WESTERN POWER DISTRIBUTION
INNOVATION

NEXT GENERATION NETWORKS

INNOVATION STRATEGY

February 2017

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Executive Summary

Role of innovation within WPD

Innovation is core to our business strategy. We always seek to find better ways of working. We have adopted many innovative ideas into our day to day operations that improve the efficiency and effectiveness of the way we deliver our services to customers. Our track record of innovation and change spans from the implementation of good innovative ad-hoc ideas from staff all the way through to formal innovation projects.

We look for innovative developments across five broad areas;

- Network performance and efficiency - searching out better processes, equipment and technology that ensure we continue to be efficient;
- low carbon networks – supporting future electricity demand and generation requirements;
- smart grids and meters – developing new techniques and utilising enhanced data to help develop more dynamic network control;
- environment – reducing our business impact on the environment;
- customer service – developing smarter ways of delivering better customer service.

These areas of work are interdependent and progress in one area will often help to enhance innovation development in another.

The objectives of WPD's innovation are to:

- develop new smart techniques that will accommodate increased load and generation at lower costs than conventional reinforcement;
- improve performance against one or more of our core goals of safety, customer service, reliability, the environment or cost effectiveness;
- ensure solutions are compatible with the existing network;
- deliver solutions so that they become business as usual;
- provide value for money.

The way that we approach innovation is fundamental to delivering these objectives efficiently. WPD's Innovation Strategy is to:

- actively involve staff from across the business in the generation of ideas, development of solutions and implementation of projects;
- work with our stakeholders to understand their needs;
- make use of innovation incentives and funding provided by the Government, the regulator and other funding organisations;
- use a small core team to coordinate innovation projects;
- define clear objectives for each project so that delivery can be focused and progress can be tracked;
- avoid theoretical research or innovation which does not have clear objectives;
- incorporate innovative solutions into existing equipment and processes;
- share what we learn with other organisations and learn from others.

Customers and stakeholders are a valuable source of ideas as they are directly affected by our performance. Our stakeholder engagement process for innovation is the same as for all other areas of our business. Innovation is a key theme of our stakeholder engagement sessions. Stakeholders understand that innovation cuts across all areas of our business and provides improvements and benefits to all the areas.

New ideas also come from several other sources. They can come from within WPD and are often based on improvements to existing practice or recent experiences. They can also incorporate learning from other DNO projects. In some cases academia will approach us with a theoretical idea which we can develop into a solution. We also look for ideas in other sectors where there is the potential for technology developed outside of the electricity industry to be brought in, modified and used.

Our innovation projects shape how we are thinking about the future. We will continue to innovate and undertake new projects that will build upon what we have already learnt from the projects we and other DNOs have carried out. We set out within this Innovation Strategy the progress we have already made, the predicted output from the various projects currently being undertaken and the future projects planned.

1. Document purpose

This document sets out the detailed Innovation Strategy for Western Power Distribution (WPD). It describes our approach to innovation and describes how we continue to innovate within our business to improve efficiency and set the foundations for smart grids.

It was produced as part of the RIIO-ED1 business plan and has since been reviewed and re-issued annually to reflect changing external factors, business priorities and to incorporate learning from the previous 12 months. The document applies to all four WPD distribution licences of West Midlands, East Midlands, South Wales and South West.

The Innovation Strategy looks at the long term development of our distribution assets and customer service caused by changing customer needs. The Strategy looks through to 2035, yet naturally provides more detail on the shorter term priorities, requirements and proposed initiatives.

This document provides all the information that Ofgem requires in an Innovation Strategy for a licenced network operator, namely:

- evidence of how previous innovation funding has been used effectively and resulted in improved outcomes for consumers;
- the high-level problems and/or challenges which the sector/company expects to face over the period, and the justification for initiating projects to address these;
- the consequences of innovation not occurring;
- the process or methodology by which we will focus on future innovation;
- demonstration that the problems/challenges have been identified/prioritised and justified in consultation with stakeholders;
- discussion of the relative priorities, risks, benefits, value for money and potential customer impacts;
- deliverables and potential deliverables from the research or development or trials, such as defined learning on an issue, revised codes, new charging methodologies etc.;
- a description of our processes for reviewing and updating the innovation strategy;
- a description of our approach to ensuring the efficient roll-out of successful innovation into business as usual (including innovation developed by other DNOs).

This document is one of three annual reports related to innovation. The other two can be found on our website:

Environment and Innovation Summary Report – Ofgem requirement

https://www.westernpower.co.uk/docs/About-us/WPD-Innovation-and-Environment-Report_2015-16.aspx

Annual NIA Project Summary – NIA Governance requirement

https://www.westernpowerinnovation.co.uk/Document-library/2016/WPD-NIA-Summary-15_16-Final.aspx

2. Introduction

2.1 What is innovation?

Innovation is the process of having new ideas, developing them into practical solutions and implementing them into equipment or processes in order to improve network performance or customer service. It will provide more flexible solutions that are better, cheaper or quicker than the current ways of doing things. The RIIO-ED1 Network Innovation Incentives and the Government's Carbon Plan bring huge change and significant opportunities to innovate. Innovation does not have to be on a large scale; sometimes improvements can be achieved through evolutionary change, involving incremental improvement to existing methods.

2.2 Why do we innovate?

We rely on innovation to maintain our position as a frontier performer in network performance and customer service. Innovation is targeted at all of the key outputs of safety, cost efficiency, customer service, reliability and environment. In the past innovation has proved beneficial by allowing us to continually improve in these areas. Future innovation will allow us to continue these improvements and will also help us to address the challenges brought about by the Carbon Plan.

2.3 How do we innovate?

Innovation is core to our business strategy. We have a small innovation team dedicated to exploring innovative ideas including the delivery of smart grid projects. Our projects are predominantly generated from ideas from staff and stakeholders. When our projects involve the installation of equipment on our network or require a change to business processes we do this in the same way as our standard engineering activities using the skills and efficiencies of our engineering teams. We also draw on the expertise of our suppliers and help them develop solutions. Furthermore, we work with a range of research establishments utilising their specialist skills.

2.4 Stakeholder involvement

Innovation is a key theme of all stakeholder engagement sessions. Our stakeholder engagement process for innovation is the same as for all other areas of our business. Stakeholders understand that innovation cuts across all areas of our business and can provide improvements and benefits to all the areas. We welcome ideas from our stakeholders and openly encourage them to put forward their suggestions.

3. Background

3.1 Government and regulation

Our main sources of innovation funding are managed by Ofgem, the industry regulator. Ofgem has established a variety of funding mechanisms to develop future networks that support the Government's Carbon Plan. We work with both Ofgem and the Department of Business, Energy and Industrial Strategy (BEIS) to support their ambitions, targets and meet their and our obligations.

We also engage with BEIS and Department for Environment, Food and Rural Affairs (DEFRA) on related matters such as Climate Change Adaptation (CCA) that looks to the longer term effects of climate change on the UK electricity industry.

We actively engage in the development of regulatory and legislative policy and our learning from innovation projects informs the proposals we make in our responses to consultations. The results from our projects are published and freely available via our website, which enables all stakeholders to benefit from our learning.

3.2 Innovation funding within the UK

In the period between 2005 and 2010, Ofgem set up the Innovation Funding Incentive (IFI). Its purpose was to improve the quality of research and development within the UK electricity industry. The Registered Power Zone scheme (RPZ) was also set up to support network demonstration projects related to Distributed Generation.

In 2010, and continuing through to 2015, Ofgem introduced the Low Carbon Networks Fund (LCNF). The LCNF was designed to support the development of low carbon technologies within the UK electricity industry and facilitate the changes brought about by the Carbon Plan. It contained three elements; large scale projects funded through a competitive process (Tier 2); smaller scale projects that are self-certified (Tier 1) and a discretionary reward where Ofgem will provide an additional allowance for companies that successfully develop learning that generates benefits for the industry.

We are undertaking the highest number of innovation projects of the UK DNOs.

DNO	Tier1/NIA	Tier2/NIC	Other	Total
WPD	39	7	4	**50**
SSE	44	4	1	**49**
UKPN	36	7	0	**43**
ENW	30	5	0	**35**
SP	17	3	0	**20**
NPG	18	1	0	**19**

In RIIO-ED1 the Network Innovation Allowance (NIA) and Network Innovation Competition (NIC) has replaced the previous schemes. The NIC has a greater value and is open to the electricity transmission companies. We will continue to develop innovation projects through these mechanisms. For NIC we publish an annual Call for Proposals as we recognise that innovative solutions can also be developed from within our existing supply chain.

We have also secured support and funding from the Engineering and Physical Sciences Research Council (EPSRC), Energy Systems Catapult and Innovate UK.

3.3 Smart Enablers

Whilst we are developing new smarter techniques to support low carbon technology (LCT) developments, we will continue to provide electricity to customers by constructing new network and maintaining our existing assets. We will also be reinforcing the network in response to load increases.

Whenever this work is done we have an opportunity to look ahead to the future. Assets commissioned today are likely to still be in place beyond 2055 and in preparation for future load growth, we can take advantage of installing assets with a higher specification or with functionality inbuilt for future use.

We already provided some preparation for the future and will continue to develop a wider range of 'future-proof' innovative options in RIIO-ED1.

3.3.1 Pre-installing LV monitoring capability

It is anticipated that we will require more data about the LV network to inform automatic network management schemes. Whilst the data requirements are simple (e.g. near real time voltage and current readings) they are not currently available. The easiest place to obtain this data is at the low voltage distribution cabinets at distribution substations. These cabinets have historically been fitted with simple CTs to give an indication of peak load on a local meter.

When the cabinets are manufactured it is a cost effective process to uprate the CT to a more accurate unit and wire it to a terminal block where monitoring equipment can be connected when required. This prewiring enables the use of more complex monitoring equipment without the need to interrupt customers or work on the cabinet. The additional cost of these CTs is low relative to the full cost of the cabinet (1.4% of the total cost). WPD has been specifying this arrangement since 2010 and we will continue to do so.

3.3.2 HV switchgear flexibility

It is likely that in the future we will need to move load from one part of the HV network to another to make the most use of network capacity. The most efficient way of moving load is to operate 11kV switches remotely. At this stage we do not have sufficient data to know specifically where this functionality will be required but we can plan ahead by purchasing switchgear which is prepared for automatic operation.

The actuators that drive operating mechanism are relatively expensive, but factory fitted wiring, CTs and connections to accept the actuators can be incorporated into switchgear units with a minimal cost increase. Installing switchgear that is prewired for automation avoids the need to change switchgear at a later date. The cost of the prewiring is low (1.5% of the total cost) and WPD has been specifying this arrangement since 2009 and will continue to do so.

