ANNEX 23: INNOVATION STRATEGY

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Bringing energy to your door

Our Innovation Strategy

March 2014

Our innovation strategy

Welcome to Electricity North West's innovation strategy document. This document describes how innovation plays a key role in helping Electricity North West deliver a responsive and sustainable business for our customers, stakeholders, and the millions of people who depend on us every day.

Innovation is one of our core values and we are leading the industry in developing innovative solutions that challenge and improve the way we do things for our customers and stakeholders. Our innovation strategy sets out why we innovate, in what areas our efforts are focused and most importantly the benefits to customers from our past and future innovation plans. Our track record in developing industry leading technologies and techniques within DPCR5 continuing into RIIO-ED1 has enabled us to commit to £131 million customer savings in our RIIO-ED1 business plan through cost avoidance and efficiency improvements.

Our innovation work spans the entire range of our activities; our work on condition based asset management techniques has fundamentally changed the way network assets are managed delivering tens of millions of £s of savings for customers; our smart grid work has pioneered new commercial and technical approaches that will deliver the transition to a low carbon economy at an affordable cost to customers. Our future innovation programme builds on this, encompassing both smart grid and smart metering to deliver benefits across customer service, asset management and network resilience. Over the past four years we have developed world leading network automation technologies to improve the reliability of supply to our customers. These systems automatically restore power to hundreds of thousands of customers every year and we are continuing to develop this technology.

At the heart of our innovation strategy is the principle of maximising the use of existing assets via innovative solutions to deliver greater value for customers. Whilst new technologies will be required to supplement existing assets we believe this approach is the key factor in delivering value across the entire service range. If it is possible to encompass our smart grid strategy in its most simple form it is to: "Reliably transport the optimum amount of energy through our network whilst ensuring the effects of aging assets are managed to deliver optimum service for our customers and value for Electricity North West and our stakeholders".

Our industry leading Capacity to Customers (C_2C) and Customer Load Active System Services (CLASS) projects, funded under the second tier Low Carbon Networks (LCN) Fund are examples of applying additional low cost smart technology to existing assets to maximise their utilisation. C_2C combines a revolutionary development in network management with innovative commercial contracts to maximise the amount of capacity available to customers, whilst CLASS aims to revolutionise network voltage management to deliver a demand response without customers being affected. The recently awarded eta project (renamed Smart Street) aims to transform the operation of the low voltage network enabling customers to quickly and cheaply connect Low Carbon Technologies.

We will invest over £26 million in innovation in DPCR5 and propose to invest at least £24 million in RIIO-ED1 that will deliver £133 million of customer savings in RIIO-ED1 and an anticipated £180 million in RIIO-ED2. We are seeking an innovation funding rate of 0.8%, equivalent to £3.0 million per annum, for RIIO-ED1. Our plan is detailed in this document, the main aim being to continue the preparation for the transition to a low carbon economy by developing tools, techniques and equipment that make more use of existing assets, already funded by our customers. As a single DNO we are not able to leverage group innovation funding ie multi DNO allowances. Whilst we will maximise use of other DNOs' R&D work, failure to secure the full 0.8% would place our business in a position of being unable to deliver the level of innovation benefits we have forecast in our business plan and hence increase costs to customers.

This document is for all our stakeholders. We'd welcome comments on any aspect of our innovation strategy and we will continue to seek stakeholder input into our innovation strategy and plans on a bi-annual basis as they are amended to reflect external influences through the period 2015 to 2023.

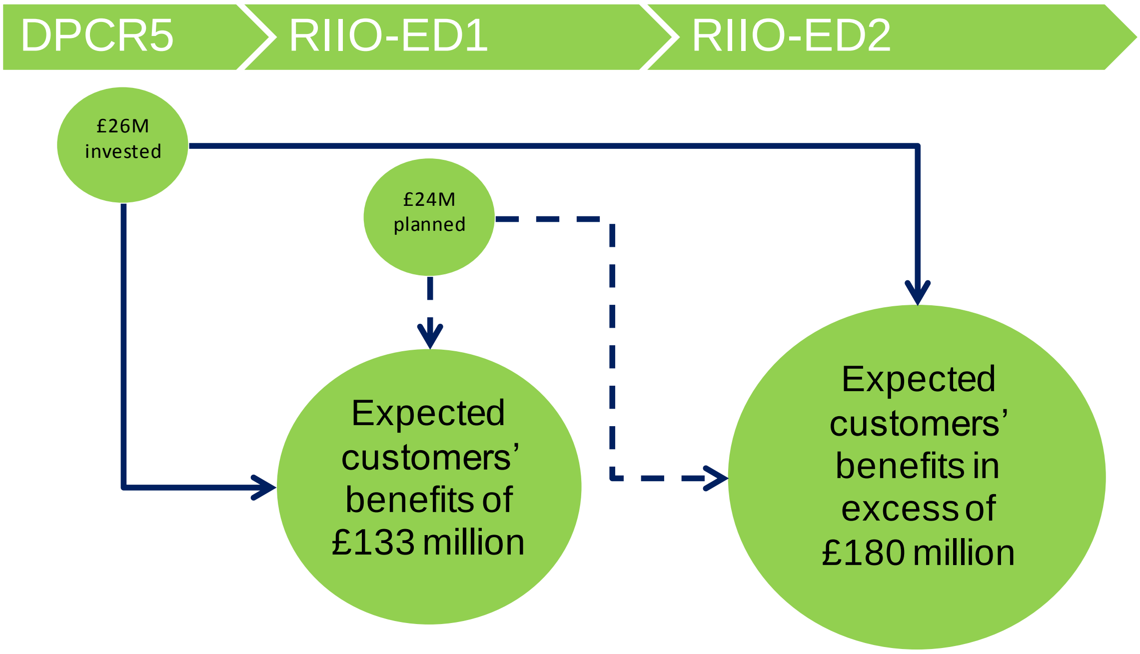
Steve Johnson, CEO

Contents

1. We are delivering benefits to our customers

In DPCR5 we expect to invest over £26 million in innovation, this combined with our innovation plan for the RIIO-ED1 period will enable us to deliver about £132.5 million of benefits for customers in RIIO-ED1 and predict to deliver in excess of £180 million benefits in RIIO-ED2. Figure 1 illustrates the customer savings that are directly enabled through our innovation plan. This is a significant return on investment.

Figure 1: Predicted customer savings from previous and future innovation spending compared against traditional techniques



Our work with stakeholders shows that their requirements centre around three consistent themes, namely reliability of supply, sustainability of operations and affordability of service. Figure 2 below shows diagrammatically their priorities centred on the key requirement of providing excellent customer service.

Figure 2: Our stakeholders' priorities

Our innovation plan is driven by these stakeholder priorities and our focus for the remainder of DPCR5 and RIIO-ED1 is split correspondingly into three broad areas which are illustrated below and described in more detail through a sample of case studies in the following sections.

Table 1: Key innovation themes

Affordable reliability	• Optimise the life of assets to keep costs down whilst maintaining reliability through refurbishment and monitoring.
	• Operate networks in new ways to deliver more capacity or value to customers though real time automation.
Customer Service	• Improve customer reliability through better understanding of macro asset performance and intervention timing.
	• Offer new services and choice to new and existing customers.
	• Keeping our customers better informed
Sustainability	• Enable customers to adopt low carbon technologies at an affordable cost.
	• Allow low carbon / renewable DG customers access to network capacity for less.
	• Reduce the carbon cost of our operations and investments

We are seeking an innovation funding rate of 0.8% for RIIO-ED1 which equates to an annual investment of £3.0 million on our innovation portfolio. This is a slight reduction in the level of investment we made in DPCR5 but above the default value of 0.5% for a licensed distribution network operator.

The reduced funding proposed in the RIIO-ED1 period is the result of two factors. First, we anticipate that more learning will be available from the wide range of projects being delivered by others or developed collaboratively with other partners. This allows us to identify and implement best practice solutions without the full cost burden of extensive research and development being passed on to our customers. Second, we have already funded a number of innovations from the efficiencies they yield in our expenditure plans, such as Connect and Manage and our work on promoting energy efficiency. We will continue to utilise this approach in RIIO-ED1.

The additional 0.3% requested above the default value, which equates to £1.1 million per annum, is sought to fund the full scope of our proposed innovation programme; without this funding we will be unable to deliver the expected customer savings through RIO-ED1 and ED2. Over £50 million of customer benefits are at risk, which if the funding was not granted would increase costs to customers.

We also understand that we may not be able to predict the scale and complexity of future innovations. For larger scale innovations we will apply for additional funding through the Network Innovation Competition (NIC) with our partners. Plus we will seek funding from the Innovation Roll-out Mechanism (IRM) that will also allow us to deliver RIIO - ED1 innovations with our partners for our stakeholders. We are committed to sharing our knowledge and experience with other DNOs through our continued chairmanship of and contribution to industry forums and working groups.

2. Real value from innovation

Our customers should be confident that our innovation journey is aimed at continuously improving networks so that they are reliable, affordable and sustainable whilst delivering excellent customer service. In DPCR5 we have already shown that our innovation can deliver real performance improvements and benefits for our customers.

Innovation in reliability

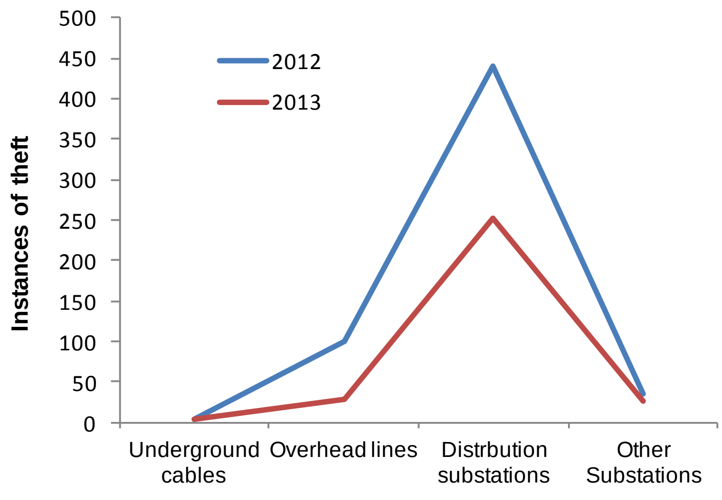
Knowing when to invest in replacing, refurbishing or retiring our assets has a fundamental effect on the reliability of our network and the quality of service experienced by our customers. We have developed best practice asset management strategies through the development and extension of Condition Based Risk Management (CBRM) and Condition Data Capture, which allows greater visibility of the health of our assets. Once we understand the health of our assets we can then determine the appropriate intervention and investment required. We have led the industry in pioneering this approach and it is now widely used and referenced by all DNOs.

CBRM helps us develop whole life asset management strategies based on analysis of current and expected future performance. We have invested £0.5 million in this initiative so far and have realised approximately £50 million in benefits through cost and delivery efficiency and scope optimisation. CBRM is now a business-as-usual activity and has played a major part in supporting our business plan.

We partnered with the University of Manchester to research the benefits of in-situ oil regeneration for our transformers. We can now regenerate transformer oil on-site through this pioneering technique, reducing the need for removal and replacement and significantly extending the operating lives of our transformers. Extending the life of existing transformers also has significant carbon benefits reducing the consumption of steel, copper and other resources. We have used the Innovation Funding Incentive (IFI) investment of £0.2 million to defer significant non-load related investment during RIIO-ED1. In RIIO-ED1 we plan to use this technique to avoid the replacement of over 12 Grid and 77 Primary transformers, which will save customers an estimated £33 million.

We have worked extensively with local police forces and specialist security advisors to develop a number of innovative techniques to complement more traditional security strategies in order to secure our network and reduce the number of customers suffering supply interruptions due to criminal activity. These initiatives have been successful in both stopping further increase in metal theft and in helping deliver a 46% reduction in theft instances.

Figure 3: Trend of instances of theft from distribution network



Examples of innovative techniques include:

- *Metal theft* – A marking system for copper earth tapes and cables that allows positive identification of the materials rendering them extremely difficult to dispose of without detection;
- *Active tracking* – New technology adapted from military applications where tracking devices are attached unobtrusively onto most types of substation assets and materials. The equipment can then be monitored and tracked when moved, allowing recovery from theft; and
- *New security measures* – A number of initiatives specifically targeted to limit the impact of theft at substations including a £3.2 million implementation of new electrical mechanical locking systems across 500 sites to prevent illegal access to secondary network substations.

Innovation in sustainability

We play a lead role in the Smart Grid Forum and development of the Transform model that is used by all Distribution Network Operators to quantify the needs and benefits from smart grid solutions. We have also used IFI funding to develop a more granular network capacity management model which we call our Capacity Headroom model. This model supplements Transform and allows us to understand how our customers use our network now and forecasts the future impact of adopting Low Carbon Technologies (LCT) such as electric vehicles and heat pumps on the LV network individual feeder-by-feeder level. Whilst this model tells us where our load carrying capability has to increase we also use it to more accurately target our future requirement for smart grid or network reinforcement solutions. This ensures that we can deliver low carbon solutions whilst minimising the cost of network reinforcement for our customers.

Our stakeholder engagement has clearly shown that in order for customers to adopt LCTs, the connection experience must be streamlined and simple. We have led the ENA heat pump and electric vehicle group to implement customer-friendly connections processes.

We have developed Demand Side Response (DSR) solutions to ensure we can support more sustainable technologies whilst maintaining reliability and affordability. DSR involves customers agreeing to shift their consumption patterns away from times of peak demand. This gives us more options to optimise network capacity and less reliance on reinforcement work. We have developed new technologies and commercial options under our Second Tier LCN Fund innovation projects to allow us to connect more renewable / low carbon generation and demand to our networks. These technologies will be developed further under our RIIO-ED1 innovation plan and we have included over £10 million of savings for customers in reinforcement costs through RIIO-ED1 under the DECC Low scenario.

Innovation in affordability

The cost of connecting to our network can be prohibitive for some customers. We have invested in the development of innovative commercial arrangements under our LCN funded Capacity to Customers (C_2C) programme to make this service more affordable.

New commercial arrangements allow customers to connect to the network using latent network capacity and offer voltage managed contracts for Distributed Generation customers. The real-time network voltage is used to control the use of existing assets, enabling us to minimise the connection costs of new generation connections. We are the first DNO to enter into these types of commercial arrangements with customers.

We recognise that developing solutions to address fuel poverty and help our vulnerable customers is extremely important. We have been working with a range of charities and government bodies to truly understand the issues around fuel poverty and how we as a DNO can make a positive difference. We have worked with Save the Children and National Energy Action (NEA) and have hosted a working dinner on fuel poverty with MPs from the North West at the Houses of Parliament. By focussing on the price impacts of every decision we have put together a business plan that proposes the largest reduction in distribution charges of any DNO to ensure we play our part in reducing fuel poverty.

