business as usual.

We offer no particular written contribution in response to this question but would be happy to share some of our experiences in any follow-up to this consultation.

[11] It may be acknowledged that a second panel member is a Fellow of the Institution of Engineering and Technology.

7 Are there any other issues we and the independent evaluator should consider as part of the review?

We offer no particular contribution in response to this question.

8 To what extent do you consider that the LCN Fund has succeeded?

The stated objective of the LCN Fund was to help DNOs understand how they provide security of supply at value for money and facilitate transition to the low carbon economy.

Achieving such an understanding requires projects that generate appropriate learning to inform on the technical viability and cost-effectiveness of innovative technology solutions or business processes. We view the most successful learning as that which enables sufficient evidence-based understanding to make a robust business case for adopting the innovation as 'business as usual' or, equally as important, making a robust case against adopting the innovation.

Our view of the success of the LCN Fund is based on assessment of the learning outputs, the level of dissemination of project learning, and the effectiveness of the accumulated learning to inform a business case for 'business as usual'. Our assessment has been made on a review of the formal published literature from closed projects and from RIIO-ED1 submissions.

8.1 Learning Outputs

We have found the availability and format of information varies significantly across projects. Tier 1 projects publish close-down reports following a common format whilst many Tier 2 projects have produced on-line libraries containing huge amounts of material including raw data sets, insight reports, white papers, academic papers, technical recommendations, commercial templates, formal close-down reports and themed learning reports. Whilst a significant amount of learning has undoubtedly been generated, comparison and synthesis of learning across projects is challenging and a cross DNO picture of BAU status for any specific innovation is not easily determined.

We note that there is a significant variety in the quality or depth of evidence provided by learning outputs. Where well-designed and implemented technology trials have

generated detailed results over significant time periods, robust conclusions on technical viability have been drawn. If costs of replication have also been given sufficient consideration and utilised in appropriate cost benefit analysis (CBA), a view on business case for BAU has been taken. We note that learning outputs do not always achieve this. There are cases where technology has been trialled but reporting indicates that either choice of location, time period of the trial, or other confounding factors do not allow meaningful results to be presented. Although some modelling or extrapolation based on related data may have been attempted, this cannot support as robust conclusions as detailed trial results would.

From the variety of approaches to field trial implementation, reporting and extrapolation, there is undoubtedly scope to extract best practice in *experiment design* and *analysis of results* that enhance the value for money from future innovation spend.

8.2 Dissemination

Dissemination has primarily occurred through publication of learning outcomes as described above, project specific dissemination events and via the LCNI conference. Although the LCNI event has undoubted value in networking and gathering of the stakeholder community, our view is that it primarily provides a public presentation of 'who is doing what' rather than enabling productive knowledge sharing[12].

Although many projects trial similar solutions and technology we have found no synthesis of learning for LCNF projects across common areas of activity. However, we note that in the areas of active network management of distribution networks (ANM) and electrical energy storage, DNOs have contributed to ENA and EA Technology led projects to produce best practice guides.

We suggest that further collaborative efforts in these and other areas comparing technical results and cost benefit analysis would serve to highlight which solutions are closest to BAU and where further innovation investment is either required or unjustified.

We would also strongly suggest that Ofgem either carry out or commission a proper evaluation of the learning that has come out of the LCNF and other innovation schemes in order to determine what lessons have been learned, both for the benefits of key players but also for Ofgem in helping to improve the design of future schemes.

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[12] The Energy Networks Association (ENA) has been responsible for the organisation the initial LCNF conferences and, now, the LCNI conference. The events have improved significantly over the years. However, our view and the view of many others we spoke to at the event in 2015 is that the opportunities for learning are, to a very large extent, held back by the quality of organisation. This includes a failure to provide a clear programme that offers accurate information on what can be expected in the various presentation sessions running in parallel.

8.3 Accumulated Learning

We identify six core areas that encompass the majority of LCNF project activity and learning outputs.

8.3.1 Network visibility

Many projects have focussed on network monitoring and visualisation as well as smart meter data acquisition and analysis. Technical capability and understanding of requirements for monitoring have been significantly developed in general (but to greater and lesser degrees between DNOs). Specific points we highlight here are:

- New 'after diversity maximum demand' (ADMD) assumptions, customer categorisations and profiles for use in planning software (such as WinDEBUT[13]) are now available along with enhanced low voltage (LV) substation load profiling. However, these vary between projects and a consensus is yet to be reached.
- Although an updated understanding of load may be expected to have significant value, the new load time series profiles broadly follow expected patterns and look very similar to the legacy profiles, perhaps because anticipated changes such as more electric heating, electric vehicle charging and flexible demand have not yet taken place to any significant extent. More advanced, probabilistic methods of modelling and forecasting load have had limited attention – advanced planning techniques are likely to be required but are in very early stages of development.
- Findings on low carbon technology (LCT) ADMD and half hourly profiles are from small sample sets – further work to characterise the variety of LCT demand for robust planning will be necessary as deployments increase.
- Strategies for staged deployment of network monitoring and optimal use of network and smart meter data have been proposed – approaches vary between DNOs and further knowledge sharing and collaborative efforts to establish best practice seem merited.
- Several RIIO ED1 plans state an intention for advanced data acquisition and utilisation; however, the data analytics techniques/tools required to maximise the value of this data are in early stages of development (or indeed absent) from LCNF outcomes and hence represent an area of innovation priority for DNOs.

8.3.2 Flexible demand

In the area of management and control of responsive demand, extensive trials have taken place ranging from directly controlled load in the industrial and commercial (I&C) sectors to domestic consumer tariffs.

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[13] http://www.eatechnology.com/products-and-services/create-smarter-grids/windebut

- I&C demand side response (DSR) trials have generated good evidence and business cases for BAU seem to be clear and positive.
- Trials of residential Time of Use (ToU) tariffs have shown limited network benefit and positive business cases for BAU have not been identified.
- Trials of direct control of domestic load have shown limited network benefit and a business case for BAU has not been identified.
- It appears that DNO interaction with residential consumer demand resource is unlikely to progress without further research and innovation work to develop a market offering that can provide a greater and more reliable location-specific response.
- Managed electric vehicle (EV) charging trials indicate good potential for DSR of new LCT loads – this area should be a focus for innovation as LCT penetrations increase.

8.3.3 Storage

LCNF projects have seen a high level of activity around the technical testing of electrical energy storage at varying scales for voltage control and power flow management along with some development of the commercial and policy aspects of DNO deployed storage though several key projects are yet to report fully.

- Storage (particularly at large scale) appears unlikely to have an economic justification for deployment by DNOs without significant reduction in costs and major efforts to clarify the regulatory and legal aspects.
- Independent of the particular technology used, large scale storage may be an attractive, flexible solution for DNOs if it can be contracted from 3rd parties. However, there are still significant issues to be resolved with connecting storage that must be free to pursue multiple revenue streams with requirements potentially in conflict with a DNO's.
- Small scale storage, e.g. embedded within energy users' premises, may become an attractive solution as technical understanding and control methods develop. However, except in respect of heat, costs are still prohibitive.

8.3.4 Connection of distributed generation

Several early LCNF projects addressed the topic of connection of distributed generation (DG, i.e. that embedded within a distribution network) using Active Network Management (ANM) and new commercial arrangements. The broad conclusions seem to be:

- ANM for DG connections should be a business as usual option considered by all DNOs and used wherever it is provides the most economical solution to the accommodation of DG.
- The solution has matured; extensive experience has been garnered and shared.
- DNOs have collaborated to produce an ANM best practice guide.

- Some commercial templates, planning tools and stakeholder engagement and information tools are now available.
- Further development of technical solutions and commercial models should take place as part of core business.

8.3.5 New network assets and enhanced utilisation of assets

Deployments of voltage management hardware, new approaches to asset ratings and alternative network configurations have been extensively tested. In many cases, the technology is not new but is new for use on GB distribution networks.

- Hardware solutions including reactive compensation, voltage regulators, enhanced automatic voltage control (AVC) at primary substations and secondary substation on-load tap-changing transformers (OLTCs) have been successfully trialled. However, definitive conclusions on the most cost-effective combination of hardware under various scenarios have yet to be made and further collaborative work on best practice voltage control strategy is required.
- New network configuration and operational policy at both HV and LV have been trialled successfully; comparisons between this solution and other options are needed to enable planning decisions.
- Real-time thermal rating (RTTR) capabilities have been well progressed and strong evidence provided on the value of such schemes to enhance managed DG connections. However, more generally, there are conflicting statements on the need for real-time ratings and, in some projects, enhanced monitoring to determine bespoke static ratings have been proposed as sufficient.

8.3.6 System management: progress towards more active operation

Some of the LCNF innovation work lends insight into aspects of the possible transition of the Distribution Network Operators to Distribution System Operators (DSOs). The prevailing message from LCNF projects regarding enhanced system management is to suggest a strategy of incremental, targeted deployment of more sophisticated monitoring and control, e.g. as issues emerge or LCT hotspots develop, to deploy monitoring and modelling to understand the problem then assess available standalone solutions versus re-enforcement. We note that most control solutions in LCNF projects have been deployed as standalone solutions dedicated towards local voltage control or power flow management. Where wide area coordinated control has been attempted, a compelling business case has not been identified. This strategy of responsive action – following hotspots with standalone control solutions – is reflected in RIIO-ED1 submissions. This leaves open questions such as: when does coordination happen? Is a distribution system operator role being planned for?