3.3.3 Hotspot reinforcement

We continue to undertake works to extend, replace and reinforce our network as a part of normal asset management. In some locations this provides the opportunity for us to complete works over and above the base scheme to provide network reinforcement for future LCT needs.

We have worked with CSE to develop a shortlist of locations, 7% of our distribution substations, where we are confident that this additional work will be required in the future. Our additional works include oversizing transformers and cables when they are being replaced as a part of other works.

3.3.4 LV retrofit monitoring

The provision of a business as usual retrofit product for LV cabinets allows us to simply upgrade older parts of our network when additional visibility is required. It is a smart enabler which doesn't need to be added in a pre-emptive way as the monitoring system can be added to LV cabinets as and when it is needed.

3.3.5 Smart Grid Forum

The Smart Grid Forum (SGF) was set up in 2011 to bring together key stakeholders in the development of a GB smart grid. The SGF helps network companies address future network challenges and ensures system benefits are considered in the development of smart grids.

We continue to be active in many of the SGF workstreams. Workstream 6 deals with Commercial and Regulatory Matters. We have been involved in knowledge sharing events for this group, where we explained the experiences of customer engagement and DSR. One of the key outputs from the group is the requirement for greater visibility of DSR between DNOs, TSO, suppliers and aggregators. We are already in discussion with National Grid on this topic. We are also planning to prototype a market visibility platform with British Gas.

Workstream 7 considers the future of distribution networks out to 2030 (DS 2030 project). It has modelled representative real networks to validate the findings from the Workstream 3 Transform system. DS2030 has concluded that future networks will require a combination of smart and conventional solutions.

4. Innovation Progress

4.1 Completed research and development projects

The Innovation Funding Incentive (IFI) & Registered Power Zone (RPZ) mechanisms were designed to deliver value to end consumers through safety improvements, increased cost efficiency, improved customer service and reliability and also environmental improvements.

Examples of successful IFI projects completed since 2005 are listed in the table below along with which outputs they benefit. This is followed by a brief description of each project.

IFI Projects	Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
Reference network model		✓	✓	✓	✓
Impact of climate change and weather analysis	✓	✓	✓	✓	✓
Phase ID Tool	✓	✓	✓	✓	
Network Finger Printing		✓	✓	✓	✓
Half Hourly Metered Customer Archetypes		✓	✓		✓
Earthing information system	✓	✓		✓	✓
Generating value from smart meter data		✓	✓	✓	
Condition based risk management	✓	✓		✓	✓
Management of Electricity Distribution Network Losses		✓			✓
Power Communications Meter		✓	✓	✓	✓
Domestic Demand Response Network Study		✓	✓		✓

4.1.1 Reference network model

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓	✓	✓

The project created a model that could represent different circuit groups, to allow power system analysis of network performance. Parameters can be changed allowing us to predict the effects of different investment options. The output has been used subsequently within further IFI studies including in the support of Smart Grid Forum modelling work. The models will be further developed to support strategic planners in making long term investment decisions.

4.1.2 Impact of climate change and weather analysis

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓	✓	✓	✓	✓

A DEFRA funded project involving climate projections was used to develop new methodologies and probabilistic predictions to assess specific energy industry impacts. The project has improved our knowledge allowing us to better plan for future scenarios including the increase risks of both flooding and lightning as well as changes to the thermal loading of overhead lines.

4.1.3 Phase ID Tool

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓	✓	✓	✓	

This project developed and demonstrated a tool that can reliably detect and identify the individual phase a customer is connected to, without extensive and expensive monitoring for the entire LV network. This tool provides high accuracy visibility of the phasing connectivity through non-invasive methods without customer interruptions, allowing more effective network optimisation to be planned. The tool is being used on Innovation Projects where we need to identify phase connectivity, such as our Losses Investigation work on the Isle of Man. It could also be used to identify phase connectivity should cluster of Low carbon technologies cause phase imbalance at distribution substations.

4.1.4 Network Finger Printing

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓	✓	✓

This analysis and research project developed a method to group together networks of similar topologies and impedances so that the effect of harmonic distortions created by additional connections in that area can easily assessed. By identifying the key factors in understanding the frequency response of their network, this allows a more informed decision during the new connections planning process. This work will feed into further R&D in the field of power quality.

4.1.5 Half Hourly Metered Customer Archetypes

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓		✓

This statistical analysis project investigated if scalable customer profiles for domestic customers can be created and how effective their usage is in determining EHV and HV system loads. Usage of these profiles allows planning tools to have a better view of the network and reduces the duplication of effort by individual parties involved in load estimation. The output will be used to support our new energy forecasting development project.

4.1.6 Earthing information system

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓	✓		✓	✓

This project developed a Geographic Information System (GIS) to assist DNOs in the installation of rural ground earthing systems. Carried out in conjunction with the British Geological Survey, it provides a graphical presentation of ground conditions and estimates the likelihood of suitable earthing resistance being met. The system has recently been further developed and is now provided as an overlay in our GIS systems used regularly by network planners.

4.1.7 Generating value from smart meter data

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓	✓	

This Technology Strategy Board (TSB) funded project was delivered jointly with the Centre for Sustainable Energy (CSE). It looked at possible methods of undertaking data mining on the vast pool of data that will be available following the smart meter roll out, and how the information produced can be of maximum use to WPD and the wider industry.

4.1.8 Condition Based Risk Management (CBRM)

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓	✓		✓	✓

The Condition Based Risk Management project has delivered a tool to determine optimum replacement triggers for network assets. CBRM data is also being used to optimise maintenance periods based on condition.

4.1.9 Management of Electricity Distribution Network Losses

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓			✓

The project investigated the concept of making distribution networks as energy efficient as economically possible. It raised awareness of issues and proposed solutions which take more account of losses in network design. The project created a set of recommendations which are being addressed through our Losses Strategy.

4.1.10 Power Communications Meter

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓	✓	✓

The project developed a simpler remote telemetry unit (RTU) for use at smaller distributed generation sites. It allows our control room to have the visibility they require without the complexity of a conventional RTU. The unit now forms a part of our standard set of solutions for the connection of new generators.

4.1.11 Domestic Demand Response Network Study

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓		✓

The project investigated the potential of using domestic energy control systems to manage demand and offset the impact in locally connected generation. The study results were used to develop a follow on Tier 1 project called Sunshine Tariff.

4.2 Innovation Performance to date

Innovation has always been a key part of WPD's development strategy and our ability to take an innovative approach to day to day working and problems that we face has made us the most successful DNO in the UK.

Innovation projects often come from ideas that have flowed from staff and these have helped us to deliver excellent levels of performance in safety, reliability, customer service, the environment and cost efficiency. Completed innovation projects are detailed within the table below, which also identifies the areas where improvements have been achieved.

	Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
DNO to SO Control Interface	✓	✓	✓	✓	
Isles of Scilly Smart Grid			✓	✓	✓
PV Impact on Suburban Networks		✓	✓	✓	✓
Smart Hooky			✓	✓	✓
Voltage Control Demonstration	✓	✓		✓	
Early Learning	✓	✓	✓	✓	
Seasonal Generation		✓		✓	✓
LV Sensors	✓	✓		✓	
Active Fault Level Monitoring	✓	✓	✓	✓	
Community Energy Action		✓	✓		✓
Electric Boulevards			✓		✓
ECHO		✓	✓		✓
Sunshine Tariff		✓	✓		✓
SVC-2	✓	✓	✓	✓	
Voltage Reduction Analysis		✓	✓		✓

4.2.1 DNO to SO Control Interface

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓	✓	✓	✓	

This project developed the first technical interface between a DNO and SO system using the ICCP protocol. The development of the solution has since been utilised on subsequent innovation projects within WPD and other DNOs. It forms the basis of future operational data sharing between DSO and SO functions.

4.2.2 Isles of Scilly Smart Grid

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
		✓	✓	✓

WPD worked with the islanders through this project to help make the isles energy self-sufficient. The project established real time monitoring of substations, using a range of communications techniques, including broadband power line carrier over 11kV networks along with 450MHz and 2.4 GHz radio communications. The project also developed advanced remote generation control.

4.2.3 PV Impact on Suburban Networks

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓	✓	✓

The introduction of feed-in tariffs within the UK has shown a significant increase of micro generation connected to the low voltage distribution network, including solar panels (i.e. PV panels). This is particularly an issue on suburban networks. This project investigated how to monitor and determine the effects of installing large numbers of solar panels (i.e. PV panels) on Low Voltage (LV) suburban networks. Nottingham is one location with up to 1.2 megawatts (MW) of PV panels installed on domestic properties in the Aspley and Meadows areas. Through this project, WPD learnt how high density PV panels affect eight distribution substations and compared the predicted network characteristics against the measured results.

4.2.4 Smart Hooky

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
		✓	✓	✓

Building on the successful Low Carbon Communities Challenge, this trial aimed to help WPD understand how a rural community uses electricity at different times of the day and find out how electricity networks could accommodate more low-carbon technology.

The project also looked at delivering a customer engagement and incentive programme; a community data measurement and display capabilities; at-scale Power Line Communications (PLC) demonstration; High Voltage (HV)/Low Voltage (LV) substation monitoring technologies; and a miniature smart grid telecommunications network. Smart Hooky allowed homeowners to understand the impact of their own behaviour on their energy consumption and on the environment.

4.2.5 Voltage Control Demonstration

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓	✓		✓	

As Distributed Generators (DG), such as wind turbines and photovoltaics (PV), become more common the growing number of connections to distribution networks increasingly cause voltage problems, due to the variable power output of the DG. This can affect the efficiency, capacity and performance of the distribution network. This project aimed to address the issue of voltage problems seen in long distribution network lines in a rural environment with DG connected. The objective was to produce a connection and control methodology and determine the effectiveness of D-SVCs (Static

VAr Compensator for Distribution Networks) to control voltage on 11kV rural networks. The project concluded that the technical performance of D-SVCs was limited on the 11kV system. The cost of adapting to devices to match the impedance of the network at individual locations was much greater than the conventional solutions. The closedown report provides a valuable body of evidence to inform future investment decisions.

4.2.6 Early Learning

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓	✓	✓	✓	

A new low carbon housing development of roughly twenty houses was developed by Melin Homes in Crickhowell, South Wales. The estate featured high efficiency houses each equipped with photovoltaics. Traditional network studies indicated that voltage limits would be exceeded without an overlay of existing 95sq mm LV cable. The scheme provided a low cost opportunity for early learning of photovoltaics (PV) voltage impacts and validity of existing electricity network design assumptions. Installation of two different size LV cables in parallel to the existing cable, with linking facilities at each end, provided a real life, on load, capability to change the impedance of the feeding LV cable and measure resulting changes in voltage performance.