We have implemented Connect and Manage strategies for low voltage domestic micro generation, such as solar panels. In Stockport we transformed our processes for connecting large numbers of solar panels on the roofs of social housing by introducing this Connect and Manage approach. This has reduced costs for Stockport Council considerably, as it negated the need for costly and time-consuming investigations into scenario and load planning. Instead, we simply connected all the solar panels, deployed inexpensive LV monitoring and dealt with a very small number of resulting problems. The trial was so successful that this Connect and Manage approach has replaced our existing process for all solar panel connections enabling benefits of lower energy costs and improved amenity in social housing across our network.

We are currently conducting a feasibility study with NEA and Stockport Council on an innovative project to upgrade their social housing stock and tower blocks to renewable heat. Rather than spending money to reinforce the local electricity network we have taken the innovative approach of improving the energy efficiency and insulation of the properties instead. The energy efficiency reduces the amount of energy required to run the properties and therefore reduces the need to reinforce our network. We will trial this approach later in the year alongside other techniques for reinforcement avoidance such as Demand Side Response. We and NEA believe that this sort of innovative approach not only saves money, and is environmentally friendly, but more importantly directly helps those most in need of support by reducing household energy bills.

Innovation in customer service

When we talk to customers they tell us that repeated supply interruptions are unacceptable. Analysis of the performance of our LV network revealed that transient cable faults produce many repeat faults and have a very significant adverse affect on our customers. These intermittent faults disrupt customers' supplies and often have no readily identifiable cause and can occur a number of times before the fault is localised and repaired.

To solve this problem, we have worked with Kelvatek, a UK technology manufacturer, to develop a number of devices such as the Modular Re-Zap (a unit that switches loads on low voltage networks) and the Bidoyng smart fuse (a device that can automatically restore customer supply in under three minutes). These devices have transformed the management of LV network cable faults. We will continue to implement this technology on our network and assist other DNOs by passing on our learning. Our initial £0.4 million innovation investment has resulted in over £2.3 million of price reductions on equipment purchases from our suppliers, a benefit that is passed on to our customers through cost reductions and more importantly improved supply reliability.

Almost 50% of the visitors to our website used a Smartphone or Tablet to access key pieces of information and over 25% of our website visitors access our website specifically looking for power cut information. With input from our customers we have developed a mobile friendly website that fits customer needs by giving customers accessibility irrespective of the mobile device they are using. This is ideal when customers are looking for information during a power cut and the use of a desktop personal computer is not an option.

In 2014 mobile internet use is expected to take over from desktop internet use, making this service crucial to enhancing our customers' interactive experience with us. Additional information on our track record of delivering customer value from our innovation projects is contained later in this document in the section titled "Our track record".

3. Innovation strategy

3.1 Why innovate?

Innovation is one of our core values and we are leading the industry in developing innovative solutions that challenge and improve the way we do things and deliver savings for our customers and stakeholders. This is our culture; it's about continuous improvement in everything we do to deliver our commitments of customer service, affordability, sustainability and reliability for our network services. Innovation is a good way of ensuring that customers continue to enjoy a value for money service. As we have demonstrated during DPCR5, modest amounts of investment in innovation projects can when successful realise material savings to customers.

Innovation funding is therefore essential to allow this work to continue and for the associated benefits to be realised by our customers and stakeholders. Innovation creates many benefits across customer service, reliability and cost reductions, depending on the nature of the benefit some are shared with customers and some accrue solely or in the main to customers. For example reductions in investment volumes, through transformer regeneration or CBRM accrue directly to customers. Other examples include Connect and Manage or new connection techniques that reduce connection charges. Where we do not receive a material share of the benefits then without innovation funding we would therefore be unable to fund the developments necessary to achieve these improvements. Some areas of innovation create shared benefits, for example network supply restoration automation. In such instances where our share of the benefits enables us to fund the work we have not requested innovation funding, this is a continuation of our policy in DPCR5. Where the benefits are shared but insufficient value accrues to enable us to fund the work we have included costs in our innovation plan to allow customers to receive the benefits.

There are significant challenges from transition to the low carbon economy, so we have a Future Networks team, within our Network Strategy directorate, focussed on finding value for money innovative solutions to these problems. We see our relationship with customers changing as we develop and offer innovative technical and commercial solutions. As we start to provide greater choice to customers and in some instance seek services from customers we will become a smarter network operator and take the first steps towards becoming a distribution system operator.

We have a demonstrable track record of delivering smart grid solutions targeted at key issues that affect our customers and network. Examples include:

- the installation of the first UK network demonstration of a super-conducting fault current limiter, which allows fault level constraints to be managed without resorting to traditional expensive switchgear replacement,
- Connect and Manage approach to the installation of micro-generation to the LV network;
- the development and deployment of the smart fuse, aimed at enhancing customer service by eliminating a high proportion of transient fault interruptions; and
- first UK installation of capacitors to the LV network for voltage regulation and optimisation.

These projects were designed to deliver real benefits to customers that could be measured and compared with traditional approaches. In addition to these, we have delivered a number of projects that have had measurable benefits for customers such as voltage control monitoring and finding ways of connecting the increasing DG without incurring reinforcement. We have delivered high levels of 'Connect and Manage' connections, facilitated through finding innovative approaches. Our work on design standards for smart grids shows that it is not in the interests of customers to always design for network extremes; rather we should operate for anticipated conditions that appropriately balance risk and infrastructure. As a part of introducing new techniques such as DSR we have most recently through our C_2C project proposed revised guidelines in ETR130 for the management of DSR. Allied to this, we have used our leadership in the ENA and in the Distribution Code Review Panel to initiate a fundamental review of the ENA Engineering Recommendation P2/6 Planning Standard.

We believe innovation in standards will continue to be a consistent theme throughout the remainder of DPCR5 and ED1. Our challenge of and leadership in the development of European codes and the evolution of GB standards will continue as a means of delivering additional value and security for customers.

3.2 Innovation principles

Our continuous improvement journey is led by the needs of our customers. Our approach to innovation is described in the three guiding principles we apply when considering innovation:

1. We aim to understand and respond to the changing needs of customers;
2. Collaboration with partner organisations find innovative solutions; and
3. Involving customers in our innovation work ensuring potential innovative solutions deliver customer benefits.

Before committing funds to a project we validate that the technology is likely to be economically viable and that the problem is within the timescale of our business plan. This ensures that we focus on projects most likely to deliver actual value to customers in the near to medium term. Whilst we do support technology that has a very long term development period such as storage, we do this through collaboration with other DNOs through the Energy Innovation Centre and EA Technology's Strategic Technology Programme. We chair EA Technology's Strategic Technology Programme.

Where appropriate, we have drawn upon the work of other DNOs to inform and enrich our own work:

- WPD's LV network templates have been of considerable assistance in our work on LV network solutions;
- Previous work by UKPN on network meshing and LV sensors has informed our view on micro DG connections;
- We have also drawn upon the work of Scottish Power Energy Networks in Active Network Management to inform our strategy on network balancing automation;
- Our work with National Grid on the strength of DSR signals from industry participants was instrumental in the formulation of our DSR projects and load-related business plan;
- We also note the work of Smarter Grid Solutions with Scottish and Southern Energy, amongst others, on DG scheduling integration into control room operations; and
- We have also worked collaboratively with other DNOs on the development of the Transform model which contains the cost benefit analysis for all known smart solutions; we used Transform to price our load related investment plan including this additional value for customers in our business plan.

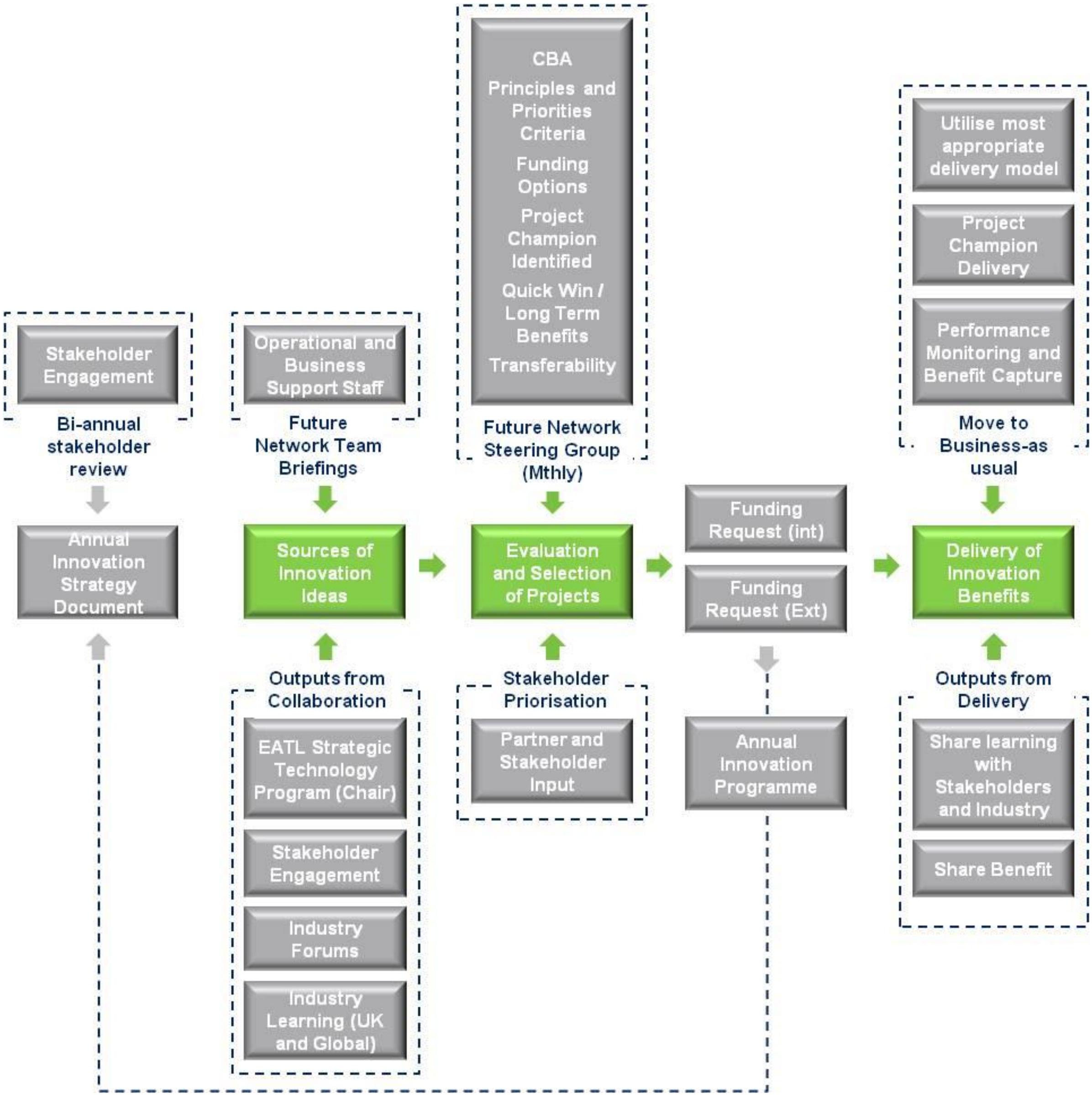
It is clear that the value arising from collaborative work on smart grids and smart meters is significantly greater than that which could be achieved in isolation.

3.3 Innovation governance

We apply robust governance to the process for identification, selection and delivery of innovation projects. Our Future Networks Steering Group, which is co-chaired by our Network Strategy and Regulation directors, is responsible for setting and overseeing our portfolio of innovation projects; whilst our Future Networks team is responsible for driving forward the innovation programme and managing the creation and delivery of innovation projects with partners.

Figure 4 overleaf shows the process for sourcing ideas, developing projects from the ideas, and evaluating and selecting projects, as well the process for transitioning innovation solutions into business-as-usual. This process has been developed to ensure our investment in innovation is tested and validated and the impacts understood prior to rolling out as a business-as-usual activity.

Figure 4: Governance process for innovation programme



We recognise that innovative ideas can come from diverse sources so the Future Networks team regularly engage with managers and teams from across the business and engage with partners eg manufacturers, academics etc and attend industry groups to listen to their issues and ideas and understand technological developments and bring these internal and external views into one place within the business.

An idea is developed into a project, including a business case, which describes the aims, objectives and expected outcomes and where in the development cycle the project is positioned therefore aiding the selection of the innovation funding source. Each project is then grouped within an innovation theme and the Future Network Steering Group will then evaluate the project against the innovation strategy and programme. If approved the project forms part of the innovation programme and is delivered with monitoring its progress against timescales, budget, objectives and outcomes on a monthly or quarterly basis. These combined processes give evaluation at a project level and provide oversight at a programme level to deliver the expected outcomes.

Our innovation strategy and the associated innovation programme are approved annually by the Future Network Steering Group. The portfolio of innovation projects is continuously under review as projects are created and submitted for funding monthly. Our Innovation strategy will be updated bi-annually with input from stakeholders via consultation.

3.4 Managing uncertainty risk

Innovation projects by their very nature contain risk in terms of funding requirement, timing and technology / commercial success. All of our projects are managed in accordance with Prince 2 project management principles with progress against all KPIs being reported monthly to our Head of Future Networks and Future Networks Steering Group.

Risk management on innovation work is more challenging than traditional projects due to the delivery uncertainty from the low technology readiness levels versus business as usual. It is therefore critical to manage this risk so as to use customers' money wisely. To this end, risk is considered from the project concept stage where we ensure that the project is designed to deliver a clear outcome whether that is a specific piece of learning, a device or technique. This focus allows us to tightly contain the scope of the project and exclude non value add tangential areas of work which are not strictly necessary and would simply add risk and cost.

Once designed the project is subject to a robust sign off process including:

- Review by the Head of Business Finance to test the validity of the business case and the contribution of each work module to the learning;
- Review by the Head of System Control to validate the operational acceptability of the technique and to approve commitment of field staff resources where required;
- Review by the Head of Future Network to ensure sufficient resources are available to deliver the project objectives, it does not duplicate work by other DNOs and the learning is valuable and transferable to our stakeholders; and
- Finally review by our Network Strategy director to ensure fit with our innovation strategy and innovation programme.

There is uncertainty in the outcome for each innovation project, irrespective of whether it is in the research, development or deployment phase. We have oversight at the programme and project level through the monthly Future Network Steering Group meetings and recently we have enhanced the internal governance and risk management approaches specifically for managing the uncertainty risks associated with delivering innovation projects.

By careful design at the concept stage we have £20 million of Second Tier LCN Fund projects in flight and have successfully delivered against every single project milestone.

3.5 Stakeholder engagement

We are able to articulate the network problem and we use strategic partnerships to generate a range of hypothetical solution options which will solve the problem and stakeholders' input to help us decide which solution option to adopt. For example in the development of our Connect and Manage approach we approached a range of stakeholders; and specifically in the case of clustering of solar PV we consulted all those affected by our proposals, including the local authority, the Registered Social Landlord (Stockport Homes) and the installer; and in the case of voltage managed connections we discussed this proposal with the generation developers active within Electricity North West's area, including their trade associations.