9 To what extent do we need to continue incentivising innovation by DNOs?

It has been documented that, in the years following liberalisation of the electricity supply industry in Britain, the industry's expenditure on research and development declined dramatically, particularly in the distribution sector[14]. Since then, Ofgem has introduced a number of schemes designed to encourage the network licensees – electricity and gas, transmission and distribution – to innovate and to be free to use a certain amount of customers' money to do so provided certain conditions are met[15]. We believe Ofgem is to be highly commended for this initiative manifested through the Innovation Funding Incentive (IFI), the Low Carbon Networks Fund (LCNF), the Network Innovation Allowance (NIA) and the Network Innovation Competition (NIC). The success of these schemes can be seen through the increased investment in innovation. However, in our view and as we have discussed above, they have not always been used as effectively as they could be. In this respect, we need to both identify the ways in which innovation is driven as a response to uncertainty, and to evaluate the role of innovation in the policy environment as it appears to be understood by Ofgem.

Given the licence condition towards 'economic and efficient' networks, various income adjustors introduced by Ofgem under the 'RIIO' price control regime to reward 'good' performance and the promise offered by various technologies such as those mentioned under Question 8, it might be asked why the network licensees need any innovation incentives. The 'economic and efficient' licence condition has been in place since liberalisation. Why, then, was it necessary to introduce IFI, LCNF, NIA and NIC? In our view, the answer concerns risk and uncertainty.

For the most part, the network licensees are seen by their shareholders- i.e. by investors – as low risk investments with unspectacular but safe returns. They are not exposed to competitive markets (except insofar as Ofgem seeks to compare one licensee with another in price reviews and to reward 'good' performers and punish 'bad' ones); their income is largely fixed and well-known quite far in advance. However, their

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[14] See, for example, Tooraj Jamasb, Michael G. Pollitt, "Why and how to subsidise energy R+D: Lessons from the collapse and recovery of electricity innovation in the UK", Energy Policy, Volume 83, August 2015, Pages 197-205. Jamasb and Pollitt report that annual expenditure by distribution network operators on R&D fell from almost £12 million in 1989/90 to just £1 million in 2003/4 but, following the introduction of the Innovation Funding Incentive, recovered to just over £12 million in 2007/8.

[15] See https://www.ofgem.gov.uk/network-regulation-riio-model/network-innovation

scope for making very large profits through some kind of competitive advantage is limited. In the past, it has also tended to be that their scope for increasing profit through cost reduction was limited as Ofgem, acting in way that it saw as best for consumers, tended to take a large part of that cost reduction at the next price control as part of the 'base line', i.e. to give much of the benefit to consumers (meaning less benefit for shareholders).

One feature of any innovation is that, by definition, it is new. Because it is new, it is unfamiliar and, hence, there seems to be a chance that it will not work as expected, will save less money than expected or will cost more than expected. In other words, there is risk and uncertainty.

Would the network licensees' investors welcome the licensees becoming bigger risk takers? Would, in the end, Ofgem welcome it? At the extreme, some innovation might lead to some increased unreliability of supply or failure to facilitate competition in the electricity market. ('Security of supply' and facilitation of the market are also network licence conditions). Even if that does not happen, a market perception of risk would lead to an increase in the licensees' cost of borrowing and, as a consequence, the cost of network investments increasing.

In our view, where IFI, LCNF, NIA and NIC have been successful has been in giving the licensees scope to address uncertainty, to explore an idea and gain knowledge about it before committing to it fully; in other words, to undertake research and development (R&D) that the companies' response to the regulatory regime – the squeezing downwards of costs – would not otherwise entertain. If done well, the R&D would be of long term benefit to consumers as innovations could be identified in which there can be confidence, not only with respect to delivering the core service at least cost but also in enabling new services to aid the low carbon transition.

10 Are there any other issues we need to consider as part of the LCN Fund benefits review?

10.1 The provision of expertise

We believe it is very important that NIA and NIC projects involve individuals with experience in the clear articulation of research questions, the design and execution of experiments and the reporting of results. At least some of those competencies need to lie within the network licensees that are responsible for managing projects, spending the money and reporting findings. However, the network licensees might also engage

outside parties that can contribute in those areas. There is a clear need for such capability to be maintained, both within the network companies and outside. However, it is also the case that, if innovations identified as providing benefits to customers are to be implemented, they depend on appropriate skills within the core businesses of the network licensees and successful transfer of knowledge from a completed project into the core business.