4.2.7 Seasonal Generation

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓		✓	✓

The Seasonal Generation Deployment project explored the opportunity to utilise temporary generation, used for festivals and events in summer, installed in to primary substations to mitigate against the effects of winter peaks on the system. The project was terminated in summer 2013 when it became apparent that it was uneconomic for generation owners to deploy units on a seasonal basis at a cost that would be lower than traditional reinforcement costs. Despite the project termination, several learning outcomes were identified within the trial that will assist future projects or business as usual initiatives that consider the use of distributed generation.

4.2.8 LV Sensor Evaluation

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓	✓		✓	

As UK distribution networks migrate to a smarter grid, there will be an increasing requirement to improve the visibility of the Low Voltage (LV) distribution network. There is currently limited monitoring of the LV network and as customers change their usage habits and more renewable generation connects to the network, it is vital that we are aware of and understand the impact it will have. As part of our Tier 2 LV Network Templates project, we conducted a consultation with the other DNOs to see if there were alternative methods of obtaining current measurements without the need for customer interruption. UK Power Networks (UKPN) were separately investigating commercially available LV monitoring solutions that do not require customers to be interrupted during installation. The LV Sensor project was established as a joint Tier 1 scheme between WPD and UK Power Networks to test and share learning associated with evaluating a range of off-the-shelf LV monitoring solutions. The project resulted in the development of WPD policies and framework supply contracts for LV monitoring solutions.

4.2.9 Active Fault Level Monitoring

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓	✓	✓	✓	

Our Active Fault Level Monitoring Tier-1 project sought to, for the first time, be able to accurately generate real-time 11kV Make and Break fault level values. The project used both new and established technologies to develop an 11kV AFLM device. As part of the project the device was designed, built and robustly tested in a laboratory environment prior to energisation on the 11kV network in Birmingham.

The project provided significant learning in terms of the variability of Make and Break fault levels based on time of day, month and season. This data is now actively feeding in to our Tier-2 Project, FlexDGrid, and business as usual network system analysis activities. Through the provision of real-time fault level data the opportunity to change the network operating arrangement, based on this data, to ensure the network is suitably optimised to either allow additional generation or demand connections or to further increase the security of supply to customers is being further investigated.

4.2.10 Community Energy Action

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓		✓

The Community Energy Action project investigated the methodology and practicality of engaging with domestic communities to deliver demand side response. The project investigated whether engagement on a community level could be an alternative to conventional reinforcement and what was the most appropriate way to do this. Financial incentives were used as a key driver to generate demand response, however, throughout the project it was learned that in the 10 economically and geographically diverse areas this was not seen as a strong driver.

Whilst the techniques tested in this project did not lead to a significant reduction in demand on the distribution substations it has enabled additional demand response techniques to be considered. We are now testing different implementations of demand response through other innovation projects, such as: direct appliance control, tariff based and direct commercial arrangements with industrial and commercial customers. The lessons from this and other projects will be valuable to DNOs when deciding on demand side response policies for full deployment.

4.2.11 Electric Boulevards

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
		✓		✓

The Electric Boulevards project investigated the effects of replacing the conventional diesel powered busses in Milton Keynes with an electric bus fleet. The project centred on the use of inductively charged bused, overnight at the depot and along the bus route. This was the first scheme of its kind in the UK.

Inductive chargers were installed along the bus route and the bus depot and the effect of these charges on the distribution network were investigated. Originally an intelligent system to manage the charging requirements of multiple vehicles was to be trialled; however, due to the potential risk of all buses not being available from overnight charging this element of the project was removed.

The project showed that inductive vehicle charging can be used to replace traditional diesel engines. It was also shown that the disturbances caused on the network due to the inductive chargers do not have a detrimental effect on the operation of the network. Although no further projects are currently planned in the WPD area, learning from this project is now being used on projects based in London and Glasgow.

4.2.12 ECHO

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓		✓

Working with the Energy Saving Trust, ECHO looked to utilise a number of off-the-shelf interactive plug-in devices that facilitated the scheduling of loads for individual domestic appliances at two hundred premises. A range of incentives were trialled with statistically representative groups and monitored to gauge take-up of demand response events. This study allowed us to learn more about consumer attitudes towards DDSR. The scheme's intention was to generate an improved knowledge of the scale of domestic load control possible, feeding into future investment planning models. Additional learning was also generated to update parameters in the WS3 Transform Model.

4.2.13 Sunshine Tariff

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓		✓

The Sunshine Tariff project developed and trialled the feasibility of an 'offset connection agreement'. This would enable generation customers to connect to conventionally constrained networks on the basis that they can change the pattern of local demand to offset the power generated. Additional demand was sought from local domestic customers between 10am and 4pm during the summer months and was be incentivised with a reduced tariff from a supplier. The trial concluded that there are limited amounts of electrical load that customers consider to the flexible. The financial incentives from the DNO alone are not sufficient to significantly change behaviour and create network capacity.

4.2.14 SVC-2

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓	✓	✓	✓	

This project aimed to develop learning generated from a previous LCNF Tier-1 Static Var Compensator (SVC) Demonstration project, which installed an LV connected 400kVA SVC via a transformer to the 11kV network to successfully control the 11kV network voltage enabling the amount of generation to be maximised.

The aim of the second project, SVC-2, was to install three 400kVA SVC over an area of 11kV network to more widely control and optimise the network voltage. This would have involved a sophisticated control methodology to ensure the operation of the three SVCs was optimised. However, throughout investigation of the SVC optimisation methodology it was discovered that the size of the units, 400kVA, was not large enough to have a significant effect on the system. The project was therefore terminated early.

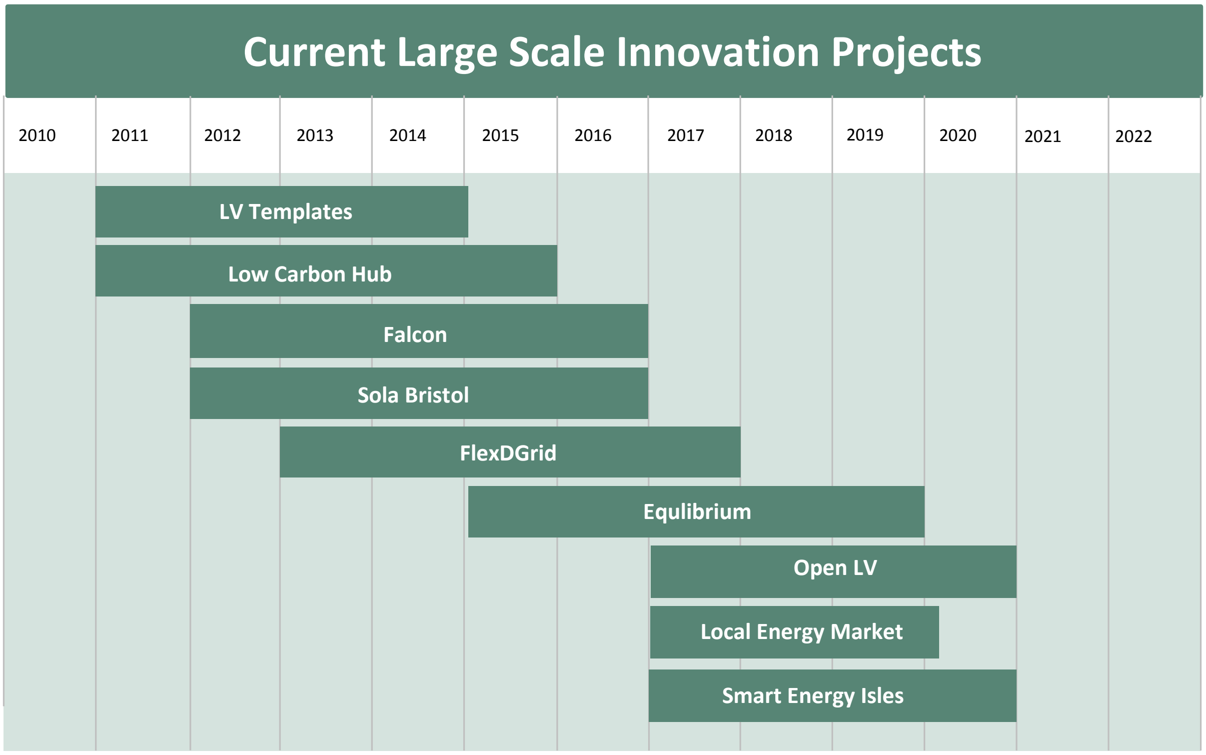
4.2.15 Voltage Reduction Analysis

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓		✓

Following promising results from the "Low Voltage Network Templates" LCNF tier 2 project as well as the "South Wales voltage reduction analysis" IFI report; this project looked to further investigate the effects of long term LV voltage reduction. Reducing network voltage can have significant benefits, particularly where there is a large concentration of resistive loads. For these types of loads reducing the voltage will reduce the maximum demand requirements and, depending on the control mechanism, can also reduce the consumption. The VRA project quantified the reaction of consumption, maximum demand and voltage profiles to voltage drop on real monitored networks. This has led to new WPD policies and the implementation of voltage reduction across our networks.

4.3 Major low carbon and smart grid projects

We have been successful in receiving funding for seven projects through the Ofgem network innovation competitions. We are also project partners in two major innovation projects funded through national and EU innovation mechanisms. The projects investigate a range of network issues from 132kV active network management to rewiring of customer homes with DC systems.



4.3.1 LV Templates

The LV Templates project was used to evaluate how low voltage (LV) electricity networks can best accommodate the low carbon future.

In 2011, 951 substation sites in South Wales were fitted with data monitors and communication equipment. The project also required voltage monitors to be fitted at the ends of the LV circuits that are fed from these substations. This required over 3,500 monitors to be installed to collect the data and send it remotely back to WPD.

The project monitored energy usage and used statistical clustering techniques to identify more accurate patterns in electricity consumption. This allowed us to develop new planning assumptions and embed them in templates that can be used to facilitate more accurate network planning.

This project ended in 2013 and demonstrated that low voltage solar generation normally generates onto the network at around 80% of its rating. We have now altered our design assumptions to reflect this, which has increased the volume of photo voltaic (PV or solar generation) that can be accepted onto the network.

It was also shown that voltage rise effects from PV are less than expected. Both these results will be used within the business and will influence national design policies and solar generation acceptance criteria.

We published network templates data making it available for all DNOs to use in planning LV network solutions. The final project reports published in the autumn of 2013 provide full template data and conclusions.

We have used the results from the LV Templates project to inform future ways of designing networks. This will allow us to better predict the effect of low voltage generation and load and ultimately enable us to accept more on to our existing network. We will also incorporate the learning from SSE's 'Thames Valley Vision' project in our implementation. Scottish Power's (SP) 'Flexible Networks for Low Carbon Future' project will also provide additional knowledge on the acceptance of low voltage generation and the design of flexible ratings.