Throughout RIIO-ED1 and beyond we will consult formally on our innovation strategy on a bi-annual basis allowing our stakeholders to comment on the direction of travel and the range and type of innovation projects. The consultation on our innovation strategy will form part of the wider stakeholder engagement planned throughout the RIIO-ED1 period.

3.6 Transition to business as usual

Managing the transition of an innovative solution based devices, technology or new operating arrangements into business as usual is the most important stage in delivering benefits to customers. To ensure we are successful we develop innovations from a low technology readiness level using IFI funding to test components or concepts, we then use First Tier LCN funding where necessary to conduct small scale live trials and where necessary utilise Second Tier LCN funding to conduct large scale tests, measure customer acceptability and develop the codes of practice, operational policies and procedures required to deploy as business as usual.

A recent example of this approach in practise is the Smart Street project, where:

- Early development of the concept and manufacture of the low voltage vacuum circuit breaker were funded by IFI;
- Work under our First Tier LV Network voltage project tested the voltage control devices in our networks and developed policies and procedures for their deployment; and
- In the Second Tier project only actual deployment at scale was funded.

Throughout the life cycle of the IFI and First Tier projects the project manager and Steering Group regularly reviewed progress and confirmed that the objectives are both still valid and attainable.

If any project is unlikely to deliver benefits due to say technology difficulties or the emergence of a more favourable approach then it is reviewed and where necessary stopped. An example of this would be the line tracker device originally developed collaboratively through the EIC which was overtaken by new commercial products from manufacturers.

3.7 Knowledge transfer

We have taken a proactive role sharing knowledge with other DNOs through the development and delivery of the annual LCN Fund conferences and taken every opportunity to attend learning and dissemination events hosted by other DNOs. A specific example of knowledge transfer into Electricity North West is the adoption of a low voltage circuit breaker developed by Tyco Energy for UKPN under a First Tier LCN Fund project that is being used as part of our own low voltage automation project.

We have also hosted events for our C_2C and CLASS projects, and we see these events as being important for knowledge transfer through the remainder of DPCR5 and into RIIO-ED1.

When thinking about knowledge transfer we involve our project partners, suppliers and even our trial customers in our dissemination events. We attend supplier trade conferences to explain our work and regularly hold briefings with our local companies on particular techniques or technologies. We utilise a wide range of dissemination techniques in addition to presentations to share the learning from our projects; we have successfully delivered Webinars, created Video Podcasts and video materials and posted them through social media channels in addition to the standard production and publication of formal white papers. Our website (www.enwl.co.uk/the-future) is the repository for sharing information, learning and knowledge created from our innovation projects.

We will continue to find new ways to share knowledge with our stakeholders. In choosing our audience we go beyond other network operators, targeting our customers, academia, manufacturers, energy suppliers, DECC and a number of trade bodies and stakeholders, such as BEAMA. These parties are all part of the overall technology adoption plan and hence critical to delivering on our commitment to share innovation opportunities with others throughout RIIO-ED1 and ED2.

4. Challenges which Electricity North West is facing

4.1 Understanding the potential challenges within RIIO-ED1 and ED2

In addition to the day-to-day challenges faced by Electricity North West, there are longer term challenges common to all UK DNOs. The challenges are not just climate change, they alos include security of supply and fossil fuel energy costs. . The following challenges are detailed as:

1. Climate and energy landscape
2. Increasing customer expectations
3. Economic climate
4. Ageing assets

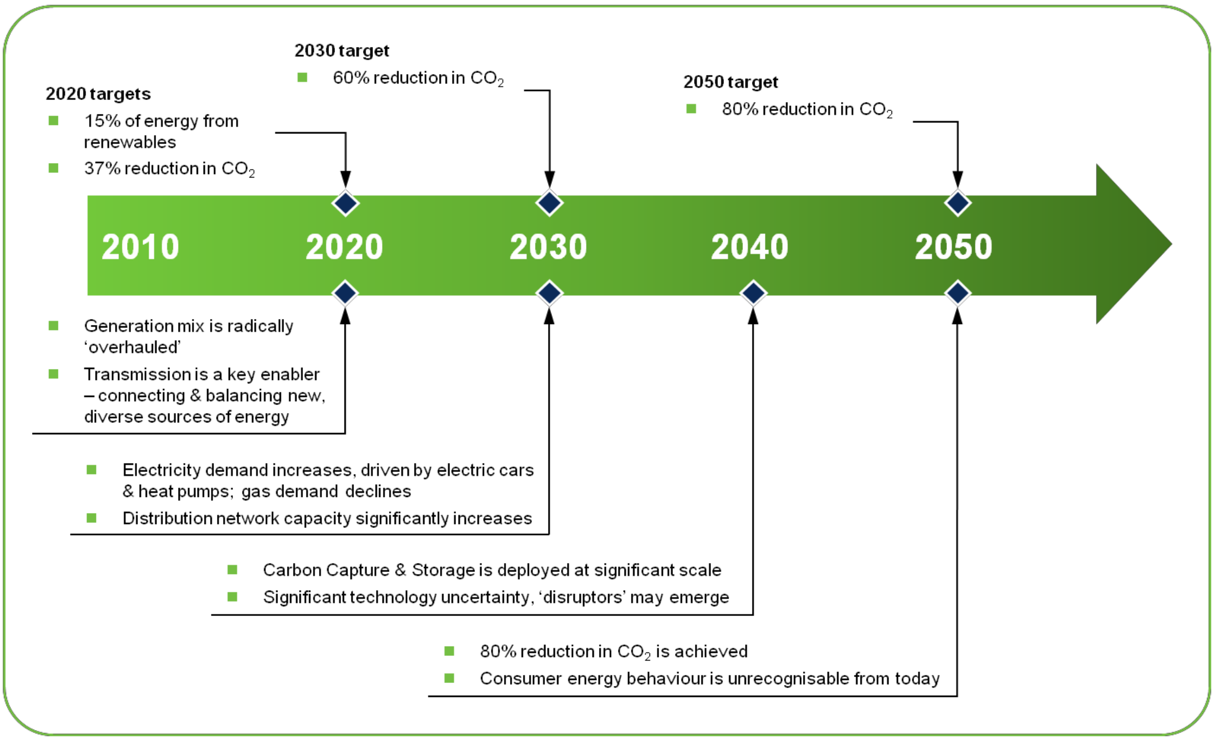
The role of UK electricity distribution network businesses has traditionally been asset centric, providing a secure and reliable service to the homes and businesses of the UK. With the advent of the fourth carbon budget, the industry is now facing one of its biggest ever challenges and needs to adopt and manage radical changes to ensure we can play our part in the migration to an affordable low carbon economy.

Climate and energy landscape

According to the DECC Energy Roadmap[1] published in July 2011 to meet the requirements of the fourth carbon budget, the key challenge for electricity distribution networks within RIIO-ED1 will be the connection of additional renewable energy distributed generation (DG). Our network already has DG equal to over 50% of maximum demand and networks in areas rich in renewable resources such as wind are already at saturation point.

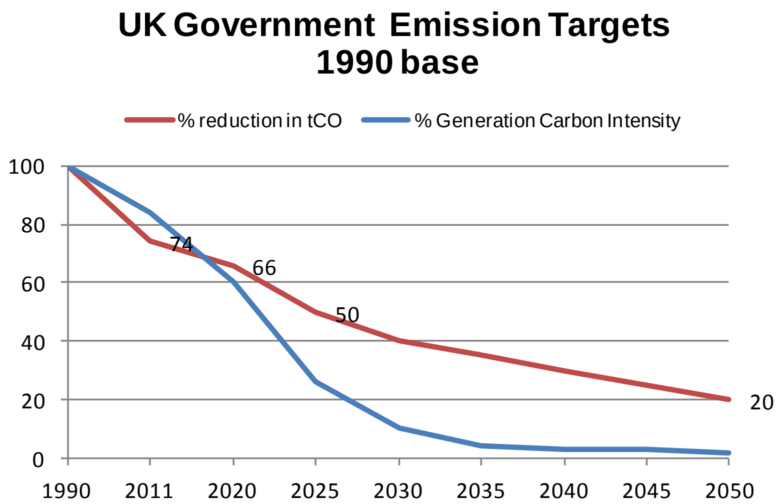
[1] http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/re_roadmap/re_roadmap.aspx

Figure 5 – UK energy roadmap



As can be seen from Figure 6, the projected rate at which the energy generation sector is to decarbonise (or the rate at which renewable energy generation is to replace fossil fuel plants) needs to accelerate over the next ten years to meet both emission reduction targets and large combustion plant directive[2] commitments.

Figure 6: Rate of decarbonisation of energy

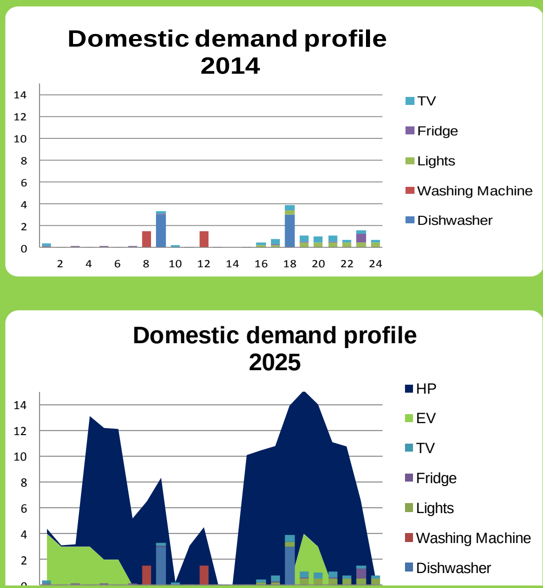


The intermittent nature of several leading renewable energy generation technologies (in the absence of mass market ready storage) has the potential to radically de-couple the link between maximum demand and prices paid to generators. For example the highest prices are now paid to generators at times of peak demand but if a significant amount of wind energy were to be available during peak demand period then obligations to purchase

[2] http://eur-lex.europa.eu/LexUriServ/site/en/oj/2001/l_309/l_30920011127en00010021.pdf

renewable energy over fossil fuel generated energy could result in unpredictable fluctuations in wholesale energy prices. This phenomenon has already been observed in Ireland with one of the richest wind energy resources in Europe where the emergence of wind following in pricing has resulted in suppliers and the TSO placing price signals into the market at time of peak demand forcing even more demand onto already congested networks.

Figure 7: Forecast changes to domestic demand profiles



One of the greatest challenges facing network operators is the future customer adoption of devices such as PV micro generation, heat pumps and electric vehicles fed from legacy networks. Incentives schemes have driven the introduction of intermittent generation on networks where it was never originally envisaged. installed on our LV network. The Renewable Heat Incentive is also expected to drive a similar level of customer activity leading to substantial additional demand from heat pumps.

As an example, solar PV feed-in tariffs introduced in 2011 resulted in a number of significant clusters of panels The majority of our customers are domestic and are fed from our secondary LV networks which for many years have followed predictable and stable demand domestic customer in 2012 and 2025 are contrasted in Figure 7 which graphically shows that the adoption of devices such as heat pumps and electric vehicles by customers will change the daily loading patterns and magnitude of their power consumption. Our domestic demand is expected to grow from 3GW to around 6GW by 2050 even with optimal scheduling. 20% of this growth is forecast to occur by 2023. To meet UK government targets some 700,000 domestic heat pumps will be fitted by 2030 adding 2 GW to our demand.

31% of the UK's 12 million vehicles are forecast to be EV/hybrid by 2030. For Electricity North West this equates to some 720,000 domestic EVs and 80,000 e-vans charging from our network adding ≈ 2GW to our demand.

By 2050 the charging demand of EVs in Manchester could exceed the city's present electricity demand of 400MW.

Increasing customer expectations

The adoption of low carbon technologies will mean that customers increasingly derive their heat and transport energy needs from electricity networks and hence the reliability of supply will be ever more critical. It simply will not be acceptable for customers to lose electricity supplies for protracted periods when homes and businesses are heated by electricity and electric vehicles are in common use. Delivering ever higher reliability levels from an ageing asset base will require innovation in network management, energy management, active automation systems, fault detection and repair technologies. Customers will also require improved information on any network outages and enhanced support.

Economic climate

The general economic challenge facing the UK coupled with sustained rises in raw fuel prices is leading to increased concerns regarding fuel poverty amongst customers. Figures published by DECC[3] show that between 2004 and 2009 domestic electricity prices rose by over 75% leading to a 5% rise in fuel poverty. These figures further indicate that over this same period electricity prices rose faster than income levels. Although distribution network costs are only a small element of the final bill paid by customers the pressure has never been greater for network operators to reduce costs and increase efficiency. Smart grids will play a critical role in enabling efficiencies across the whole range of network operator activities.

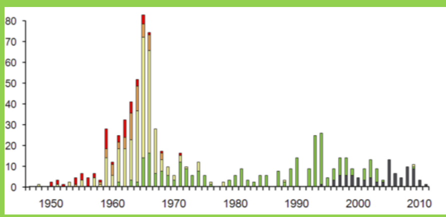
Ageing assets

DNOs manage an increasingly ageing asset base with many of our assets now approaching their traditional end of life.

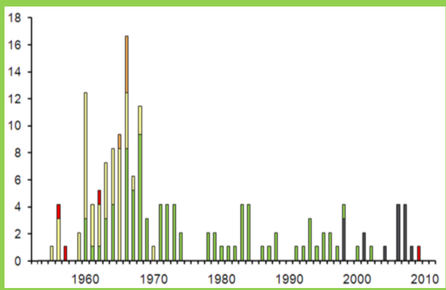
Even if it were possible to fund the replacement of these assets according to their age profile the scale of the replacement programme would be prohibitive. To improve the management of such assets and keep costs down for customers, we pioneered the industry move to Condition-Based Risk Management (CBRM) strategies. These strategies have resulted in a much more informed understanding of assets allowing their lives to be extended whilst managing risk to customers. CBRM will continue to evolve as we develop new techniques for assets such as large power transformers, switchgear, protection and civil assets. Innovation in these asset management techniques is vital to enable assets to be safely managed well beyond their design life. We are leading several major projects seeking to both better understand asset reliability and increase their load carrying capacity. Whilst such projects focus benefits on individual assets they are further enhanced by our belief that the development of criticality analysis techniques is a key component in the evolution of smart grids to ensure risk and commercial positions are appropriately balanced. These compatible technologies allow large populations of assets to be more efficiently managed with risk and investment better targeted for the benefit of customers.