An obvious place to go for the necessary experience in the process of generating knowledge is a university. The UK does have a base of expertise in power systems that compares quite well with other countries. There is also a base of academics who can contribute in respect of, for example, statistics, though few of these have much experience as yet of the particular context of power system planning and operation. However, one sign of the relative inexperience of the network licensees has been, as we have observed it, a tendency to assume that all universities have expertise in all areas. That is an incorrect assumption, and failure to engage suitably qualified project partners – whether academics or otherwise – risks inefficient use of customers' money.

A much greater penetration of low carbon generation, in particular (but not only) weather dependent renewables, will dramatically change the physical characteristics of the power system, in particular its dynamics. A relatively small system such as that in Britain will be especially sensitive to that. In our opinion, the network licensees will all require significantly enhanced technical capability in terms of both tools and expertise[16]. In the DNOs' case, in particular, that means retaining and enhancing skills among fitters and craftspeople but also developing deeper levels of core power systems understanding and creativity among professional engineers. This requires an investment in recruiting, developing and retaining people that, in our view, needs to be recognised and committed to by both senior network licensee managers and those in Ofgem responsible for setting cost recovery allowances.

10.2 The role of universities

As academics, we are conscious of the universities' role in providing basic professional education. Worryingly, across the UK as a whole, the number of people choosing to study electrical or electronic engineering at university fell by more than 40% between 2002 and 2009[17] and, if it has improved since, has done so only moderately. However, given the technical challenges that will be faced, we believe that it will be increasingly

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[16] For some discussion of relevant issues, see, for example, the suite of papers available here: http://www.theiet.org/sectors/energy/resources/modelling-reports/papers.cfm

[17] K.R.W. Bell, W. Fenton, H Griffiths, B.C. Pal and J.R. McDonald, "Attracting Graduates to Power Engineering: Successful Industrial Engagement and Collaboration in the UK", *IEEE Trans on Power Systems*, vol. 27, no. 1, February 2012.

important to attract a sufficient number of the most able individuals to electric power engineering degrees not only at a Master's level but also a doctoral level in order that at least some will benefit fully from the associated training and go on to form a critical core of senior industry engineers. However, doctoral level training exclusively within a university is not the only way that advanced knowledge can be gained. Close engagement with the challenges being addressed in NIA and NIC projects – and not only shuffling management spreadsheets around and chasing contractors for invoices – provides an excellent opportunity for individuals to learn[18]; if they are well connected with the core business and not working solely within an isolated innovation unit, transition of good ideas to 'business as usual' can be much enhanced[19].

The University of Strathclyde respondents are pleased to report that Strathclyde bucks the apparent UK trend in developing power engineers and is educating growing numbers. Although it is only one of eight universities across the UK in the IET Power Academy, it has provided more than 35% of the students on the scheme[20]. However, if the future needs of the power industry and, ultimately, of consumers are to be met:

- the numbers of good students applying to all UK universities that offer accredited electrical engineering programmes needs to be boosted; and
- simply admitting more students is not sufficient in itself.

Only so much can be done to build people up to a certain level of understanding and professionalism, and that requires investment in teaching capacity. If that is not done correctly, the tensions inherent in academics' traditional role in both providing core teaching and leading research will be increasingly irreconcilable.

Universities in the UK can play a key role in helping the power companies' transition to the new, low carbon world. This requires not only individual academics who meet standard university performance metrics by churning out learned papers but teams that are capable of helping industry navigate the challenges facing them, resolve key uncertainties and adopt appropriate innovations. In a context of continually squeezed public spending where the research councils are under the same pressures as other

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[18] In practice, industry support of PhD students can provide invaluable industrial relevance and useful results that complement the educational process, and network licensee staff can gain from exposure to the knowledge and practices of universities, provided they are given the opportunity to engage closely.

[19] Quite what organisational structures work best for both the identification and management of good R&D projects and the transfer of knowledge to inform 'business as usual' is an open question to which we do not pretend to know the answer.

[20] See http://conferences.theiet.org/power-academy/ for more about the Power Academy.

public bodies, the support provided by NIA and NIC is extremely valuable in helping to ensure that academics' work is industrially relevant and has 'impact' and in providing funding to employ researchers. However, in our view, one of biggest challenges faced by academics is the attractiveness of research contracts. Since they are typically offered only in respect of specific projects they are inevitably only fixed term and the salaries do not always compare well with other sectors where numerate, communicative problem-solvers are sought. Some investment in building and retaining research capacity is, in our, view, of long-term importance whether it comes from exclusively from Government or can be helped by other funding sources.