Although the project is formally closed we are continuing to collect data and process it. This will allow us to identify demand profile changes when customers adopt LCTs and we will then re-model the templates accordingly. The data collection and network monitoring infrastructure will also be used to support new innovation projects without the need to recreate a monitored network.

We published a discussion paper on the possibility of harmonising statutory voltage limits with those in the rest of the EU. The paper has been presented to industry groups including DECC, the Welsh Assembly Government and Ofgem. As a result of our findings the ENA have established a Statutory Voltage Limits working group, which we chair, that is considering the adoption of lower and harmonised voltage limits.

We have already reduced the voltage within the South Wales area. We collected data through 2015 so that the impact of the voltage reduction on energy consumption could be measured and we will report on this during 2016. The findings of the Electricity North West, CLASS project also confirmed our findings.

4.3.2 Lincolnshire Low Carbon Hub

The Lincolnshire Low Carbon Hub was designed to test a variety of new and innovative techniques for integrating additional low carbon generation onto electricity networks with limited capacity. We offered Dynamic Line Rating solutions and Alternative Connection Agreements on this project.

When the Lincolnshire Low Carbon Hub project was originally proposed it predicted that the solution would be replicable across the UK electricity industry in around two locations per DNO licence area. We will deploy the solution in more locations than originally predicted and we have already identified the following sites in WPD. The amount of generation that has been offered and accepted at these sites is over 200MW.

GSP Group	Active BSP Group	Quoting form	Building during
Bicker fen	Skegness	Active	Active
Grendon	Corby	Active	Active
	Northampton	Active	Apr-17
Bridgwater/Taunton	Bridgwater	Active	Active
	Street		Active
West Burton	Horncastle	Active	Active
Indian Queens	Truro	Active	Active
Swansea North	Swansea	Active	Nov-17
Pembroke	Pembroke	Active	Nov-17
Cellarhead	Meaford	Apr-17	Apr-18
Rassau	Abergavenny	Nov-17	Nov-18
Bridgwater	All remaining BSPs	Apr-17	Apr-18
Feckenham	Feckenham	Apr-18	Apr-19
Berkswell	Warwick	Apr-19	Apr-20
Bishops Wood	Hereford	Nov-19	Nov-20
Pyle	Pyle	Apr-20	Apr-21
Remaining GSPs		Jan-21	Nov-21

4.3.3 Project FALCON

Project FALCON was focused on providing an understanding of the dynamic nature of the utilisation of the 11kV network. The aims of FALCON were to facilitate the installation of low carbon technologies by delivering faster and cheaper connections on the 11kV network.

It assessed a number of alternative solutions to conventional network reinforcement. Four technical and two commercial intervention techniques were designed and tested to address network constraints.

The project developed a prototype modelling tool using real-time data to inform network planning decisions, rather than traditional indicators such as total demand and generic engineering guidelines. The project demonstrated a Scenario Investment Model (SIM) planning tool for both 11kV network design and strategic forecasting. The concept of a SIM type tool for day to day and strategic planning will be further developed beyond FALCON.

The FALCON telecommunications solution, based on mesh radio, supported the engineering and commercial trials. The solution will be further evaluated under future Telecoms NIA projects. Although the project is formally closed we are continuing to collect data from the engineering trials. The data collection and mesh radio infrastructure will also be used to support new innovation projects without the need to recreate a monitored network.

The uptake of demand side response within the FALCON project exceeded the planned 9MW target. This has been achieved through a mix of bilateral contracts and services provided through aggregators. Uniquely, the service was offered as complementary to the National Grid STOR service, meaning that customers could engage with us and National Grid at different times. As a result of our findings the ENA have established a DSR Shared Services working group.

The engineering trials within the FALCON project demonstrated and explored four innovative techniques aimed at relieving technical constraints on an 11kV network. The techniques trialled were dynamic asset rating, automatic load transfer, meshed network and energy storage. The trialled techniques are alternatives to conventional reinforcement, the conventional engineering remedy to network constraints.

The energy storage trial installed systems at five Distribution substation locations on one 11kV feeder, and provided valuable learning on site selection and installation challenges. Operational performance demonstrated: effective peak-shaving at both individual substation and feeder level; limited voltage management through reactive power output; and the potential to satisfactorily react to grid frequency (one example of an ancillary service).

Location	Location	Size
AWA Pumping Station, Middleton, Milton Keynes	Battery Storage	50kW/100kWh
Chadds Lane No.2, Pear tree Bridge, Milton Keynes	Battery Storage	50kW/100kWh
Falcon Avenue, Springfield, Milton Keynes	Battery Storage	50kW/100kWh
Ambridge Grove, Milton Keynes	Battery Storage	50kW/100kWh
Helford Place South, Milton Keynes	Battery Storage	50kW/100kWh

We will develop further primary transformer dynamic rating and load transfer techniques. We will also continue to track the development of energy storage technologies as market drivers reduce the cost.

4.3.4 BRISTOL

The BRISTOL project aimed to provide an innovative approach to operating networks utilising battery storage in a customer's premises. The battery systems stored output from PV generation and utilised it in many ways. A DC network for lighting and USB type charging, an inverter controlled by the customer and WPD and new tariffs helped manage the PV generation locally. The project also addressed issues associated with the large-scale deployment of PV generation.

In this project WPD worked with:

- Bristol City Council which deployed the technology at its sites;
- Knowle West Media Centre which coordinated customer engagement;
- Siemens who provided the technology; and
- University of Bath who were our academic partner.

The technologies were implemented in five schools, one office and 26 homes; all connected to 13 distribution substations.

The project tested the coordination of a local micro-grid and has also provided an excellent storage and DC power test bed. The BRISTOL solution is not immediately be ready for rollout by DNOs as it will require further refinement and standardisation, as a proportion of the installation is beyond the customer's meter.

4.3.5 FlexDGrid

The connection of generation to urban HV networks can lead to fault levels that exceed the rated capability of existing networks. Traditionally, higher rated assets would need to be installed to enable the generation to connect, but this project investigates alternative ways to accommodate the connection of generation.

The FlexDGrid project is based in Birmingham and seeks to explore the potential benefits from three complimentary methods:

- Enhanced fault level assessment;
- Real-time measurement of fault level; and
- Fault level mitigation technologies.

The project has already provided data which will change how we calculate fault level and will be used to alter design principles.

Real time measurement of fault level has shown that the enhanced fault level assessment calculations are correct and will allow us to more accurately categorise load and generation effect on fault level. The project is now in the final stages. Data analysis is underway to draw conclusions from the ten Fault Level Monitors (FLM) and three Fault Current Limiters (FCL) installed. The tables below indicate the progress of the FLM and FCL installations respectively.

FLM Substation	Status	Energisation Date
Elmdon	Energised	October 2014
Chad Valley	Energised	December 2014
Castle Bromwich	Energised	February 2015
Kitts Green	Energised	March 2015
Shirley	Energised	March 2015
Hall Green	Energised	April 2015
Nechells West	Energised	July 2015
Chester Street	Energised	August 2015
Bartley Green	Energised	September 2015
Bournville	Energised	October 2015

FCL Substation	Status	Energisation Date
Castle Bromwich	Energised	April 2015
Chester Street	Energised	January 2016
Bournville	Energised	February 2016

4.3.6 Network Equilibrium

The focus of Network Equilibrium is to balance voltages and power flows across the distribution system to better configure the network. This project will help to integrate additional distributed generation within electricity networks more efficiently and deliver major benefits to distribution customers. It is developing solutions that will be demonstrated across Somerset and Devon.

The project uses three methods:

- Enhanced Voltage Assessment (EVA)

This develops a new network modelling tool for 33kV and 11kV networks. It will allow better visibility of time series power flows & voltage profiles at 33kV and 11kV, not just the extreme scenarios. It will improve contingency planning, modelling, and forecasting of both demand / generation profiles.

- System Voltage Optimisation (SVO)

SVO will dynamically adjust 33kV and 11kV voltage profiles across 8 BSP's and 8 primary substations within the trial area. It will overcoming the issue of fixed voltage points at key substations by using telecommunications and centralised network management software.

- Flexible Power Links (FPL)

The project will trial the use of novel power electronics to optimise the power flows between two different 33kV networks. A Flexible Power Links will be used for first time by a GB distribution network operator and will transfer of both real and reactive power flows, on a dynamic basis, between previously unconnected networks.

WPD expect to unlock an additional 344MW of additional generation capacity across the trial area. The EVA work is complete. The SVO development work is in progress by project partner Siemens. The BSP and Primary substation sites have been identified. The FPL supplier contract was awarded to ABB following a tender process. The location of the device has now been decided.

4.3.7 Open LV

OpenLV will create a software platform which enables enhanced real time assessment and visibility of low voltage network capacity. This improved visibility will allow the distribution network companies to more actively manage this level of the network, which is necessary as more generation and demand is connected locally. Such an approach would ensure the available capacity is used more effectively, minimising the costs of reinforcement.

The decarbonisation of heat and transport through the wide scale customer adoption of heat pumps and electric vehicles will increase demand on LV networks. Under current business practice this would result in a large amount of conventional LV reinforcement, at significant cost and disruption to customers, to accommodate this increase in demand. New solutions are becoming available, but each delivered on separate, proprietary platforms.

The functionality delivered by the OpenLV Solution will be proven via three complementary Methods:

- Method 1: LV Network Capacity Uplift;
- Method 2: Community Engagement; and
- Method 3: OpenLV Extensibility to 3rd parties.

The OpenLV Solution includes the following key components:

- Intelligent substation devices that can support software
- Applications or ‘Apps’ from multiple vendors on a single device. Providing a low cost hub that, once deployed, can act as a hub for many more functions;
- A secure platform that enables the intelligent substation devices to be remotely managed;
- A secure platform that provides LV network data to community groups and third party organisations.

This will facilitate non-traditional business models by opening up network data to third parties to understand the network and deploy solutions.

The roll out of the overall Solution proposed across GB will support the Low Carbon Plan and uptake scenarios presented in the UK Government’s Fifth Carbon Budget by minimising the impacts of low carbon heating and transport on the LV network, therefore removing this as a barrier to customer adoption where it is applied. This has significant potential to deliver environmental benefits and cost savings to future and existing customers by negating and/or deferring the need to reinforce the LV network.

4.3.8 Local Energy Market

A key conclusion of the Smart Grid Forum Workstream 6 was for market participants and network operators to have visibility of each other's proposed DSR actions and requirements. Our DSR Plug and Socket project will support a much larger EU funded initiative led by Centrica in Cornwall to create a local energy market. The visibility plug and socket project will develop a platform to enable suppliers, aggregators and communities to inform the network operator of planned changes to assumed electricity profiles (either DG or demand). It will allow the network operator to post information about potential congestion, enabling a market solution to them. Any requirements for residual balancing and direct DSO schemes would thus be minimised.