Figure 8: Age Profiles

Age profile of 33kV transformers



Age profile of 132kV transformers



4.2 Challenges aligned to RIIO-ED1 framework

In our guiding principles we explained that our work plan is geared to the needs of customers in the short to medium term; specifically in the periods RIIO - ED1 and ED2. Our work with Cambridge Economic Policy Associates (CEPA) and Tyndall Centre at University of Manchester has shown that that the DECC Low scenario[4] is the most appropriate base case

[3] http://www.decc.gov.uk/en/content/cms/statistics/fuelpov_stats/fuelpov_stats.aspx

[4] Need reference to the correct Annex in WJBP

for the RIIO-ED1 period. Table 2 below describes the challenges and the associated symptoms we will see over the next 10-15 years under the DECC Low scenario grouped under the innovation themes of Networks, Carbon & Social and Customers.

Table 2: Symptoms of the challenges faced by Electricity North West in RIIO-ED1

Affordable reliability	Adoption rates for LCTs driving Network loads beyond existing capacity coupled with ageing infrastructure and a need to improve reliability of supply.
	Continued unpredictability in economic growth in the region
	High levels of DG necessitating optimisation of output or alternative methods for the storage of excess energy and greater flexibility in network loading and capacity
Customers	Customers demanding greater transparency over the way in which they are charged for electricity and more control over their own electricity consumption
	Demands for improved quality of service
	Extensive smart meter roll-out
Sustainability	Greater demands for electricity as more customers switch from gas
	Domestic use increasing by up to 20% through the connection of Low Carbon Technology (LCT) to the network
	Continued upward pressure on energy prices

Meeting these challenges with traditional techniques is unaffordable to UK energy bill payers and so to mitigate these costs we are maximising the utilisation of the existing assets through the incremental installation of new and smart technology along a path to create a smarter distribution network.

In table 3 below the challenges faced by DNOs are linked in matrix format to the priorities of our stakeholders and our innovation themes; this shows that our innovation themes map to the challenges faced and the expected outputs link directly to the key priorities identified by our stakeholders and the Ofgem outputs. This provides us with reassurance that the identified challenges aligned with the RIIO-ED1 framework.

Table 3: Innovation strategy linked to challenges and stakeholder priorities

	Challenges			
	Climate and energy landscape	**Increasing customer expectations**	**Economic climate**	**Ageing assets**
Ofgem Outputs				
Reliability and availability	●	●		●
Safety	●	●		●
Social obligations	●	●		●
Environmental Impact	●	●		●
Customer Satisfaction	●	●	●	
Connections	●	●	●	
Stakeholder Priorities				
Reliability	●	●		●
Sustainability	●	●		
Affordability	●	●	●	●
Customer service		●		
Initiative themes				
Affordable reliability	●			●
Sustainability		●		●
Customer Service	●	●	●	

5. Our response to the challenges

5.1 Understanding how the future challenges manifest themselves

The challenges outlined in the previous section manifest themselves as a range of network problems that in the past would have been solved using traditional techniques, namely investing in more assets.

The technical and physical attributes of these challenges are identical to those observed today as the physics of electricity has not changed. For example increased load requirements from a group of domestic customers will create thermal and/ or voltage issues as the capacity level of network assets are met and in some cases exceeded; or the proposed connection of a new generation facility will potentially exceed the fault level capability of the local network assets.

But the potential solutions to these challenges need a different approach utilising the latest commercial and technical innovations. Our aim is to facilitate our customers' aspirations and to do so in a manner which is in most instances unseen. Where customer interaction is necessary our aim is to make it simple as we want to avoid hindering their choices or delaying them meeting their aspirations. We aspire to deliver a reliable, sustainable and affordable service to our customers who know we are there to help them and trust us.

Therefore we must understand the scale and timing of the challenges. This means we must anticipate the expected quantities and the expected speed of adoption; recognise that some development will occur in clusters but the majority will occur randomly across the network; and develop the retrofit equipment and techniques to rapidly upgrade the network.

Climate and energy landscape

International agreements were reached through the United Nations Convention on Climate Change that committed developed countries to reduce their emissions of greenhouse gasses with the aim of "stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system"[5]. These international agreements to act on climate change were translated into EU commitments through a range of different mechanisms and in the UK resulted in the 2008 Climate Change Act which created a legally binding target to reduce the UK's emissions of greenhouse gases to at least 80% below 1990 levels by 2050. In addition to the binding emissions targets, the Committee on Climate Change, an independent body of recognised scientific and technical experts, was also created. Its remit is to inform and drive government policy enacted through the Department of Energy and Climate Change. This advice takes the form of a number of reports and 'carbon budgets' which are in effect the limit on the amount of carbon emissions permitted on the path to 2050 to achieve the agreed targets. The first three carbon budgets were released in 2008 and set the level and pace of emission reduction to set a ceiling on emissions of greenhouse gases in the UK for the three periods 2008-2012, 2013-2017 and 2018-2022. They also promoted a range of measures to achieve a path to the 2050 target. The fourth carbon budget was enacted by secondary legislation in May 2009, passed by Parliament in June 2011 and set the pace of emission reduction for the period 2023 to 2027.

Two recommendations were made that have a specific impact on Electricity North West:

- Electricity Market Reform which aims to add 30-40GW of low carbon generating plant by introducing new arrangements to promote competitive tendering of long-term contracts for investment in low carbon capacity; and

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[5] *The United Nations Framework Convention on Climate Change.* http://unfccc.int/essential_background/convention/background/items/1353.php. Retrieved 15 November 2005.

- Funding and policies to support development of technologies and new markets, key technologies being demonstrated now for deployment in the 2020s including carbon capture and storage in power generation and industry, electric cars and vans, and electric heat pumps.

As part of its ongoing commitment to these internationally agreed targets on greenhouse gas emissions reduction, the UK government has launched a number of initiatives on energy efficiency, carbon costs, renewable energy generation and electric vehicle incentives. All of these coupled with a general increase in awareness of 'energy' issues are expected to impact significantly upon electricity consumption in terms of patterns and overall levels.

The key challenges for electricity distribution networks within RIIO-ED1 will be the connection of additional renewable energy distributed generation (DG). Our network already has DG equal to over 50% of maximum demand and networks in areas rich in renewable resources such as wind are already at saturation point. As an example, solar PV feed-in tariffs introduced in 2011 resulted in a number of significant clusters of panels installed on our low voltage (LV) network leading to the presence of intermittent generation on networks where it was never originally envisaged. The Renewable Heat Incentive is also expected to drive a similar level of customer activity leading to substantial additional demand from heat pumps. One of the greatest challenges facing network operators is the future customer adoption of devices such as PV micro generation, heat pumps and electric vehicles fed from legacy networks.

Commercial mechanisms such as demand side response (DSR) and generation side response (GSR) are key commercial components of smart grids and will play a pivotal role in helping network operators meet these challenges. We have been consistently at the forefront of DSR development and usage, and were the first UK DNO to sign such contracts to defer reinforcement. We continue to innovate in this area with our C_2C project which seeks to introduce new forms of low intrusion DSR/GSR contracts for customers to both stimulate the embryonic DSR market and dramatically reduce connection costs to customers. We can also expect to see a stronger market within RIIO-ED1 for DSR and GSR across the supply value chain with demand and generation response being used to simultaneously balance networks, system frequency and commercial positions.

Our research work with Pöyry and National Grid clearly illustrates the relative strengths of DNO, TSO and Supplier balancing signals and the dominance of the latter two in current commercial trading markets. DNOs must therefore find new ways of balancing their networks both technically and commercially. Our C2C and CLASS projects are specifically designed to respond to this challenge by unlocking significant additional capacity from existing network assets and offering flexible network management tools to DNOs. Our work to date on smart grid DSR has been successful in securing a number of major DSR customers who have already begun to realise the benefits of smart grid solutions for their own cost base and will act as flagships for other commercial customers.

We believe that the above complexities, coupled with the increasing demands placed on networks in RIIO-ED1 will necessitate the emergence of DNOs as distribution system operators (DSOs). Whilst the full scope of DSO services is yet to emerge, what is clear is that DNOs will need to embrace a wide range of smart meter data services and smart grid technologies such as energy management systems to meet customers' future needs.

The current structure of electricity transmission, distribution and supply has been based on being able to balance demand with supply in real time. This is achieved by both being able to reliably predict forward demand based on a range of known factors and being able to call on highly controllable fossil-fuelled generation at times of high demand and fast acting reserve generation for short term peaks in demand. Historically, long term investments in generation capacity could be made due to a predictable understanding of forward prices and fuel costs, however, the way in which future electricity will be generated will require this approach to be radically changed. As can be seen from Figure 6, the projected rate at which the energy generation sector is to decarbonise (or the rate at which renewable energy generation is to replace fossil fuel plants) needs to accelerate over the next ten years to meet both emission reduction targets and large combustion plant directive[6] commitments.

Projections for domestic customer load growth have upper and lower projected limits but it is clear that to facilitate the migration of heat and transport to a low carbon economy, electricity network loads will increase. New commercial and technical solutions will be required to mitigate the potentially prohibitive cost to customers of traditional reinforcement-based solutions.

Figure 9 – DECC projections for increasing domestic load

Peak domestic electricity demand increases significantly…

≈2.5kW peak appliance demand for an average house

\+ ≈3kW charge for an electric car

\+ ≈8kW demand for a heat pump

= ≈10-12kW potential total demand

Distribution networks may need to more than double their capacity…

	2010	2030	2050
Household demand*	≈2.5kW	≈4.7kW	≈7kW
Number of homes	26m	31m	36m
Embedded generation	≈8GW	≈15GW	≈20GW
Network loading (kW/km)	≈75	≈170	≈300
Network scale		X2.3	X4.0

* After diversity average peak demand

Network scale vs 2010 levels

The majority of our customers are connected via typical LV networks which have been historically designed on a ‘fit-and-forget’ basis to accommodate a narrow range of loading conditions based on an average demand taking into account the diversity of customer activity. Our work has shown that whilst the performance parameters of these LV networks are not currently fully understood, there are significant opportunities to operate them in smarter ways to increase the capacity available for existing assets.

This will involve new operating regimes, real time sensing technologies, advanced network modelling and simulation techniques and the challenging of historic standards. Our Smart Street project has been born out of this challenge and incorporates LV network meshing technologies, active voltage management and conservation voltage reduction. This project will deliver direct cost reductions to customers through reduced energy charges, reduced DUoS charges and higher FiT revenues.

Economic climate

We have seen domestic electricity prices rise by over 75% between 2004 and 2009; and this trend is expected to continue as GB develops low carbon and/ or renewable generation as

[6] http://eur-lex.europa.eu/LexUriServ/site/en/oj/2001/l_309/l_30920011127en00010021.pdf

part of the plan to reduce its carbon footprint. UK energy bill payers will face increasing cost pressures, so network operators must innovate to help reduce these energy costs and increase efficiency. Smart Grids will play a critical role in facilitating efficiencies across the whole range of network operator activities.

Increasing customer expectations

We know from our stakeholder engagement in DPCR5 that our customers believe repeated supply interruptions are unacceptable; and so part of innovation programme in DPCR5 has been focussed on fault location and management – this will continue and accelerate in RIIO-ED1. As we anticipate that as customers become more reliant on electricity for their heating and transport needs then their expectations of resilience and reliability will increase. Part of the RIIO-ED1 innovation programme aims to develop the tools, techniques and equipment to operate our network in a manner making it more reliable.

With the general capability increase of mobile IT and handheld devices within domestic premises we anticipate that customers expect to access Electricity North West's services through both real and virtual channels; and when loss of supplies do occur our customers expect to be provided greater information through these real and virtual channels. Our innovation programme will look how to deliver these services using information retrieved automatically from our systems and packaged up for the customers.

Ageing assets

As the owner and operator of a significant asset base that provides a vital service to our customers it is critical that we employ cost effective tools and techniques that manage the assets and keep costs down for customers. Our pioneering move to Condition-Based Risk Management has resulted in a much more informed understanding of the assets. We will continue to develop CBRM techniques to enable assets to be safely managed well beyond their design life. This work seeks to better understand asset reliability and develop criticality analysis techniques to ensure the operating risks are understood and appropriately balanced.

These developments will enable asset solution investment and commercial service solutions investment be better targeted for the benefit of customers.

5.2 Phased approach to delivering innovation initiatives

We have broken down the key innovation areas of focus across the three time periods of DPCR5, first half of RIIO-ED1 (2015 to 2019) and the second half of RIIO-ED1 (2019 to 2023) as we develop incrementally the smart distribution networks to meet our customers' changing needs.

For example the early years of RIIO-ED1 will focus on extending the smart grid capabilities we are developing in DPCR5; for example LV network automation, active voltage control and extracting value from the network and customer data generated thereby. We will also commission a replacement network management system in this period, which will unlock additional system capacity from the wide scale deployment of C_2C, CLASS and Smart Street, which are also being developed as projects in DPCR5. The new network management system will also provide the foundation for extracting value for customers from smart meter data in the later years of RIIO-ED1, whilst we start to develop our understanding of the future transition from an asset centric distribution network operator to a distribution system operator.

6. Our track record

We are one of the few DNOs to have successfully spent their DPCR5 IFI funding of £2 million per annum. The success of our LCN Fund and IFI-funded initiatives means our customers will share in around £63 million of savings which we will deliver by the end of DPCR5. Table 4 below the right highlights our funded innovation projects and the benefit delivered in DPCR5 and projected for RIIO-ED1.