4.3.9 Smart Energy Isles

WPD are part of a Hitachi led consortium awarded EU funding to build and operate a renewable energy mircogrid on the Isles of Scilly. In additional to the integration of renewable generation the project will install energy efficiency measures and control system in homes and businesses.

4.4 Low carbon and smart grid smaller project portfolio

In addition to the large projects, WPD has is continuing to deliver a portfolio of smaller low carbon projects.

	Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
Solar Storage		✓		✓	✓
LV Plus	✓	✓	✓		
Industrial & Commercial Storage		✓	✓	✓	✓
Time Series Data Tools		✓		✓	
Superconducting Cables	✓	✓		✓	✓
Common Information Model		✓	✓		
NEXUS – Global Analysis of Telecoms		✓	✓	✓	
EV Emissions Testing	✓		✓		✓
Time Series Data Analysis	✓	✓		✓	
Project SYNC		✓	✓		✓
Losses Investigation		✓			✓
Airborne Inspections		✓		✓	
CarConnect (Electric Nation)		✓	✓		✓
ENTIRE		✓	✓		✓
FREEDOM		✓	✓		✓
LV Connect & Manage	✓	✓	✓	✓	
Carbon Tracing			✓		✓

4.4.1 Solar Storage

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓		✓	✓

The key focus of the Solar Storage project is to identify economically viable incentives the DNO can offer to DG developers for use of stored solar energy during periods of peak demand. The challenge will be to establish commercial frameworks that make battery storage an economically viable option that provides the sufficient rate of return and allows DG Developers access to other market incentives.

The battery storage system has been installed alongside a 1.3MW PV park in Somerset. Seven different usage profiles are being trialled over the course of the project, learning from the trials will be used to identify governance limitations and provide recommendations of how a BAU system could be implemented. Details of the use cases trialled and Best Practice guide will be disseminated to the wider DG community.

4.4.2 LV Plus

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓	✓	✓		

A key challenge facing the UK Distribution Network Operators (DNOs) today is the increasing demand for power being placed on residential networks e.g. by the proliferation of electrical vehicles (EVs) and the move to electro-heat. The increase in distributed generation (DG) in areas of network conventionally designed for supplying demand can lead to local voltage rises limiting capacity. Networks are also limited by the thermal current carrying capability of the existing assets. Losses within the network are defined by the inherent impedance in the assets and the load utilisation.

This project follows on from a TSB Feasibility Study which showed that a cost effective solution to these problems can be achieved on the existing infrastructure by increasing the local network phase voltage to 400V and stepping the voltage back down to 230 V at each house. DNO-owned, low-cost, 99% efficient power electronic converters (PECs) will need to be installed in the meter-box. From the earlier TSB Feasibility Study, it is suggested that a 62% capacity increase could be achieved at roughly 1/3 of the cost of reinforcement.

This system will not only increase network capacity, but also provide optimised connections for emerging EV charging, DG and energy storage. WPD will be installing up to 20 devices to be field-tested on an LV network across the Midlands.

4.4.3 Industrial and Commercial Storage

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓	✓	✓

This innovation project will demonstrate the integration of a storage device behind–the-meter on an Industrial and Commercial scale. Deployed systems will be used to optimise the energy demand of buildings, provide demand–response to the TSO, and to firm up intermittent generation particularly at sites with intermittent generation.

The project will investigate different configurations in the application of storage. These include but are not limited to peak shaving, load shifting, transmission and distribution support, phase balancing, reverse power flow mitigation and emergency backup. The project may simulate a range of Transmission System services such as STOR, response services, constraint management, reactive power, energy contracts, enhanced frequency response and any future services. The battery energy storage trial will initially be conducted at 4 separate WPD depots tabled below; with intermittent generation of varying sizes. A 50kW/210kWh ESS will be installed at each of the four sites. In order to test different configurations and better understand the benefits of this project, the locations have been selected with consideration of size, network complexity and occupancy.

This project will provide improvements in cost efficiency, customer service, reliability, and develop more innovative connection arrangements for new and existing customers wishing to deploy storage technologies.

Location	Generator	Size
13 Endeavour Park, Boston	Battery Storage	50kW/210kWh
Vale Road, Spilsby	Battery Storage	50kW/210kWh
Mardy Ind Estate, Lamby way, Cardiff	Battery Storage	50kW/210kWh
Priorswood Rd, Taunton	Battery Storage	50kW/210kWh

4.4.4 Time Series Data Tools

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓		✓	

The project will look at developing a solution for improved collection, analysis and rectification of existing SCADA data used for network planning and control purposes – This data includes half hourly recorded Volts, Amps, MW, MVAR, MVA. The incorporation of metering data and connectivity shall be considered for analysis purposes.

4.4.5 Superconducting Cables

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓	✓		✓	✓

The increasing number of electricity distribution networks reaching their capacity limits means that the need for network reinforcement will continue to grow. Reinforcing our networks using conventional approaches involves among others, building new electricity substations and installing additional transformers at the sites where capacity needs to be enhanced. This is incredibly challenging in urban environments due to limited land availability and high costs, creating the need to investigate alternative solutions.

The problem can be solved by installing new transformers or substations where it is easy to do so and then transferring their capacity to the networks that need it.

Due to their high efficiency, small volume and high capacity, superconducting cables are an attractive solution for connecting new equipment to the physically remote networks that require the additional capacity. In this project, a feasibility study will be performed to determine whether such an implementation should be considered.

4.4.6 Common Information Model

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓		

The Common Information Model for electricity is an international standard developed to support exchange of electrical network information and could be used to support the information layer of the smart grid architecture model. Project FALCON successfully developed innovative techniques to combine data for the 11kV network from key systems to create an Integrated Network Model. This project further develops those innovative solutions to create a comprehensive, accurate and portable network model in CIM format. The benefits of having data in this format will then be tested to determine whether there is a business case to convert and maintain data in this format and a requirement in the future for our software to support CIM format.

We expect that the need to share data will increase as the increase in distributed generation and storage makes closer co-ordination with parties such as National Grid necessary. The CIM is now used routinely for joint stability studies on European transmission networks and is being used in an increasing number of applications by Distribution Network Operators.

4.4.7 NEXUS – Global Analysis of Smart Grid Telecommunications

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓	✓	

Telecommunications Infrastructure will play a pivotal role in enabling Distribution Network Operators transition to a smarter electricity network and ultimately a UK-wide low carbon economy. The Smart Grid will allow greater visibility, control and protection of network assets with enhanced centralised control functions as well as autonomous de-centralised functions. Active and pro-active network management will be essential to optimise the installed assets, whilst meeting the challenges associated with more distributed generation and storage as well as dealing with consumers changing energy demands.

UK Distribution Network Operators are well positioned and highly competent at maintaining and augmenting the conventional telecommunications approaches for Remote Monitoring and Control as well as high speed protection of systems and assets. However, with the increased drive towards a Low Carbon economy within the UK, the way the electricity network is operated has been turned on its head. From a previous operating model from large generator to customer, the proliferation of medium to small scale distributed generation has necessitated a different approach to how the networks are monitored, controlled and protected. Presently, the telecommunications approaches to supporting these new initiatives are adaptations of current systems and bespoke solutions.

This current incremental approach to Smart Grid Telecoms integration can be complicated, costly and undefined in terms of scalability. This project will seek to analyse current and proposed Smart Grid Telecommunications solutions and deployments to assess suitability for integration within the UK DNO’s, taking a holistic view rather than the current incremental approach. By better understanding the Smart Grid as a whole, informed decisions can be made regarding future deployment of Smart Grid solutions and how that will interact with or replace legacy communications systems within the UK Distribution Networks.

4.4.8 EV Emissions Testing

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓		✓		✓

Electric Vehicles (EV) should be compliant with harmonized EU standards under UNECE R10, but various versions of this standard apply to the existing fleet and there is further uncertainly over which standards apply due to the transitional provisions for conformity.

Furthermore UNECE R10 only requires compliance with 61000-3-11 and 61000-3-12 for charging over 16A, which does not provide unconditional connection to the network. Without confirmation of the standards these vehicles comply to, the customer risks facing increased network charges, either due to conservative reinforcement requirements, or widespread reactive reinforcement schemes to ensure the network remains within limits.

This project will assess the harmonic disturbance of EVs by carrying out repeated charge and discharge tests for a range of vehicles and charging levels on monitored EV Chargepoints.

The results of the monitoring will be analysed and a report created on their level of disturbance and standards met. The sample size of at least 15 vehicles will ensure that the majority of mainstream vehicles in the UK are tested. The testing regime and number of charge/discharge cycles will ensure confidence is given to the results. This will take place at Millbrook Testing Facilities.

4.4.9 Time Series Data Analysis

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓	✓		✓	

Distribution Network Operators keep historic time series data within a number of databases which can be interrogated on an ‘as needed’ basis, generally for planning purposes. Due to the sheer volume of data, errors, omissions and underlying trends are difficult to spot by relying on manual intervention alone. This project seeks to investigate the use of data analytics to understand data quality and identify trends and issues which would be difficult to spot through human intervention alone.

Established ‘Big Data’ analytics techniques shall be used to process the huge amounts of time series data held for one licence area in order to identify data quality issues and emerging trends. The project will also look at what other information could be incorporated in to the ‘Big Data’ analytics to further validate data quality.

4.4.10 Project SYNC

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓		✓

Due to significant pockets of dense distributed solar connections on networks a large excess of power generated during specific times of day moves back up to the higher voltage networks. This energy is then distributed to a point where connected customers can use it. Increasingly network reinforcement is required to enable this amount of upstream power transfer. Project SYNC will investigate the use of DSR service to increase demand and reduce DG at times of output that may exceed network capability, along with new alternative arrangements with local demand connections.

4.4.11 Losses Investigation

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓			✓

Distribution Network Operators have a licensed condition to operate and efficient, coordinated and economical system and the effective management of losses across the system is paramount. Technical losses are estimated between 5.8% and 6.6% of electricity delivered and valued at approximately £900 million per annum. With over 70% of the losses occurring at 11kv and below, a detailed understanding of how these are distributed will enable DNO's to prioritise the application of loss reduction techniques to those networks which would benefit the most.

This project is looking to determine the minimum information requirements to accurately assess losses on the network. By fully monitoring several HV and LV feeders we will acquire a reference on networks losses. The monitored HV networks in this project will be installed in South Wales and the LV networks will be in the Isle of Man. We will then develop losses estimates based on several restricted datasets and test against the reference. This will give us the accuracy of each method and show the value of the different levels of information. With the learning from this project we will be able to determine the information required to create a losses register to help us instigate a targeted reduction in losses.