Table 4: Range of innovations undertaken in DPCR5 delivering value for customers and stakeholders

Stake-holder Priority	Innovation Initiative	Funding Type	Project Cost	Benefit	Saving Projection DPCR5	Benefit/ Saving Projection RIIO ED1
Customer	**Network Operation** - Development of a time domain reflectometry approach to LV fault finding	IFI	£7,000	Delivers faster repairs with less time and excavations to locate the fault saving repair costs and CML	**£3.6m**	**£14.4m**
	Network Operation - Delta V Developments & Trial - Development of a voltage gradient approach to LV faults finding	IFI	£63,000			
	Network Operation - Modular/Master Slave Rezap - Development of an LV autorecloser that will fit into all ENWL's LV fuse pillars and boards	IFI	£316,000	Reduces impact of transient faults by autoclosing post fault		
	Network Operation - FuseRestore/Bidoyng - Development of a device to automatically restore a fuse after a transient fault	IFI	£453,000			
	Network Operation - Smart Fuse	LCNF Tier 1	£350,000	Reduces impact of transient faults by autoclosing post fault		
	Network Operation/Investment Planning - Chromatic Analysis of Insulating Oil - Non-intrusive testing of Insulating Oil	IFI	£116,000	Removes the need for oil samples to be remove from transformers for analysis and allows more frequent oil monitoring		**£50k pa**
	Network Operation - Wide Area Data Gathering - Installation of a Power Line Carrier System	IFI	£95,000	Reduces the reliance on third party telecoms providers and reduces costs and increases security of communications		**£100k**
	Network Operation - Next Generation LV Board/Link Box - LV Network Automation	IFI	£579,000	Release additional capacity from distribution transformers and reduce network losses, load/generation connections at lower cost, improved power quality		**£5.5m**
	Network Operation - Customers - Research into the customer/ DNO interface and how it can be improved	IFI	£283,000	Faster more accurate information provided to customers - improved customer experience		**Qualitative**
	Network Operation - Demand control - Investigation of DNO's capability to offer technical solutions to support transmission network stability	IFI	£31,000	Allows distribution networks to be used to assist with national objectives for the adoption of renewable energy generation without customers being impacted		**Qualitative**
	Network Operation - Composite Link Box Lids - Investigation of composite materials	IFI	£11,000	Provides faster restoration times following faults		**Qualitative**

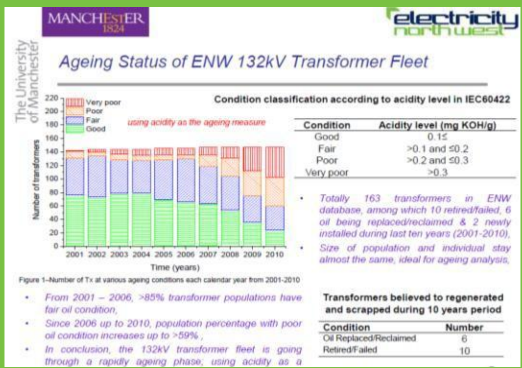
Stake-holder Priority	Innovation Initiative	Funding Type	Project Cost	Benefit	Saving Projection DPCR5	Benefit/ Saving Projection RIIO ED1
Reliability	**Investment Planning** - Oil Regeneration - Testing the capability of oil regeneration to improve health index	IFI	£270,000	Study with Manchester University into benefits of regenerating Transformer oil on site to extend their asset life		**£33m**
	Investment Planning - CBRM - Developing the ability to use CBRM outputs to define non-load investment programmes	IFI	£540,000	CBRM was initially developed for DPCR4, we have continued to develop this technique which has become the industry standard approach to asset management - improved asset decisions reliability	**>£50m**	**£65m**
	Investment Planning/Network Operation - Vegetation Management - Identification and definition of vegetation growth rates as affected by climate	IFI	£298,000	Enables targeted preparation for the affects of climate change	**-**	**Qualitative**
	Safety Network/Operation - Transient Resonance Study - Investigation into the effects of switching transformers with long cables	IFI	£70,000	Eliminates the need to provide high voltage switching devices on long cables (avoiding costs)	**£8.7m**	**-**
	Investment Planning - Network Resilience - Investigation into the potential impacts of climate change on network resilience	IFI	£24,000	Enables targeted preparation for the affects of climate change		**Qualitative**
	Safety/Investment Planning - Polymeric Investigation - Forensic Investigation of failed and new insulators	IFI	£56,000	Improves the reliability of high voltage switchgear		**Ongoing requires quantification**
	Network Planning - Harmonic Cabling Modelling - Analysis of the technical requirements for the connection of non linear loads	IFI	£9,000	Allows the connection of higher levels of generation without network reinforcement	**Avoided Costs**	**Avoided Costs**
	Investment Planning - Stay Rod Testing - Non intrusive testing of below ground structures	IFI	£17,000	Testing completed and proved inconclusive and therefore will not proceed, alternative techniques will be investigated	**-**	**-**
	Network Protection and Control - Fit Calibrate HAT's - Forensic investigation of network load measurement systems	IFI	£24,000	Allows more targeted investments and facilitates connections based on available information	**-**	**Qualitative**
	Network Performance - Nafirs - Academic Investigation of fault data	IFI	£27,000	Used to develop Quality of Supply Investments and their likely effectiveness	**-**	**Qualitative**
Affordability	**Investment Planning** - Expansion Planning V2 - Development of network models for demand forecasting and pricing	IFI	£372,000	Allows more targeted investments in reinforcement for load growth	**-**	**Qualitative**
	Network Design - Earthing - Investigation of transfer potential under fault conditions	IFI	£5,400	Reduces investments in underground electrode systems	**-**	**Qualitative**
	Network Operation/Design - Fault Current Limiter - Development and installation of a super conducting fault current limiter	IFI	£540,000	Avoidance of network reinforcement to mitigate fault levels exceeding equipment safety ratings	**-**	**£3m**

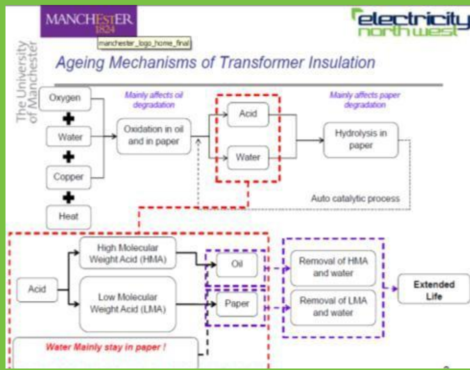
Stake-holder Priority	Innovation Initiative	Funding Type	Project Cost	Benefit	Saving Projection DPCR5	Benefit/ Saving Projection RIIO ED1
	Safety/Investment Planning - OLTC Monitoring - Acoustic monitoring of OLTCs	IFI	£277,000	Enhances safety of operatives following high profile OLTC failures and is also used to assess health of asset for more targeted investments	**£750k**	**£500k**
	Network Capacity - Dynamic Line Rating - Weather related overhead line ratings	IFI	£323,000	Allows the connection of wind turbines to remote overhead lines	**-**	**Avoided Costs**
	Network Capacity - Storage - Defining the economic and regulatory benefits of energy storage	IFI	£183,000	Facilitates the connection of low carbon technologies allowing demand management	**-**	**Qualitative**
	Network Planning - Load Related Risk - Development of load- related output measures to succeed the current Load index (LI) methodology	IFI	£20,000	Allows more targeted investments in reinforcement for load growth	**-**	**Qualitative**
Sustainability	**Demand Side Management** - DSM Signals - Assessment of DSR price signals	IFI	£15,000	Understand benefits of ENWL's Low Carbon Network Tier 2 project, C_2C-realised through avoiding investment in network reinforcement and Demand Side Response	**-**	**£10m**
	Network Capacity - Load Allocation - Development of software to project and identity overloads due to the projected take up of low carbon technologies	IFI	£460,000	Improved modelling of inherent capacity on the network as required by local conditions of increased demand and generation	**£1m**	**£600k**

A significant element of our strategy is aimed at investigating a range of issues relating to our asset management and utilisation strategy. We believe that a fuller understanding of asset condition and hence risk is a pre-requisite of a smart grid and we have developed world-leading asset management strategies through the development of condition-based risk management and condition data capture which allow greater visibility of the 'health' of our assets. These techniques, coupled with the development of criticality indices have allowed us to reduce the scope of our investment programmes whilst maintaining visibility of the increasing risk. The savings from these techniques offer substantial value for money for customers measured in tens of millions of pounds.

Case Study 1 - Oil regeneration

We have carried out research into the benefits of oil regeneration treatments for large transformers and the ability of these treatments to improve the asset health index. Manchester University carried out the investigation which included on-site regeneration of transformers under load and a definition of the life extension. This approach has allowed up to substantially reduce the number of primary transformers due for replacement during the RIIO-ED1 period.





We have combined this condition information with life cycle modelling and now clearly understand how assets change condition over time and the factors that drive these changes. We have developed failure mode analysis to a high degree and have used this information to develop whole life cycle management strategies resulting in a close correlation between condition and performance both now and in the future. Our work with the University of Manchester is an example of how we have brought new transformer regeneration techniques to production readiness. This technique allows ageing grid and primary transformers to have significant life extension. The benefits of this will be realised by customers throughout RIIO-ED1 where we plan to use this technique to avoid the replacement of 12 Grid and 77 Primary transformers saving customers over £39 million.

Our work to further develop asset management techniques will continue throughout RIIO-ED1 and we plan to incorporate asset connectivity, security of supply management and more fully understand how interconnected assets in a smart grid interact to form an overall asset risk service profile.

Case study 2 – Modular Rezap

The Rezap device was initially introduced as a trial in 1997 and has since become a standard means across UK distribution networks to manage intermittent faults which may repeatedly operate fuses and disconnect customer's supplies but which cannot be easily located and repaired. The units are routinely used to switch loads on low voltage networks and are often used to switch high fault currents leading to an onerous duty on the device. One issue restricting the use of the Rezap was its size leading to it being unable to fit in a number of outdoor ground mounted substations so it was agreed to partly fund a project to resolve this issue.

Our focus in DPCR4 and 5 has been to focus on macro-performance, whereby we analysed overall trends, developed industry leading network automation software and developed leading inferencing software systems. These have allowed customers to enjoy real performance improvements in the reliability of their supply and the quality of information and support they receive during major events such as storms.

Our transmission restoration software is a particular example where we have successfully implemented the only multi voltage level self healing smart grid application. This system alone has avoided hundreds of thousands of customer interruptions.

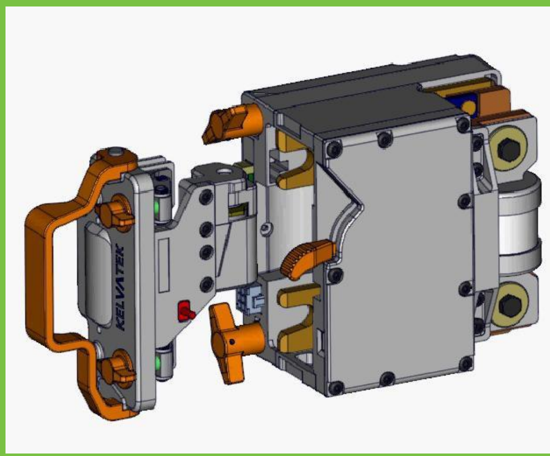
On our LV network, we have worked with manufacturers to develop a number of devices such as the Rezap, the modular Rezap and the Bidoyng fuse restorer. These devices have transformed the management of LV network cable faults and prevent tens of thousands of customer interruptions due to transient network faults each year.

For our DG customers we have focused on allowing them to connect at the lowest possible cost. Our First Tier LCN Fund Connect and Manage project has shown that traditional network modelling techniques do not accurately predict the effect of devices such as micro-generation on network voltage. We have successfully connected over 33MW of clustered LV micro DG without any significant reinforcement.

Underpinning this connect and manage approach is the ability of the DNO to monitor the effects of DG. Prior to the advent of smart meters, we have had to develop and deploy new tools to allow us to effectively monitor DG and our smart joint is an example of innovation in this area. In addition, we have re-used Bidoyng units as advanced network sensors which coupled with the smart joints to provide a comprehensive monitoring package.

Low voltage smart joint

Smart Fuse



DG will remain one of greatest customer challenges in RIIO-ED1 and we will continue work started in our CLASS project on advanced network voltage management techniques.

We believe that the adaption of existing network assets for new services is central to any successful smart grid deployment and this approach will be core to our strategy. This asset optimisation approach allows us to respond more rapidly to issues such as the clustered adoption of new technologies whilst keeping costs to customers to a minimum.

As smart meters are deployed, these will be integrated into our control room systems allowing better management of network power flows and further improved fault diagnostic techniques. The realisation of smart meter benefits will require cleansing of existing data and these costs are detailed in our business plan.

In addition to our leadership of Workstream 3 and the development of our future capacity headroom model[7], we have invested significant time and resource in understanding and forecasting the impact of low carbon technologies on networks.

Our stakeholder engagement clearly shows that in order for customers to adopt these new technologies the connection experience must be streamlined and simple. We have already noted our leadership of the ENA work groups in this area. We will continue to work with stakeholders to develop new technical and commercial solutions such as C_2C and other flexible connection arrangements.

We have achieved a leading position on commercial innovation and commissioned a report by Pöyry Management Consulting to investigate the potential strength of price signals under various scenarios to drive customer behaviour.

The commercial models used to deliver services to our customers are becoming ever more important and we have recognised the opportunity to enhance the economic opportunity for new connections. Our C_2C project is a clear example of how connections can be facilitated at significantly reduced cost by adopting new commercial arrangements that exploit latent network capacity. Such arrangements are ideal for customers such as landfill DG sites which

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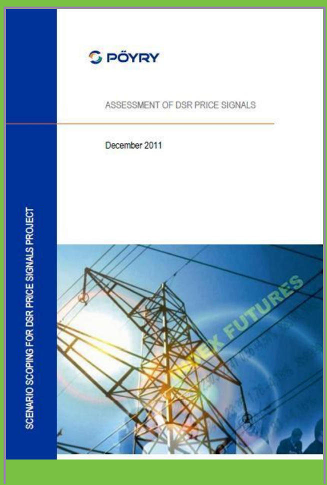
[7] This model provides a top to bottom model of the entire Electricity North West network and enables LCT penetration scenarios to be over laid onto various economic activity levels to produce an assessment of future network utilisation and hence reinforcement / Smart Grid technology intervention requirements.

can store and use methane gas to generate electricity. These sites often only have enough gas to generate for 10 or 15 years therefore our new flexible connections are an ideal way of avoiding expensive reinforcement charges to build assets that may last for 40 years or more.

Case Study 3 - DSR

Pöyry Management Consulting was jointly commissioned by Electricity North West and National Grid to explore further the interactions of potential DSR use by Electricity North West (as a DNO), National Grid (as TSO) and suppliers as different key end users and to examine relative strengths of DSR price signals that each might be able to provide to the market.

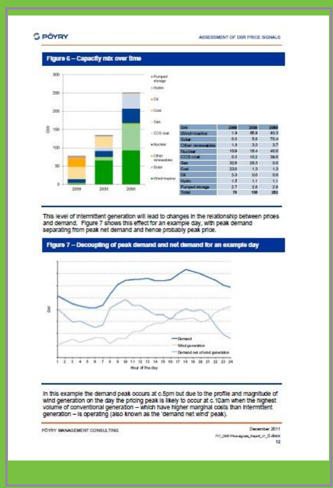
The expectation is that a decarbonised generation sector will lead to the GB market containing large amounts of low marginal cost generation; much of this will be in the form of wind, which is also intermittent. Concurrent with the decarbonisation of electricity generation, further electrification of the heat and transport sectors is expected, particularly from the late 2020s onwards, in support of the 2050 emissions target.

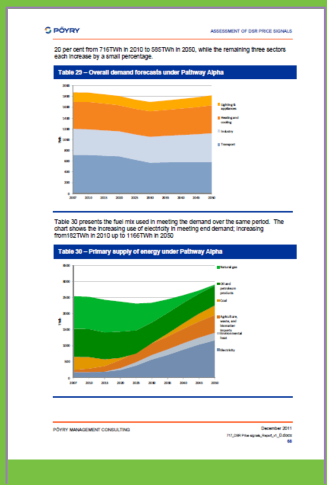

PÖYRY

ASSESSMENT OF DSR PRICE SIGNALS

December 2011

SCENARIO SCOPING FOR DSR PRICE SIGNALS PROJECT





We have invested time and effort in understanding the value to customers in our present service offerings and what will be required in the future.