4.4.12 Airborne Inspections

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓		✓	

Airborne Inspections aims to maximise the efficiency of inspection flights, carried out by WPD's helicopters, by ensuring that high quality camera data is collected, processed, stored and presented in a way that can guarantee the best value per survey for the end user. The project will focus on the integration of existing asset management information in to the sensing system and the development of 'in air' reporting capabilities to allow timely data transfer to interested parties of any significant on site issues.

4.4.13 CarConnect – Electric Nation

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓		✓

As groups of neighbours acquire Plug-in Vehicles (PIVs), localised clustering of demand is likely to cause problems for electricity networks, as proven through the My Electric Avenue (MEA) project. MEA showed that approximately 30% of GB low voltage networks will need reinforcement by 2050, if adoption of electrification of transport is widespread (i.e. meeting DECC's High EV Market Growth Forecast). This represents a present day cost of £2.2bn to UK customers – Transform Model® analysis, based on UK Government forecasts of nearly 40 million PIVs on UK roads by that time. The UK Government is committed to the electrification of transport – as illustrated by its recent investment into ultra-low carbon vehicles such as its extension of grants for PIV chargers, PIV car subsidies and the Go Ultra Low Cities Scheme.

This project will use three methods to enable DNOs to identify which parts of their network are likely to be affected by PIV/ vehicle to grid (V2G) uptake, and whether PIV demand control services are a cost effective solution to avoiding or deferring reinforcement on vulnerable parts of their networks.

- Method 1: Modelling

This project will provide DNOs with an assessment tool to predict where PIV/V2G market penetration may cause network problems.

- Method 2: Monitoring

This project will develop an algorithm deployable on an existing substation monitoring facility that will enable the effect of PIVs on a LV network to be retrospectively analysed and allow the measureable impact to be compared against the modelling tool output.

- Method 3: Mitigation

This project will adapt existing smart charger technology, including V2G chargers as they become ready to deploy and existing commercial charger management services and deploy these in a mass-market customer trial to prove the technical/economic viability of PIV/V2G demand control to avoid or defer network reinforcement and to prove that such systems are acceptable to customers.

The customer trial will include a wide range of PIVs, with a range of battery sizes and charging rates to prove such systems can be deployed in a future with a diverse PIV market.

The objective of this project is to equip GB Distribution Network Operators with the tools and solutions to enable them to manage PIV market growth.

4.4.14 ENTIRE (WPD Flexible Power)

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓		✓

Project ENTIRE is a four year project that will be building on the lessons learned from the commercial trials within Project FALCON. The project is seeking to address the conflicts between a DNO and National Grid contractual requirements. This will be achieved by developing new systems and contracts with commercial customers to allow WPD to fulfil its requirements whilst also enabling it to sell the aggregated capacity into other DSR schemes when not required for the DNO. These services could include balancing services procured by National Grid. A key initial stage will be to locate all of the existing generation, whether currently connected to the network or not, and engage with their owners to explain the benefits of joining our new DSR scheme. This will include regular payments for making their assets available to WPD and third party DSR opportunities.

As part of the ENTIRE Project, WPD will be launching its Flexible Power campaign looking to contract with approximately 100MW of demand turn down (or generation turn up) in the southern parts of its East Midlands area. The requirement is technology agnostic and so is open to storage or any other flexibility provider. The service will be used to manage constrained networks and will mix business cases of deferred reinforcement alongside enabling connections ahead of upgrades. As such, the timescales of the requirements form several years to potentially enduring solutions. When not required by WPD, providers will be encouraged to participate in alternative services to generate additional revenues. This can be done through a new WPD in house capability or through another third party aggregator.

New systems developed within the project will manage customer's assets such as stand-by generators and large loads from heating, cooling and pumps. WPD will be able to monitor these in real-time to ensure that they are available, as well as start, stop, meter outputs and settle the billing for the services they participate in. Initial system functionality will be tested by connecting up WPD's own stand-by assets and mobile generation fleet.

The project will be focussed on two areas within the East Midlands that have been identified as requiring new GSPs (Grid Supply Point) which are very major capital works that will take several years to complete. WPD will use the new DSR capability to reduce peak winter demands and potential constraints on the existing GSPs which are becoming increasingly heavily loaded and reduce any operational risks associated with them.

4.4.15 FREEDOM (Flexible Residential Energy Efficiency Demand Optimisation and Management

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓		✓

The research objective is to better understand if hybrid heating systems are technically capable, affordable and attractive to customers as a way of heating homes. This project aims to investigate the feasibility of the use of heat pumps on both Western Power Distribution's & Wales & West Utilities' network in order to:

- Demonstrate the ability of the hybrid heating system to switch between gas and electric load to provide fuel arbitrage and highly flexible demand response services;
- Demonstrate the consumer, network, carbon and energy system benefits of deployment of hybrid heating systems with an aggregated demand response control system; and
- Gain insights into the means of balancing the interests of the consumer, supplier, distribution and transmission network while seeking to derive value from the demand flexibility.

The research will document the outputs of the pilot installations, the system interfaces and customer feedback that will enable us to continue to the next steps towards a commercial solution.

4.4.16 LV Connect and Manage

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓	✓	✓	✓	

Network reinforcement can be too expensive and too time-bound to respond to low carbon technology (LCT) connections on the low voltage (LV) network, particularly if rapid clustering occurs (such as with electric vehicles and PV installations). Due to uncertainties in volume, location and type of LV connections, it is not possible or efficient for WPD to plan network reinforcement (traditional base-case solution) can be too expensive and can take too long to deploy, delaying customers' connections to the network.

A comparison of PV installations registered for the FiT and with WPD data shows only ~60% match in notified LV connections. Despite forecasting, there is still a lot of uncertainty as connections might not materialise or might materialise in more abundance than expected.

Technology for Active Network Management (ANM), which extends communications and controls to customers' meters and is able to deal with bi-directional power flows, is still unproven and needs to be trialled by WPD in a low-risk way, to assess whether or not this option is a viable alternative to network reinforcement.

This project will demonstrate and prove that LV ANM can be used as a short-term measure, whilst network reinforcement takes place, to facilitate the timely connection of customers. The solution can then be re-deployed to another area when the need case arises. Moreover, the ANM solution provides a long-term alternative to network reinforcement in cases where the investment in traditional assets is not economically viable or other reasons (such as the disruption to customers) prevents reinforcement taking place. In order to maintain the highest standard to service its customers, WPD plans to connect them as quickly and cost-effectively as possible and then actively manage them, once connected.

The LV Connect and Manage Method involves the deployment of communications and control infrastructure to allow LCTs to connect to the network in a timely manner and be managed in an active way. We will also be installing 50 domestic energy storage devices behind the meter in customers' homes in order to demonstrate the management and control of distributed energy resources in constrained networks. This will involve, limiting the power exported by LCTs to the network at times of LV network congestion or increasing the power demand of LCTs (heat pumps, energy storage and/or EVs) to keep the network within technical limits.

4.4.17 Carbon Tracing

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
		✓		✓

There is currently no mechanism for telling a customer the actual sources of generation in their area. By providing a mechanism for them to find out that this will act as a catalyst for more information about generation, a potential new avenue into the community and those customers with an interest of where the energy they use comes from.

In addition this project could also help with the engagement and use of Demand Side Management- allowing customers to see the impact of using their LCTs and possibly shifting their load.

The project will start with the procurement of the technical support required to build the app and website. There will then be some controlled trials with selected customers before launching it publically in order to determine the level of interest and whether or not it works to a level that does indeed create /satisfy the interest of end customers.

After the trial we will then roll this out across all of WPD's areas. In order to obtain access to interested customers we will be partnering with the Carbon Trust on this part of the project. They will be actively working with us and the customers to hold surgeries and trials with customers to ascertain interest and monitor it with us throughout the project.

4.5 Collaborative projects with other DNOs

We collaborate with other DNOs and TOs through the Energy Networks Association. New projects are delivered through ENA's Collaborative Energy Portfolio group. Ongoing projects are:

4.5.1 Statistical Ratings

This project is led by WPD on behalf of other network operators. We have developed an overhead line test rig at our Stoke Depot. Working with scientists at EATL the project will explore new techniques to assign ratings to lines on a probabilistic basic taking into account external factors such as weather.

4.5.2 REACT

This REACT project was led by National Grid on behalf of other network operators. Over the last 10 years there has been a steady reduction in reactive (inductive) power required through the grid supply points (GSP's) and in some case a reversal has occurred such that reactive (capacitive) power is supplied back to the grid. This manifests itself as a change to the Q/P ratio at the GSP's, which is itself, representative of the power factor of the grid. The project aimed to look at the reasons for this decline and to help understand how the transmission network voltages can be kept within limits. It is informing work on the introduction of new network codes.

4.5.3 DS2030

This project was led by National Grid on behalf of other network operators. The work was part of Smart Grid Forum Workstream 7.

4.5.4 P2 Review

This project is led by Electricity North West on behalf of other network operators. Engineering Recommendation P2/6 sets out standard design criteria to ensure security of supply. Changes to the distribution network, especially the introduction of distributed generation and future demand response, mean that the standard will need to be adapted. This research project is evaluating standards used in other countries and assessing the potential for changes. A subsequent phase of work will see a new P2/7 standard developed and introduced.

4.5.5 Collaborate Energy Portfolio (CEP)

The DNOs have established a process for identifying and developing shared innovation projects. Managed by the ENA, the CEP has access via framework contracts to research providers. Research ideas are initiated by standing ENA technical groups on plant, overhead lines, cables and transformers. Projects can also be nominated by any individual DNO or by the ENA engineering committee (ENFG).

5. Why do we innovate?

5.1 External factors and trends

The changing global attitude towards fossil fuels is driving customers towards greater electrical solutions for heating and transport. The generation sources which support this increased demand are more renewable and distributed in nature.

Creating a passive network that supports this increased electricity usage would be expensive using purely conventional methods. Our innovation strategy seeks, investigates and evaluates affordable alternatives. The alternatives may include solutions that postpone expensive investment whilst there is uncertainty. They may also provide long term active solutions to the management of networks.

These new type of loads, coupled with a mismatch of when the energy is needed compared to when renewable DG generates, leads to substantial growth in morning and evening peak demand. The size peaks are an order of magnitude greater than today. To build the networks big enough to cater for these peaks would lead to significant over capacity most of the time. In certain regions it is also likely that there will be a summertime/daytime peak of generation export due to solar generation.

Changing energy profiles, larger peaks in demand, substantial swings in DG output and a more active energy market will create challenges for us as we manage our network. The installation of monitoring and control systems to regulate Distributed Energy Resources (DER) which include distributed generation, active demand and flexible storage provides a potential solution but represents a step change in operations from our passive past.

The transition from operating a passive system sized to support maximum demand, to one where DER is actively controlled dependent on real time and forecast energy flow is commonly referred to as a Distribution System Operator (DSO). Innovation Projects have helped informed our DSO Strategy. Current and future projects will deliver further insight into the new roles and responsibilities of the DSO. They will often be critical in advising on the nature and timing of business change.

Innovative solutions can also improve the security of electricity supplies by ensuring generation matches demand in local areas. Solutions could enable sections of the electricity network to be run in isolation for short periods of time.

Distribution network technology will continue to advance and we can gain benefits by adopting it. Our experience shows that new solutions available today will become standard in the near future. For example, Active Network Management (ANM) was bespoke when our Low Carbon Hub project started in 2011. ANM is now business as usual and we have a framework agreement in place with three vendors.

There will also be an evolution in the capability of LCTs such as electric vehicles and heating solutions. Technology breakthroughs are also likely, for example, in the cost and density of energy storage devices. Network innovations we are developing today will need to adapt or be replaced with new solutions over time.

5.2 Responding to Government policy

Concerns about climate change have led the Government to produce the Carbon Plan setting out the UK’s commitment to reducing greenhouse gases by 80% by 2050. New challenges will emerge for DNOs because the Carbon Plan seeks to drive down the levels of carbon released by both heating and transport activities thereby shifting demand from oil and gas to electricity. The scale and pace of the changes are uncertain but we need to be ready to accommodate the changes when they arise.

The aspirations within the Government’s Carbon Plan will increase demand on the network and there will also be more DG.

We have already observed the effects that changes to Government policy can have. The feed-in-tariff for generation has led to a significant increase in the volume of applications for generation connections, with many applications being received just prior to when subsidies are reduced as generator developers seek to maximise their returns from incentive mechanisms.

Devolved Government policy in Wales may lead to specific demands and need for innovative solutions. Our plan is flexible and therefore able to accommodate these.

We expect that some LCTs will also see a high level of uptake which will be influenced by Government subsidies or incentives. The strength of incentives will alter the speed and volume of uptake.

In preparation for future changes we will engage with developers, local authorities and other expert groups to ensure that our preparation plans are targeted in the most beneficial areas.

Our work with the CSE has identified that heat pumps are only likely to be deployed in areas where the housing stock is suitable for them. Likewise, the numbers of electric vehicles are likely to grow in areas where the social demographic suits early adoption. This means that it is highly likely that LCTs will be clustered closely together leading to a compound effect on specific parts of the network.

In the future customers will use electricity in different ways. They will be more aware of their own generation and demand, with some customers becoming more self-sufficient. The existing passive use of electricity will turn into a more active system.

The impact of new forms of generation and demand will become clearer during RIIO-ED1 and into RIIO-ED2 and our plans need to be flexible to respond to changing circumstances. We will accommodate any changing requirements into our Innovation Strategy as part of the annual review.

The rollout of smart meters will provide new data capture opportunities. We will develop systems to analyse the data that will become available to assist in understanding where issues are arising and enable the deployment of domestic Demand Side Response (DSR) where appropriate.

There has recently been a desire by policymakers and industry to consider the whole energy system rather than just electricity or power. The deployment and operation of heat networks and the future of gas infrastructure are intrinsically linked to electricity future capacity. We are actively engaged with the Energy System Catapult’s “Smart Systems and Heat” innovation work in Bridgend.

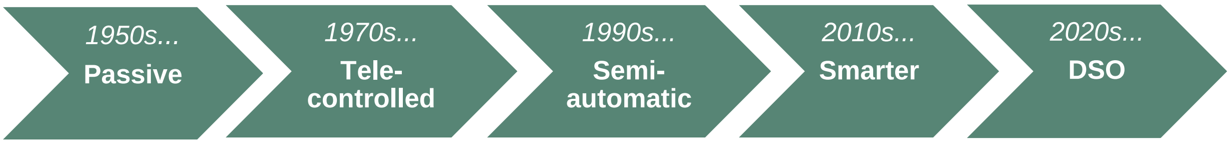
There is concern over potential energy shortfalls on cold, still, dark winter evenings where generation may not meet demand and to address excess generation on summer, windy, sunny day times with minimal load. The government has established a Future Systems Power Architecture (FSPA) task force led by the IET to report on these issues and consider technical system stability. WPD are supporting the FPSA work through involvement in committees and working groups.

5.3 The need for innovation

DNOs will have to become more creative and develop new ways of delivering a network that can respond quickly to both the increased demands from LCTs, such as storage, heat pumps and electric vehicle charging, but also to accommodate the connection of more locally based DG such as photo voltaic and wind.

Networks have evolved progressively since the major electrification of the UK in the 1950s and 1960s but the challenges arising from adoption of the Carbon Plan will require us to change the way we operate more quickly than has been necessary in the past.

Over the last fifty years our network has become far more sophisticated and responsive, but more change will be required during RIIO-ED1 for it to become ‘Smarter’.



5.3.1 Passive

Early electricity networks operated in a simple and passive way. All network switching actions required manual intervention and responses to a loss of supply required people to be on site to understand what had happened and make the changes. If a network required reconfiguration it was done manually.

5.3.2 Telecontrolled with remote operation

Advances in communication technology allowed us to provide a network that could in part be operated remotely. This was applied to the higher voltage levels and was predominantly limited to control of source circuit breakers at primary substations. Manual switching on site was replaced by remote control at a control centre. The communication systems also allowed more real time data about the loading of the network and configuration of running arrangements to be brought back to the control centre.

5.3.3 Semi-automatic / automatic response to specific events

Further advances in communication enabled remote control to be installed more widely on the networks. This allowed more operations to be conducted on the network without the need for manual switching.

Developments in control systems also allowed this equipment to be controlled automatically using logic sequences. Ever more sophisticated NMSs could check and reconfigure networks automatically to provide quick restoration of customers' supplies in a high proportion of HV faults.

5.3.4 Smarter

We are now developing networks that will be more autonomous in the future. The networks will use data from various sources to determine their state and respond accordingly. The data will include weather data, metering data and other information obtained from dedicated monitoring.

Enablers to be added – data, monitoring, connections, ANM, DSR

5.3.5 DSO

In addition to reconfiguring running arrangements in response to faults, the smarter networks of the future will dynamically respond to predicted and actual network loading, output from distributed generators, weather conditions and other parameters to maximise the utilisation of available network capacity. They will enable the most amount of generation to be exported, reconfigure networks or adjusting demand to make best use of the assets. Smarter networks will also allow us to reduce technical losses.

5.3.6 Consequences of innovation not occurring

The need for innovation is set out in this document. It shows the way that we expect the use of the network to change in the future. It is clear that the Carbon Plan will introduce significant challenges that increase the importance of maintaining reliability and customer service to customers during a time when customers change their electricity usage habits.

For our main output areas of safety, reliability, customer service, the environment and cost efficiency we have been a frontier performer for many years. This performance is founded on a strong belief in innovation and continual improvement in all the key output areas.

The consequence of innovation not occurring would be that our performance would not improve further and could potentially decline. Over time, all the output areas of safety, reliability, customer service, the environment and cost efficiency would suffer. If this were to continue over the long term, the work and funding required to restore performance levels would be immense.

Achieving the Carbon Plan places a new set of demands on the electricity distribution network where the majority of LCTs will be connected. Without the innovative and flexible arrangements we are introducing, we would need to build a large passive network to accept the proposed volumes of LCTs. The cost of a passive network to accept the level of LCTs that we expect within the RIIO-ED1 period would be £128m more than the innovative and flexible network we plan to build.

5.4 Dealing with uncertainty

A high degree of uncertainty exists with respect to the GB Energy System and it is therefore important that we seek and use key sources of external data and guidance to ensure that we have the best forecasts possible.

Whilst we are guided by national scenarios developed by BEIS we also employ organisations such as Energy Savings Trust, Centre for Sustainable Energy and RegenSW to tailor them to the WPD regions. To aid consistency in the development of Operability Frameworks we are aligning future WPD scenarios to those used by National Grid.

The detailed understanding that we gain guides the development of our innovation projects to deliver solutions for the potential problems we expect to encounter.

Wherever possible we also ensure that our projects are scalable and capable of providing more generic solutions that can be adopted irrespective of the specific type and level of LCTs that drive increases in electricity usage in the future and can also be transferable to other DNOs.

6. Prioritising innovation topics

6.1 Scope of innovation

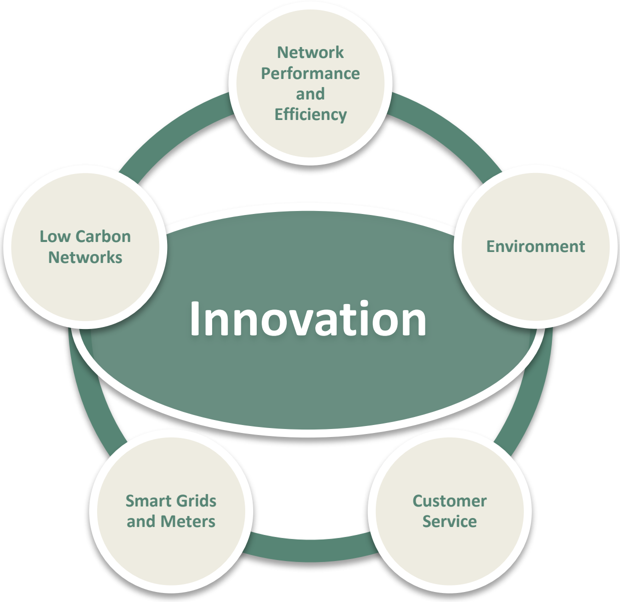
We always look for better ways of working. We have adopted many innovative ideas into day to day operations that improve the efficiency and effectiveness of the way we deliver our services to customers.

Our track record of innovation and change has been developed from the implementation of good innovative ad-hoc ideas from staff all the way through to formal innovation projects.

Our innovation developments can be described across five broad areas;

- Network performance and efficiency - searching out better processes, equipment and technology that ensure we continue to be efficient.
- low carbon networks – supporting future electricity demand and generation requirements;
- smart grids and meters – developing new techniques and utilising enhanced data to help develop more dynamic network control;
- environment – reducing our business impact on the environment;
- customer service – developing smarter ways of delivering better customer service;

These areas of work are interdependent and progress in one area will often help to enhance innovation development in another.



Our existing portfolio of innovation projects is already shaping how we are thinking about the future. We will continue to innovate and carry out new projects that will build upon what we have already learnt from the projects we and other DNOs have carried out.

6.2 Innovation objectives

The objectives of WPD's innovation are to:

- develop new smart techniques that will accommodate increased load and generation at lower costs than conventional reinforcement;
- improve performance against one or more of our core goals of safety, customer service, reliability, the environment or cost effectiveness;

- ensure solutions are compatible with the existing network;
- deliver solutions so that they become business as usual;
- provide value for money.