We will bring new innovative commercial services to the market that reflects the requirements of connectees rather than the asset-centric view of our network that has dominated for many years.

The provision of consistent low cost and flexible connection offers will require further innovation work in areas such as harmonic filtering and storage to allow the benefits of these new technologies to be passed on to customers.

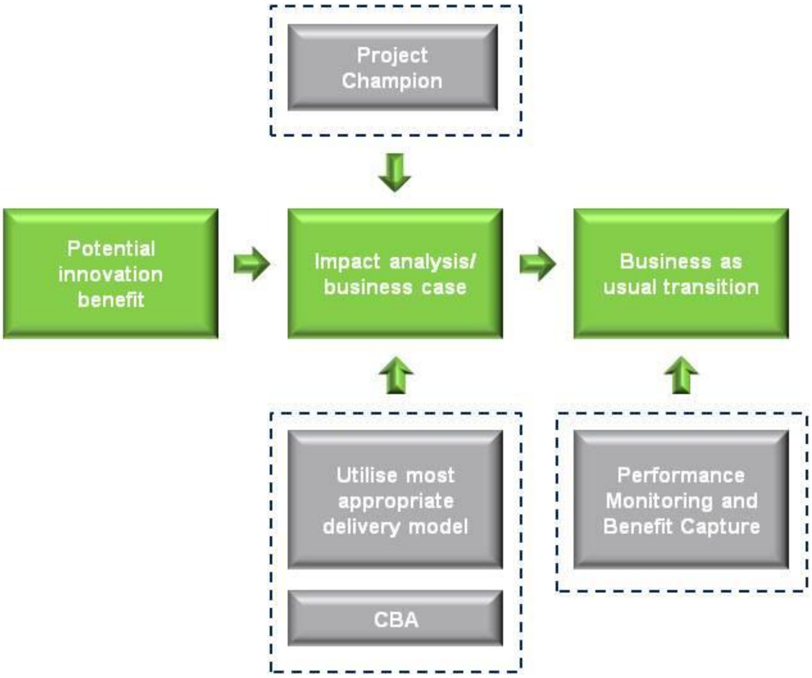
Our work in the CLASS project recently funded by Ofgem under the Second Tier LCN Fund funding competition will, in addition to reinforcement deferral, allow us to develop added value services for customers from techniques such as automated frequency response. The techniques that will be proven by CLASS will allow savings of hundreds of millions of pounds for UK customers in the future.

7. Rolling out successful innovation as business as usual

The critical step in delivering benefits to customers from innovating is managing the transition of a solution, device, technology or other innovation into business as usual. The governance framework, described earlier in the Innovation strategy section, showed our high level approach to taking a project output from an Electricity North West managed project or from an external source (whether domestic or international).

We track others' innovation activities alongside the delivery of our innovation projects. As projects move through their lifecycle and it becomes clear that the outputs have the potential to be embedded as business as usual a Project Champion is identified for each project. The Project Champion has the responsibility for evaluating the innovation and deciding whether the innovation should be transition into business as usual. Figure 10 overleaf shows the Project Champion has the responsibility to complete the business case for the innovation and evaluate the change required to implement the innovation in the business. At this stage the aligned with RIIO-ED1 programme will be confirmed and a go (or delayed go) or no-go will be determined.

Figure 10: Innovation strategy linked to challenges and stakeholder priorities



These activities will be completed with the support of the Future Networks team and will follow, where appropriate, the normal project management approval and delivery processes to ensure consistency.

Where there is a multi-directorate impact the Future Networks team will assist in the co-ordination of multi-directorate changes with the Project Champion leading and agreeing the implementation with the business managers. For example the introduction of a new piece of equipment will require some level of policy changes that could impact on a procurement process (ie development of a standard/ specification for supply change development) and/ or an operational process (ie development of a Code of Practice for the operation and maintenance arrangements) both which may require briefing and/ or training.

On implementation the Project Champion has the responsibility to monitor and confirm the identified benefits have been obtained.

8. Our innovation plan

8.1 Delivering innovation in RIIO-ED1 2015–2023

Our DPCR5 innovation strategy is focussed on discrete projects aligned with our key stakeholder priorities of reliability, affordability sustainability and customer service. Moving forward the RIIO-ED1 plan will shift focus to combine these areas, recognising that future smart grid needs will increasingly require a co-ordinated approach to the forecasted challenges and to meet broader stakeholder priorities.

Our RIIO-ED1 initiatives will require extensive third party collaboration for delivery. Almost 80% of our current IFI funding goes to third parties (such as universities and UK businesses) and makes a significant contribution to the regional Research and Development investment. We anticipate a similar apportionment of funds through RIIO-ED1.

Table 5 overleaf shows across the RIIO-ED1 timeline the range of innovation initiatives planned grouped within the stakeholder priorities. Further information on each of the initiatives is contained within Annex 1.

8.2 RIIO-ED1 2015-2019

Through 2015-2019 we will focus upon completing the network capability initiatives currently in development in DPCR5 (LV network automation and storage for example) and in the capture and use of the extensive amount of load and usage data that will be provided by smart meters to further enable the development of smart grids.

During this period we expect increasing customer demand and the clustered connection of low carbon technologies to push local network capacity to its limits. We will focus on understanding in greater detail the capability of our network to expand and meet demand increases whilst maintaining exceptional levels of reliability and customer service.

We will use innovative approaches to provide a smarter response from our current network:

- Focus on the collection of real-time data on network performance, capacity and load from automated data capture, including data from smart meters;
- Use advanced system simulation and modelling techniques such our Capacity Headroom Model to identify and quantify network capacity and identify areas of strain on our network in real time;
- Integration of smart meters into control room systems;
- Progress development of technologies currently in research through continued collaboration with our partners to achieve our stakeholder priorities;
- Develop and invest in our employees' core skills in the areas of commercial, financial and technical innovation;
- Focus on the delivery of priority services for vulnerable customers and those affected by fuel poverty;
- Continue our leadership in industry forums and working groups.

Testing the network smart grid capability is one discrete step in the on-going process of migrating to a more active network approach and a demand side response. We will also consider our post-2019 activity and how experience from this early stage affects the development timescale.

8.3 RIIO-ED1 2019–2023

Our focus in this period will be the delivery of our data strategy and use of smart meter information to drive further efficiency, reliability and low carbon capacity on our network:

- Micro level data management of network performance;
- Move from research and development to industrialisation of developed technologies;
- Response to stronger market demand within RIIO-ED1 for DSR and an increased requirement to manage network constraints and balance network supply;
- Development of RIIO-ED2 investment plans based on real time data and Demand Side Response outputs;
- Roll-out of solutions supporting the increased level of heat and transport load on our network.

Once we have developed the smart grid techniques to ‘drive’ the network in this way it will be possible to fully define the financial benefits in measurable terms for our stakeholders.

Real time operations will necessitate a revision in our approach to data management and communications; data will become a key asset and we will use it to inform our overall network operations, asset management and service performance across all elements of our business. We will use data to drive innovation.

- Completion of our innovation delivery plan and the realisation of the potential from these systems will underpin our RIIO-ED2 investment plans. The ED2 period is forecast to see a dramatic increase in the rate of heat and transport load on electricity networks and industrialisation of the developed technologies. Readiness for this uptake will be a key priority between 2019 and 2023.

Table 5: Timeline for RIIO-ED1 Innovation Initiatives 2015-2023

Stakeholder Priority	Innovation Project Initiative	Year\ Voltage	2015	2016	2017	2018	2019	2020	2021	2022	Projected Project Expenditure (£m)
Reliability/ Sustainability	Load Impact Modelling	LV									**£0.82**
		HV									
Reliability/ Affordability	Thermal Capability	LV									**£1.2**
		HV									
Reliability/ Affordability	Asset Management	LV									**£1.2**
		HV									
Reliability Customer service	Automatic Fault Restoration	LV									**£1.5**
		HV									
Reliability/ Sustainability	Development of Autonomy	LV									**£0.82**
		HV									
Affordability/ Sustainability	Network Configuration	LV									**£1.2**
		HV									
Affordability	Reference Networks	LV									**£1.2**
		HV									
Affordability	Network Modelling	LV									**£1.65**
		HV									
Affordability/ Customer service	Feeder Operational Modes	LV									**£1.2**
		HV									
Sustainability	Voltage Management	LV									**£2**
		HV									
Sustainability	Feeder Design	LV									**£1.5**
		HV									
Sustainability	New Materials	LV									**£1.2**
		HV									

Stakeholder Priority	Innovation Project Initiative	Year\ Voltage	2015	2016	2017	2018	2019	2020	2021	2022	Projected Project Expenditure (£m)
Sustainability	Data Clouds	LV									**£1.2**
		HV									
Customer service	Demand Side Response	LV									**£2**
		HV									
Customer service / Affordability	New Connections	LV									**£1.2**
		HV									
Customer Service	DSO Services	LV									**£2.92**
		HV									
Customer service	High Performance Computing/ Data Manipulation	LV									**£0.82**
		HV									
										Total	**£23.63M**

8.4 Innovation initiatives aligned to RIIO-ED1 framework

Each of the initiatives have been developed to ensure the expected outcomes deliver benefits in the areas identified by our stakeholders ie their key priorities; and the whole innovation programme has been reviewed to ensure the initiatives collectively fulfil in both breadth and depth the Ofgem outputs expected from the RIIO-ED1 framework. Table 6 below shows the cross-referencing of the each initiative to the Ofgem outputs and our stakeholder priorities confirming our proposed RIIO-ED1 innovation programme aligns with our stakeholders' priorities and Ofgem six outputs. As described earlier in the innovation governance section we will manage and monitor the delivery of each innovation project and the delivery of the whole innovation programme as this is key to the realisation of our stakeholders' requirements and the expected Ofgem outputs.

Table 6: Innovation initiatives linked to Ofgem outputs challenges and stakeholder priorities

Innovation Project Initiative	Ofgem Outputs						Stakeholders' Priorities
	Reliability and availability	Safety	Social obligations	Environmental Impact	Customer Satisfaction	Connections	
Load Impact Modelling	●			●	●	●	Reliability/ Sustainability
Thermal Capability	●	●		●	●	●	Reliability/ Affordability
Asset Management	●	●	●	●	●	●	Reliability/ Affordability
Automatic Fault Restoration	●				●		Reliability/ Customer service
Development of Autonomy	●	●	●	●	●	●	Reliability/ Sustainability
Network Configuration	●	●	●		●	●	Affordability/ Sustainability
Reference Networks	●			●		●	Affordability
Network Modelling	●		●	●			Affordability
Feeder Operational Modes	●		●	●	●		Affordability/ Customer service
Voltage Management	●	●		●	●	●	Sustainability
Feeder Design	●	●	●	●	●	●	Sustainability
New Materials	●	●	●	●	●	●	Sustainability
Data Clouds	●			●	●		Sustainability
Demand Side Response	●		●	●	●	●	Customer service
New Connections	●		●	●	●	●	Customer service / Affordability
DSO Services	●		●	●	●	●	Customer Service
High Performance Computing/ Data Manipulation	●	●	●	●	●	●	Customer service

8.5 The consequences of not innovating

Innovation is an essential part of our RIIO-ED1 business plan and preparation for the expected increased uptake of Low Carbon Technologies in the latter part of RIIO-ED1 and into ED2. Not innovating will have a detrimental impact on our ability to deliver against our stakeholders' key priorities of affordability, reliability, sustainability and customer service. Not innovating would have the direct consequence of:

- Losing the opportunity to maximise the use of existing assets and reducing the cost of operating networks;
- Inability to develop and test alternative techniques instead of relying on traditional reinforcement solutions;
- Hindering the low carbon transition due to the lack of understanding of the impact of low carbon technologies and the portfolio of solution options;
- Hinder our ability to engage with customers in the operation of the network and offer a range of alternative connection and operational arrangements; and
- Hinder our ability to think through and test the roadmap from a distribution network operator to a distribution system operator.

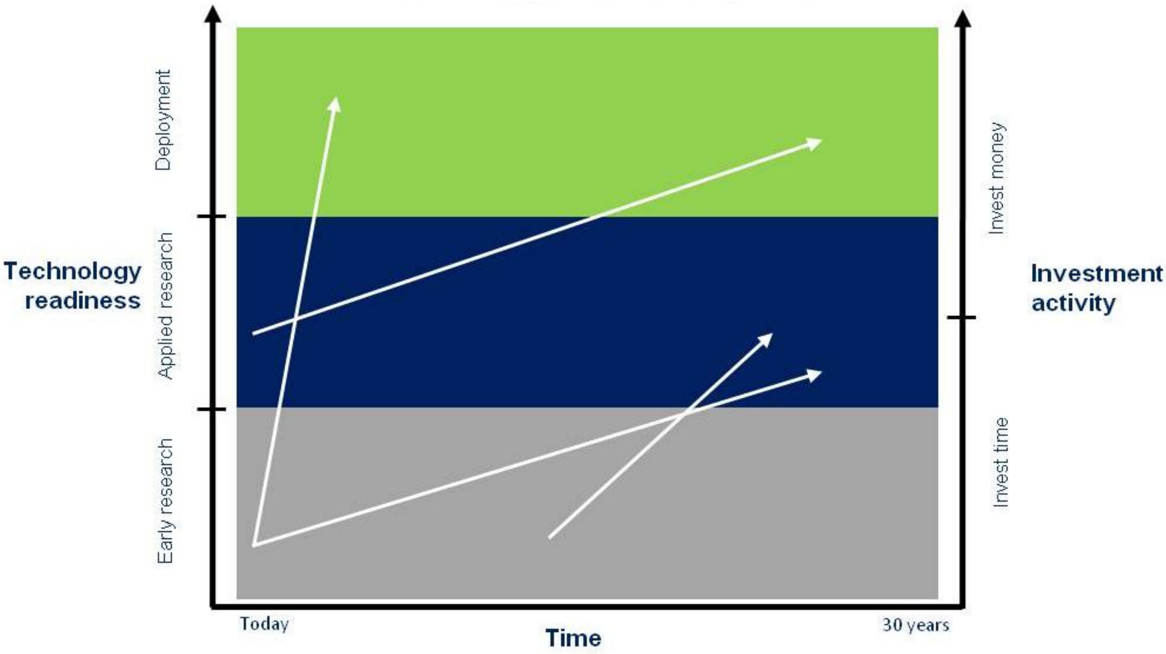
Further information on the consequence of not undertaking each of the innovation initiatives targeted for RIIO-ED1 is contained within Annex 1.

8.6 Ongoing strategy development

Our innovation strategy will evolve through 2015 to 2023. Each year we will review our strategy and the associated innovation programme and every other year we will seek input from our stakeholders on our approach and direction. The development of a deliverable smart grid strategy, contained in annex 13, for RIIO-ED1 requires rules to guide our innovation investment decisions. Our strategy needs to take into account new and emerging technologies that might today appear to be far from being commercially available but may have a significant effect if they did reach a high technology readiness level.

We need to ensure we have a proactive role in relevant product/ technical developments and keep all elements of these developments under surveillance. To enable this approach we have defined a technology development life cycle that is relevant to our businesses future needs. Figure 11 below illustrates our lifecycle approach to guide when we should support and when we should invest.

Figure 11: The challenge of predicting relevant technology development



For example our early stage support (of the technology development cycle) could be with technical specifications or target price points and in later stages support could be with appropriate financial investments. We see many new technologies that could be relevant to DNOs including carbon fibre cables, power electronic transformers and circuit breakers and nano-materials. The challenge is to look into the future and direct our limited resources at those developments to ensure the right pace of new technology development and adoption. We have developed clear rules that help us to rationalise decisions and define which areas offer the greatest benefits for our stakeholders. Our overarching objective is efficient delivery and use of our own network capacity. We also need to be clear where we expect the market to deliver innovations, but concurrently ensure we are fully aware of where new markets and opportunities arise for example retail market developments from greater customer engagement.

9. Glossary

BEAMA	British Electrotechnical and Allied Manufacturers' Association
CAPEX	Capital Expenditure
C_2C	Capacity to Customers – an LCN funded project
CBRM	Condition Based Reliability Maintenance
CHP	Combined Heat and Power
CLASS	Customer Load Active System Services – an LCN funded project
DECC	Department of Energy & Climate Change of UK Government
DG	Distributed Generation
DNO	Distribution Network Operator
DPCR	Distribution Price Control Review period ie DCPR5 is 2010 to 2015
DSO	Distributed System Operator
DSR	Demand Side Response
EIC	Energy Innovation Centre
ENA	Energy Networks Association
EHV	Extra High Voltage, voltages greater than 11kV, up to and including 132kV
EV	Electric vehicle
ETR	Engineering Technical Report
FFC	Fluid Filled Cables
GB	Great Britain
HV	High Voltage, voltages greater than 1000V up to and including 11kV
IET	Institution of Engineering and Technology
IFI	Innovation Funding Incentive
IRM	Innovation Roll-out Mechanism
KPI	Key Performance Indicator
LCN Fund	Low Carbon Network Fund
LCT	Low Carbon Technologies
LRE	Load Related Expenditure
LV	Low Voltage, voltages up to and including 1000V
MP	Member of Parliament
NIA	Network Innovation Allowance
NIC	Network Innovation Competition
NLRE	Non-Load Related Expenditure
OPEX	Operational Expenditure
PV	PhotoVoltaic
QoS	Quality of Supply
RIIO-ED1	Revenue = Incentives + Innovation + Outputs (RIIO) – first electricity distribution price control (ED1)
RIIO-ED2	Second electricity distribution price control (ED2) under RIIO framework
RTU	Remote Terminal Unit
RTTR	Real Time Thermal Rating
TSO	Transmission System Operator
UK	United Kingdom
UKPN	UK Power Networks

10. Annex 1: RIIO-ED1 Innovation Initiatives

Load Impact Modelling

Area	Reliability/ Sustainability	**Objective**	• Develop load models • Investment planning • Capacity thresholds
Expected outcome		Improved design standards and investment decision	
Consequence of not undertaking		Reduced ability to prepare effectively for connection of new LCTs	

Background

The adoption at scale of low carbon technologies is forecast to increase the demand for electricity over the RIIO period. The effects of these demand increases in on distribution network capacity and investment planning need to be appropriately understood in order to optimise interventions and thus avoid potentially expensive reinforcement. Energy usage and peak load forecasting over the RIIO period is extremely complex with high levels of uncertainty owing to the unknown and at times random patterns of adoption of these new technologies. Appropriate visibility of the ongoing relationship between demand growth and associated network investment is a key issue underpinning network investment needs over the RIIO period.

Proposal

The objective of this project is to develop and deploy a suite of planning tools which aim to replace empirical techniques and which can be used to model the effects on the distribution networks with increases in electrical loads. It is proposed to construct a total system peak loading model to evaluate and quantify the relationship between demands and investment and allow us to better quantify the volume and value of network side response available.

Benefits

This project will bring benefits to customers in the form of improved distribution network capacity and investment planning. It will enable us to better model the relationship between the adoption of low carbon technology and the requirements for network investments.

Tasks

Tasks	**Resource**	**Duration (months)**	**Indicative Costs**
Functional Specification	Internal	24	£0.82m
Development of network models	Academic/Tech Provider		
Produce demand forecast scenarios	Internal/Academic		
Technical Specification	Tech provider		
Design and build tools	Tech provider		
Test	Tech provider		
Deploy	Tech provider		
Analysis	Internal		

Thermal Capability

Area	Reliability/ Affordability	**Objective**	• Develop enhanced ratings • Investment planning • Capacity thresholds
Expected outcome		Improved system utilisation and updated operating standards	
Consequence of not undertaking		Opportunity lost to maximise utilisation of existing assets; likely requirement for additional network investments	

Background

A significant amount of work has been undertaken to establish the true ratings of electricity distribution network assets as opposed to standard nameplate ratings designated by original equipment manufacturers. This work has begun to establish the true link between loadings, ambient temperature and asset degradation or aging but to date it has been in the main limited to examining individual asset groups, particularly large and expensive transformers that can be monitored and examined with relative ease.

Proposal

It is proposed to take a more holistic approach to network thermal capability with the aim of enabling higher circuit ratings for the connection of low carbon generation and loads. The project will build on the work carried out to date but will examine and develop models for entire circuits and all components within those circuits. It will further develop the link between loads and asset degradation with the aim of moving away from traditional 'seasonal' circuit ratings. Initial work has shown that transformers for example can accept considerably higher loads (particularly in winter) with no negative effects and it is thought that this approach could be extended to entire circuit provided the necessary understanding could be developed. The approach could be used to enhance ratings at particular time of the year or to provide higher short term ratings under outage conditions.

Benefits

The benefits from this project will arise from being able to run networks to their actual limits (within thermal and ageing parameters) so releasing further network capacity across all voltage levels.

Tasks

Tasks	**Resource**	**Duration (months)**	**Indicative Costs**
Establish priorities for circuit elements	Internal	36	£1.2m
Review work to date	Academic/Tech Provider		
Enhance available models	Internal/Academic		
Develop enhanced monitoring based on sensitivity analysis	Tech provider		
Install monitoring on selected circuits	Tech provider		
Develop IT hardware and links to Network Management System	Tech provider		
Measure increased capacity	Tech provider		

Asset Management

Area	Reliability/ Affordability	**Objective**	• Investment planning • Capacity thresholds • Asset life extension
Expected outcome		Improved condition based assessment and operating practises	
Consequence of not undertaking		Lost opportunity to maximise life of existing assets; likely requirement for additional network investments	

Background

Electricity distribution network asset management techniques have changed radically since privatisation, moving from time-based interventions according to manufacturers' instructions to data capture and condition-based management techniques. This change has led to significant improvements in asset reliability and life extension and enhanced efficiency and the techniques developed by this industry have been adopted by other utility industries both domestic and overseas.

Proposal

It is proposed to continue to enhance our approach to asset management to reflect the ageing nature of our network and the evolution of network running arrangements where networks will experience higher loadings. The investigation will include all aspects of asset management and broadly cover issues such as:

- An enhanced understanding of how different assets change condition (from healthy to requiring maintenance or intervention) and the factors that drive these changes;
- Further development of methods to design optimum intervention strategies;
- Development of a better understanding of materials and data analysis and data gathering; and
- Extending non-intrusive testing techniques.

Benefits

By common agreement the development of condition-based asset management techniques has resulted in significant financial benefits to our industry. The results of this project will allow us to employ the latest techniques and data analysis algorithms to ensure that we can meet the challenge resulting from long term changes to the role of distribution networks in supporting the migration to a low carbon economy.

Tasks

Tasks	**Resource**	**Duration (months)**	**Indicative Costs**
Review of previous work and development of specific aims and objectives	Internal	36	£1.2m
Development of asset classes	Internal		
Development of enhanced data management and manipulation	Tech provider		
Sensitivity analysis of condition data capture	Academic		
Forward modelling and scenario analysis	Tech provider/ Academic		
Integration into BAU	Tech provider/Internal		

Automatic Fault Restoration

Area	Reliability/ Customer service	**Objective**	• Network automation • Improved QoS • Improved reliability • Improved availability
Expected Outcome		Enhanced fault restoration capabilities	
Consequence of not undertaking		Lost opportunity to improve system reliability; reduced customer satisfaction	

Background

Technical developments in the form of improved telecommunications, more advanced remote terminal units with enhanced battery performance together with advances in network control room management functionality has allowed operators to automate the restoration of supplies in the event of a faults. These techniques have been successfully applied to higher voltage networks significantly enhancing the quality of supply. In recent years, this technology has now begun to be deployed on lower voltage networks thus facilitating the potential adoption of automation on these networks.

Proposal

The project will look to trial the deployment of automated fault restoration on the low voltage networks. It will build upon the principles developed as part of higher voltage deployments and seek to leverage the integration of new smart grid technology on the low voltage network including automated low voltage substations and link boxes. The project will develop a number of alternative restoration algorithms.

Benefits

The project will benefit customers by significant enhancing the reliability of the low voltage networks and reducing the duration of low voltage interruptions. This is considered to be a particularly key development as customers become increasingly reliant on safe and reliability electricity as they adopt low carbon technology to heat their homes and power their cars.

Tasks

Tasks	Resource	Duration (months)	Indicative Costs
Functional specification	Internal	48	£1.5m
Development of network models	Academic/Tech Provider		
Select trial networks	Internal		
Technology selection	Internal		
Technical specification	Tech provider		
Procurement	Internal		
Design and build (Software)	Tech provider		
Test	Tech provider		
Deploy	Tech provider		
Analysis	Internal/Academic		

Development of Autonomy

Area	Reliability/ Sustainability	Objective	• Develop load models • Investment planning • Capacity thresholds
Expected Outcome		Optimised use of network assets	
Consequence of not undertaking		Reduced capability of network to host low carbon loads	

Background

In the most general sense Autonomy can be defined as the ability of a person or entity to make informed decisions. The concept is widely used in many physical sub-systems where sets of rules are developed and systems are enabled to follow and act on these rules without resorting to third parties for guidance or checks. Autonomy is already used at higher voltages to restore supplies to customers following faults on EHV networks through automatic restoration systems where 'healthy' parts of the network are automatically switched back in without any input from network control engineers.

Proposal

As automation is extended across the network to lower voltage levels through the development of low voltage circuit breakers and as thermal and enhanced ratings are developed it will be necessary to make an increasing number of decisions regarding network configurations to release the additional capacity required. The aim of this project is to recognise that it will become impractical to increasingly require control engineer intervention to manage networks and a greater level of network 'self-awareness' will be required. This could include automatic meshing of low voltage networks to manage loads based on thermal ratings of distribution transformers. The project will examine data links and command and control algorithms and will merge network protection and control functions into a single entity with the aim of removing the requirement for human intervention.

Benefits

It must be recognised that the scale of switching and network control decisions may increase exponentially in response to the deployment of new switching devices and the need for additional network capacity. The benefits of this project will result from a better ability to run the electricity network to its limits across ever greater areas and voltage levels and it will also eliminate the potential for errors.

Tasks

Tasks	Resource	Duration (months)	Indicative Costs
Project scoping	Internal		
Requirements definition	Academic/ Internal		
Sensing and data transmission	Tech provider		
Autonomy algorithm development	Internal/Academic	36	£0.82m
Implementation	Tech provider		
Testing	Internal/Tech provider		
Deployment	Internal/Tech provider		

Network Configuration

Area	Affordability/ Sustainability	Objective	• Network design • Network operating standards • Commercial contracts
Expected outcome		Updated operating practises	
Consequence of not undertaking		Opportunity to maximise use of existing assets	

Background

Historically in the UK electricity networks have been designed to delivery electricity generated at scale in large out of town power plants to customers in load centres via interconnected transmission systems and radial distribution networks. The flow of energy was unidirectional from the point of generation to the load centres and the role of the customer was as consumer. However, the increases in embedded generation, the adoption at scale of low carbon technologies and the role of the customer as an active participant in energy markets is changing the characteristics of distribution networks resulting in increasingly dynamic, bi-directional power flows.

Proposal

The objective of this project is to develop and trial alternative distribution network configurations which aim to best address the emerging challenges of low carbon loads and the changing requirements of customers.

Benefits

This project will bring benefits to customers in the form of improved distribution network designs and configurations which facilitate the low cost adoption at scale of low carbon technologies.

Tasks

Tasks	Resource	Duration (months)	Indicative Costs
Design	Internal	36	£1.2m
Develop commercial contracts	Academic/Tech Provider		
Specify and develop new technology	Internal/Tech Provider		
Procurement	Consultants		
Construction	Internal		
Analysis	Internal/Academic		

Reference Networks

Area	Affordability	**Objective**	• Reference networks • Modelling • Planning and design
Expected outcome		Improved network design and operating standards	
Consequence of not undertaking		Impaired ability to effectively manage networks with LCTs connected	

Background

The adoption at scale of embedded generation on HV and LV networks will increase the difficulty associated with obtaining appropriate voltage regulation across these networks throughout the seasonal load cycles. The addition of large electrical heating loads and vehicle charging will add to this challenge. Issues associated with phase voltage imbalance and harmonics are also of concern to operators.

Proposal

The objective of this project is to develop a small number of reference networks to support ongoing planning and design of future networks based upon common network and demand characteristics. The reference networks will be used to characterise the effects of the adoption of low carbon technologies and to support the development of a suite of mitigation measures to best address the emerging challenges of low carbon economies and the changing demands of customers. As both design and operation have a direct effect on end customers, there is a case for appropriate simulation and testing of new designs and changed operating practices before using such new approaches for real. Testing, modelling and simulation will allow approaches to be both de-risked in terms of customer effects and optimised in terms of customer benefits. Some modelling, such as the power system behaviour of individual new power system components is business as usual and for which well established test approaches exist. But many aspects of considerations beyond single components of the power system do not have well established assessment approaches, and a degree of development is required in many cases.

Benefits

This project will bring benefits to customers in the form of improved distribution network planning and design thus reducing overall costs and facilitating the transition to low carbon networks. Failure to be able to easily assess and test new design and operating approaches could reduce the benefits of possible network efficiencies available to customers, and in some cases expose them to new risks.

Tasks

Tasks	**Resource**	**Duration (months)**	**Indicative Costs**
Functional specification	Internal	36	£1.2m
Technical specification	Academic/Tech Provider		
Design and build (Software)	Internal/Tech Provider		
Test	Consultants		
Deploy	Internal		
Analysis	Internal/Academic		

Network Modelling

Area	Affordability	**Objective**	• Operation and control • Modelling • Planning and design
Expected Outcome		Enhanced modelling tools	
Consequence of not undertaking		Inability to appropriately model the effects of the connection of LCTs	

Background

Historically in the UK electricity networks have been designed to deliver electricity generated at scale in large out of town power plants to customers in load centres via interconnected transmission systems and radial distribution networks. The flow of energy was unidirectional from the point of generation to the load centres and the role of the customer was as a consumer. However, the increases in embedded generation, the adoption at scale of low carbon technologies and the role of the customer as an active participant in energy markets is changing the characteristics of distribution networks resulting in increasingly dynamic, bi-directional power flows.

Proposal

The objective of this project is to develop network modelling tools which will provide the capability to assess the effects of the adoption of low carbon technology, support the analysis of the impacts of alternative network configurations, and provide optimisation of network investment versus commercial arrangements. Network models to be applicable in both operational and planning timescales.

Benefits

This project will bring benefits to customers in the form of improved distribution network models which will provide improved capability to assess the effect of emerging customer demand requirements and understand the need for associated network reinforcement.

Tasks

Tasks	Resource	Duration (months)	Indicative Costs
Functional specification	Internal	36	£1.65m
Development of network models	Academic/Tech Provider		
Data collection, cleanse and load	Internal/Academic		
Technical specification	Tech provider		
Design and build (Software)	Tech provider		
Test	Tech provider		
Deploy	Tech provider		
Analysis	Internal/Academic		

Feeder Operational Model

Area	Affordability/ Customer service	**Objective**	• Operation and control • Configuration • Standards and design
Expected Outcome		Alternative network operating configurations	
Consequence of not undertaking		Lost opportunity to maximise use of existing assets	

Background

Increases in embedded generation, the adoption at scale of low carbon technologies and the role of the customer as an active participant in energy markets is driving change in the characteristics of distribution networks resulting in increasingly dynamic, bidirectional power flows. Traditionally low voltage feeders are designed and operated on a taper and forget configuration where the feeder is largely static with its configuration only being altered for maintenance activities or when customers complain of power quality. All feeders are protected by fuses and many are fitted with link boxes. Fuses and links can be replaced by retrofit smart devices such as switch fuses offering the capability to mesh networks or reconfigure in real time.

Proposal

The objective of this project is to develop alternative network operating modes which are better suited to the future demand characteristics of low carbon technologies and embedded generation. The project will consider the costs and benefits of the various options supported by field trials and simulation.

Benefits

This project will bring benefits to customers in the form of optimum power and energy transfer across the load cycle thus facilitating the connection of low carbon technology at lower cost. The alternative operational modes will result in improved power quality and reduced harmonic distortion.

Tasks

Tasks	**Resource**	**Duration (months)**	**Indicative Costs**
Functional specification	Internal	36	£1.2m
Development of network models	Academic/Tech Provider		
Select trial networks	Internal		
Technology selection/ spec	Internal		
Procurement	Internal		
Design and build (Software)	Tech provider		
Test	Tech provider		
Deploy	Tech provider		
Analysis	Internal		

Voltage Management

Area	Sustainability	**Objective**	• Voltage regulation • Losses • Harmonics/Unbalance
Expected Outcome		New network voltage operating solution and standards	
Consequence of not undertaking		Lost opportunity to maximise use of existing assets and meet the emerging requirement of customers	

Background

The adoption at scale of embedded generation on the HV and LV networks will increase the difficulty associated with obtaining appropriate voltage regulation across these networks throughout the seasonal load cycles. The addition of large electrical heating loads and vehicle charging will add to this challenge. Issues associated with phase voltage imbalance and harmonics are also of concern to operators.

Traditional LV feeder design is based on a voltage standard as outlined in BS EN50160 which assumes stochastic loads and a demand of 1.5kW per customer. This gives a nominal feeder voltage drop of 7% at maximum demand with a slightly higher than nominal sending voltage. Studies indicate that existing networks can accept micro-generation penetration levels of up between 25% and 50% but that beyond these levels voltage standards cannot be guaranteed.

Proposal

The objective of this project is to develop new innovative techniques for achieving distribution network voltage management which are aim to best address the emerging challenges of low carbon economies and the changing demands of customers.

Benefits

This project will bring benefits to customers in the form of improved distribution network voltages and network efficiency which will have the effect of facilitating the low cost adoption at scale of low carbon technologies and the transition to a low carbon economy.

Tasks

Tasks	**Resource**	**Duration (months)**	**Indicative Costs**
Functional specification	Internal	48	£2m
Development of network models	Academic/Tech Provider		
Select trial networks	Internal		
Technology selection	Internal		
Technical specification	Tech provider		
Procurement	Internal		
Design and build (Software)	Tech provider		
Test	Tech provider		
Deploy	Tech provider		
Analysis	Internal/Academic		

Feeder Design

Area	Sustainability	**Objective**	• Design • Planning • Reinforcement
Expected Outcome		New network design standards	
Consequence of not undertaking		Lost opportunity to maximise use of existing assets	

Background

The current design of the LV network effectively places the HV transformation point up to 1000m from the feeder end customer. This design drives a higher installed LV to HV network ratio than used in other designs such as in the USA. Installing a higher number of smaller transformers closer to the end customer has a number of technical advantages such as improved voltage regulation and power quality but at a potentially higher overall cost. A longer term objective is therefore to revisit this connection design with a view to optimising performance and costs on a smart grid.

Proposal

The project will consider alternative LV feeder designs which are better suited to accommodating higher penetration of low carbon technology. The project will consider a range of options including both tactical network addition and the designs to be deployed on totally new installations. The project will consider the cost and benefits of the alternative options.

Benefits

The project will benefit customers by ensuring that the low voltage networks can readily accommodate the connection at scale of low carbon technology such as PV, EV charging and electric heat pumps without the requirement for significant cable overlays.

Tasks

Tasks	**Resource**	**Duration (months)**	**Indicative Costs**
Design	Internal	36	£1.5m
Develop designs	Academic/Tech Provider		
Procurement	Consultants		
Construction	Internal		
Analysis	Internal/Academics		

New Materials

Area	Sustainability	Objective	• Develop load models • Investment planning • Capacity thresholds
Expected Outcome		Knowledge of alternative materials for use in power systems	
Consequence of not undertaking		Hinder the ability to make decisions on the use of alternative materials in power systems	

Background

Generally assets installed on electricity networks originally consisted of copper conductors and steel tanks and containers and in the main cellulose and mineral oil-based insulation media. Recent decades have seen the introduction of polymeric-based insulation and gasses such as sulphur hexafluoride but mounting environmental awareness and raw material costs has served to increase the need to find more acceptable; alternatives, in terms of cost, reliability and environmental impact.

Proposal

Research has demonstrated that a range of new materials are under development that could offer considerable benefits to the design of electricity network assets. These include nano-engineered materials, Graphene, carbon nanotubes and room temperature superconductors. This project intends to examine the availability and applicability of these materials but it should be clearly stated that the project will not fund material development; rather it is aimed at working closely with materials scientists and developers both in industry and academia to ensure we influence appropriate developments.

Benefits

The benefits of this project will be in the long term and are hard to define. The rate of material developments is such that towards the end of the RIIO ED1 period in 2023 there is a remote possibility that literally revolutionary new materials may be available for commercial use. Any developments of these materials will not be funded by us but support for a broad range of near and longer term innovations must be a part of any balanced innovation strategy.

Tasks

Tasks	Resource	Duration (months)	Indicative Costs
Research	Internal	36	£1.2m
Engagement with relevant experts	Academic/Tech Provider		
Financial modelling of potential benefits	Tech provider		
Trials	Tech provider		
Evaluation	Tech provider		

Data Clouds

Area	Sustainability	Objective	• Data management • Operations • Planning
Expected Outcome		Data storage and management specification	
Consequence of not undertaking		Hinder the storage and manipulation of smart metering data	

Background

The development of smart grids and the increased use of automated technologies on HV and LV networks have resulted in significant increases in the deployment of network sensors and monitors; a trend that will continue throughout the RIIO period. This together with the expected arrival of smart meters will result in extremely high volumes of loading and other analogue data which will be available to network operators to support future network operations. The management of these new high volume data sets presents a significant challenge to network operators who are likely to need this data (often in near real-time) to support network operation and planning.

Proposal

This project will investigate options available to the network operator for the capture, storage and extraction of network data. The project will consider the full range of data sets that will become available as outlined above and how best this data can be captured and stored. Storage options are likely to include consideration of cloud solutions as well as traditional physical media. The need to extract meaningful information from these large data sets is clear and the project will consider the business requirements and the most appropriate analytics and reporting methods.

Benefits

This project will benefit customers by allowing network operators to better utilise existing infrastructure owing to the availability of much richer data. This data will support the deployment of smart solutions which will in turn facilitate the adoption of low carbon technologies and the transition to a low carbon future.

Tasks

Tasks	Resource	Duration (months)	Indicative Costs
Functional specification	Internal	36	£1.2m
Technical specification	Academic/Tech Provider		
Design and build (Software)	Internal/Tech Provider		
Test	Consultants		
Deploy	Internal		
Analysis	Internal/Academic		

Demand Side Response

Area	Customer service	**Objective**	• Commercial Innovation • Investment planning • Network Capacity
Expected Outcome		New commercial arrangements	
Consequence of not undertaking		Lost opportunity to develop a range commercial options for customers	

Background

The concepts of Demand Side Response (DSR) are well known following many years of academic investigation both in the UK and abroad. DSR encompasses a broad range of commercial arrangements across the complete energy supply chain and recent innovations such as Electricity North West's Capacity to Customers Project offering post-fault DSR have highlighted the unexploited potential for novel trading arrangements between all actors and the benefits returned to customers.

Proposal

This project will not fund any research into the concepts of DSR as they are already well known. It is intended to use the funding to continue the development of innovative contracts that will require both legal and commercial input to exploit opportunities presented by new technical developments.

Benefits

The benefits of DSR are many but the fundamental element is ensuring we can offer new high-value (to customers) services by exploiting network capacity based on physical limits rather than traditional passive network standards.

Tasks

Tasks	Resource	Duration (months)	Indicative Costs
Staff development	Internal/Consultant	48	£2m
Investigation into commercial innovations	Internal/Consultant		
Investigation into legal innovations	Internal/Consultant		
Customer engagement	Internal/Consultant		

New Connections

Area	Customer service/ Affordability	**Objective**	• Commercial Innovation • Investment planning • Capacity thresholds
Expected Outcome		New connection arrangements based around commercial arrangements	
Consequence of not undertaking		Lost opportunity to develop a range commercial options for connection customers	

Background

Electricity North West has pioneered the relatively new area of commercial innovation in regard to new connections to our network with the specific aim of facilitating more cost effective and efficient connections of low carbon technologies for our customers. The connect and manage approach is a novel method of facilitating our customer's needs and the advent of advanced monitoring and data manipulation should allow this approach to be more widely extended.

Proposal

This project will continue to develop this and other methods of commercial innovation across all voltage levels and for all customer groups with the aim of ensuring Electricity North West can continue to deliver the most efficient service for our customers. The project will examine all elements of connection agreements and the opportunities afforded by new monitoring and control technologies and will identify the skill required by our staff to exploit new opportunities.

Benefits

Commercial innovation is as fundamentally important to the delivery of an efficient network as is technical innovation, and in some cases can deliver significant financial savings for customers. Benefits will result from ensuring we can explore all aspects of network operations to deliver the most effective commercial arrangements for our customers.

Tasks

Tasks	Resource	Duration (months)	Indicative Costs
Review	Internal	36	£1.2m
Identification of skill sets required	Academic		
Customer engagement	Consultant		
Model contract development	Internal		
Financial appraisals	Internal		
BAU integration	Internal		

DSO Services

Area	Customer service	**Objective**	• Network design • operating standards • Commercial contracts
Expected Outcome		New DSO service specifications	
Consequence of not undertaking		Lost opportunity to understanding potential DSO role	

Background

The European Commission is prompting member states to develop their energy markets and regulatory regimes to facilitate the introduction of Distribution System Operator (DSO) services. According to the Union of the Electricity Industry European (EURELECTRIC) UK DNOs will face the new challenges of facilitating effective retail markets, in addition to undertaking their traditional roles of operating, maintaining and developing an efficient electricity distribution network. These retail markets will be where customers will be provided with options allowing them to seamlessly choose the best suppliers, tariffs and services best tailored to their needs.

Proposal

It is clear at the moment that this migration from a passive network owner to an integrated system operator will present many challenges within the UK regulator environment and whilst the objectives are fairly clear, the path to achieve these objectives is fraught with difficulty. This project will investigate how these services can be defined and developed and how Electricity North West can implement these customer offerings to ensure we can operate our business in response to new demands and customer behaviour. It is envisaged this activity will continue to develop throughout the RIIO period.

Benefits

The benefits from this project will arise from ensuring we can remain at the forefront of offering services our customers need.

Tasks

Tasks	Resource	Duration (months)	Indicative Costs
Definition of the DSO role	Internal/Consultant	36	£2.92m
Examination of current business structures and offerings	Internal/Consultant		
Customer engagement	Internal/Consultant		
Gap analysis	Internal/Consultant		
Identification of the skills and people required to effect these changes	Internal/Consultant		
Implementation and business development	Internal/Consultant		

High Performance Computing/ Data Manipulation

Area	Customer service	**Objective**	• Develop load models • Investment planning • Capacity thresholds
Expected Outcome		Data processing specification and application	
Consequence of not undertaking		Hinder the understanding of the manipulation of smart metering data	

Background

In order to manage the expected increase in electricity distribution loads the way networks are managed will need to change significantly. This will be based on both the amount of data gathered by monitoring and surveillance tools and the extent to which the network will be automatically managed by new protection and control algorithms. It is already apparent that the costs associated with managing the increasing levels of monitoring data being gathered using current IT infrastructure is prohibitive. Therefore a radically new approach will be required to analyse and act on greatly increased data volumes.

Proposal

High performance computer systems are obviously capable of processing significant amounts of information in very short time scales. This project is not to investigate the performance of these systems but rather to examine the costs and benefits of such approaches to electricity distribution network management. This project will investigate the analysis of Smart Meter data and the potential to use the data for network management purposes as new meters are rolled out across the geographical regions of our network.

Benefits

The new demands on electricity distribution networks as we move to the significant adoption of low carbon technologies and the exponential increase in data being generated by a range of sensors means that our current approach to data storage and management will be inadequate. This project will define the requirements for new systems and test and implement the necessary solutions.

Tasks

Tasks	Resource	Duration (months)	Indicative Costs
Project scoping	Internal	24	£0.82m
Investigation of the ‘state of the art’ of HPC systems	Academic/Tech Provider		
Investigation of data storage and hosting	Internal/Academic		
Trials and analysis	Tech provider		
Development of future proof HPC platforms	Tech provider/internal		