6.3 Approach to innovation

The way that we approach innovation is fundamental to delivering the objectives efficiently. WPD's innovation strategy is to:

- actively involve staff from across the business in the generation of ideas, development of solutions and implementation of projects;
- work with our stakeholders to understand their needs;
- make use of innovation incentives and funding provided by the government, the regulator and other funding organisations;
- use a small core team to coordinate innovation projects;
- define clear objectives for each project so that delivery can be focused and progress can be tracked;
- avoid theoretical research or innovation which does not have clear objectives;
- incorporate innovative solutions into existing equipment and processes share what we learn with other organisations and learn from others.

6.4 Generating ideas

Customers and stakeholders are a great source of ideas as they are directly affected by our performance.

New ideas also come from several other sources. They can come from within WPD and are based around improvements or recent experiences. They can also incorporate learning from other DNO projects. In some cases academia will approach us with a theoretical idea which we could develop into a solution.

We also look for ideas in other sectors where there is the potential for technology developed outside of the electricity industry to be brought in and modified. For example the FALCON project had network control algorithms which are based on those developed for aircraft flight control. Our Airborne inspections project is repurposing techniques use in the defence sector for the identification of targets and hazards.

6.5 Selecting and prioritising ideas

Ideas that are generated are grouped against the five broad areas of innovation development. They are then assessed against the innovation objectives and subsequently prioritised.

All potential projects are subject to a cost benefit assessment as part of our standard business approvals process.

The positive impact of projects on our customers is considered as part of the selection and prioritisation process. We also consider the possible negative impact to customers, for example the effect on short term network performance whilst the work to deliver a project is ongoing.

6.6 Developing plans for innovation

Innovation in smart solutions will help us to accommodate LCTs through RIIO-ED1 and into RIIO-ED2. Our RIIO-ED1 business plan set out expectations for how smart interventions will reduce our investment plans by £128m across the period.

Our innovation plans are regularly reviewed against new information from UK industry, worldwide research, learning from Network Innovation projects and outputs from the Smart Grid Forum.

We take account of other ideas and initiatives external to the business which can be jointly developed with our ideas. In some cases this allows us to utilise funding from other bodies. We also look for ideas which follow on from earlier Innovation projects to maximise the benefits of investments already made.

This includes building on successful projects delivered by other DNOs. One example of this was the research which underpins our FlexDGrid project. This was developed as an IFI research project by Scottish Power Energy Networks and was then further enhanced as a measurement technique by one of our own LCNF projects. Another example is where we have compared results with other DNOs on the effects on network load from voltage changes.

6.7 Stakeholder engagement for innovation

Our stakeholder engagement process for innovation is the same as for all other areas of our business. Innovation is a key theme of all stakeholder engagement sessions. Stakeholders understand that innovation cuts across all areas of our business and provides improvements and benefits to all business areas. Innovation remains a key theme for our Customer Panel. The panel helped us to prioritise future projects. In addition to innovation projects the panel support our work to assist the distributed generation community.

In addition to our stakeholder engagement process, we look for feedback on innovation at other panels and groups wherever possible. We work closely with RegenSW, a renewable energy group in the south west of England, who are keen to support the introduction of renewable generation across their area.

We use the Distributed Generation forums, now run by the ENA, to seek other views and to compare our initiatives with those of other DNOs. We support the Major Energy Users Council (MEUC) and have presented our innovation proposals to them for comment and feedback.

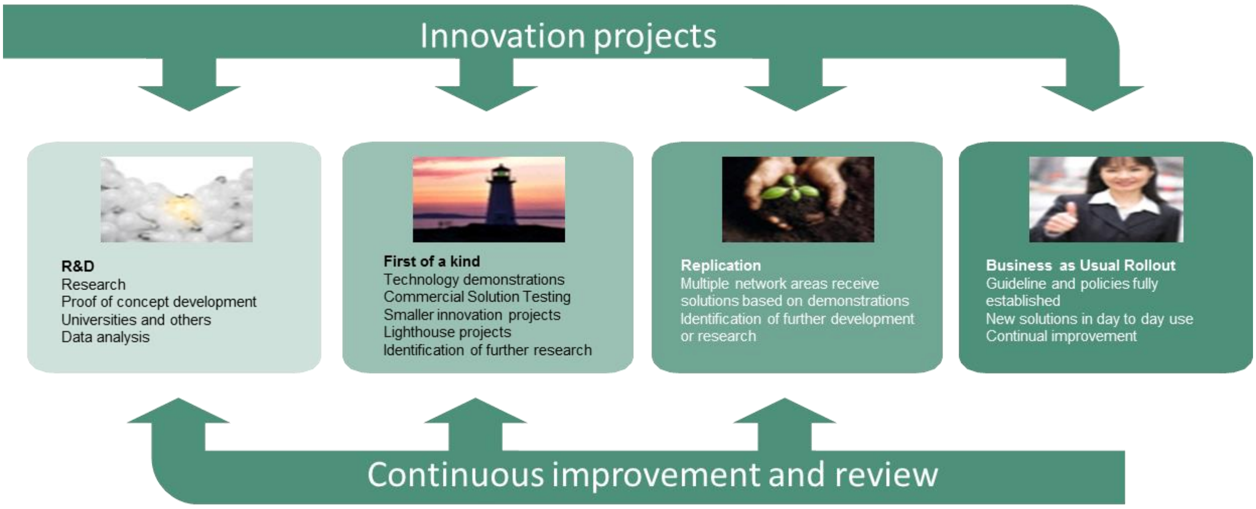
7. Innovation Priorities

7.1 Stages of Innovation

Projects will continue to deliver additional knowledge across all output areas. The project portfolio will remain balanced across multiple areas:

- working at various stages of development spanning higher Technology Readiness Levels (TRL) 3 to 8;
- exploring both technology and commercial solutions;
- covering the whole range of asset types and network voltages;
- assessing risk, with no projects carrying unnecessary risk;
- utilising a variety of external funding mechanisms to supplement our own R&D budget.

Lower TRL projects will generally be carried out by external research partners under supervision of WPD engineers. Higher TRL projects which, in the shorter term, are more likely to produce a solution for our network or processes will mostly be delivered in-house using business as usual teams.



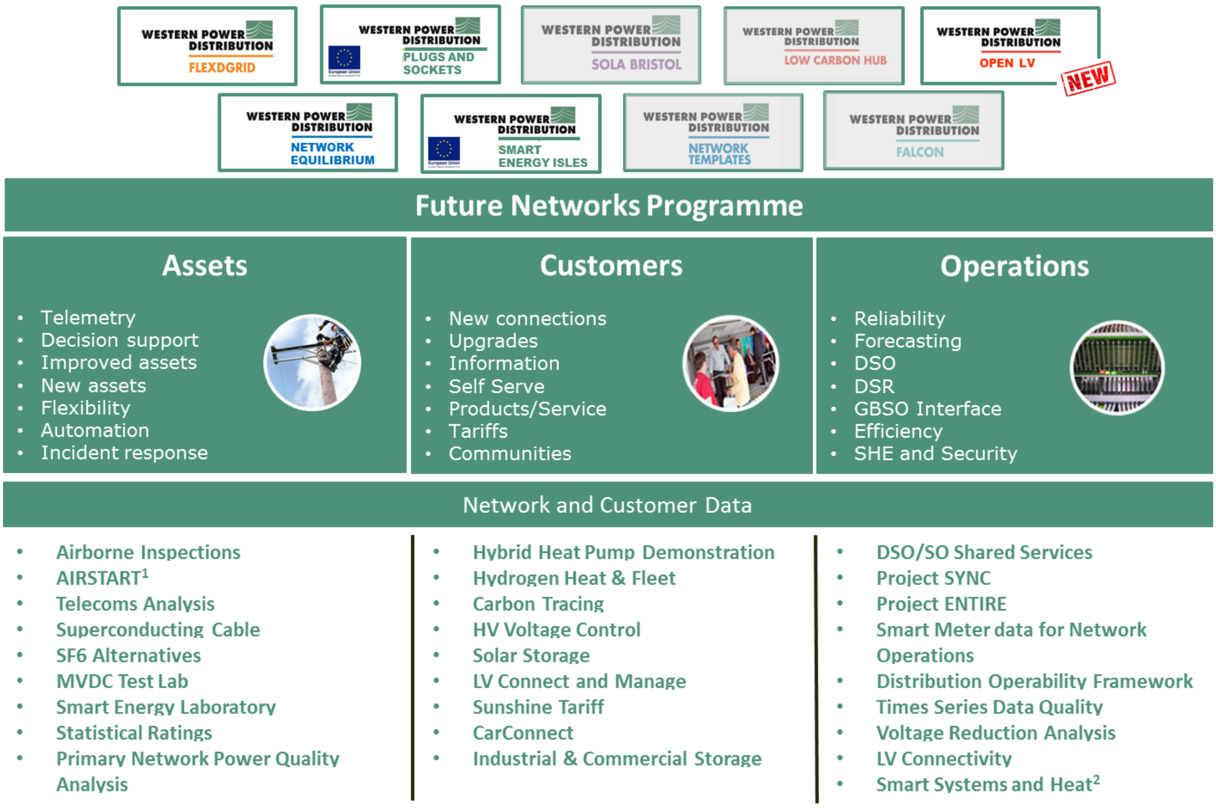
The full 'research to implementation' timescale can often take 5 to 10 years. That is why we focus internal teams on higher TRL stages, building on knowledge from earlier studies outside our own organisation.

7.2 Forming the innovation programme

Smart grid innovation projects are grouped into three main categories. These are:

- Assets – Projects in this category collect data from the network to enhance modelling. They also test alternative investment strategies that can postpone expensive investments.
- Customers – These projects develop new solutions to enable customers to connect low carbon technologies. They may also involve testing of new customer tariffs or working with communities to provide local energy solutions.
- Operations – This category of projects demonstrate direct benefits to active network operations from the application of technology.

The projects within the innovation programme are constantly changing as new ones are initiated and existing ones completed. A snapshot of the programme is shown in the diagram below.



Note: 1 – Funded by Aerospace Technology Institution; Note 2 – Funded by the Energy Systems Catapult

7.3 Funding the innovation programme

For RIIO-ED1 we have been allocated a Network Innovation Allowance (NIA) of 0.5% of total regulated revenue, around £58m throughout the period. We also work with partners to provide innovative proposals for larger projects to be funded through the Network Innovation Competition (NIC). This is done through an annual Call for Proposals in response to specific challenges we identify.

We will also continue to make use of any other available funding sources when appropriate, in particular National and EU funding mechanisms.

In addition to NIA and NIC projects we will continue to support research and development in partnership with other DNOs.

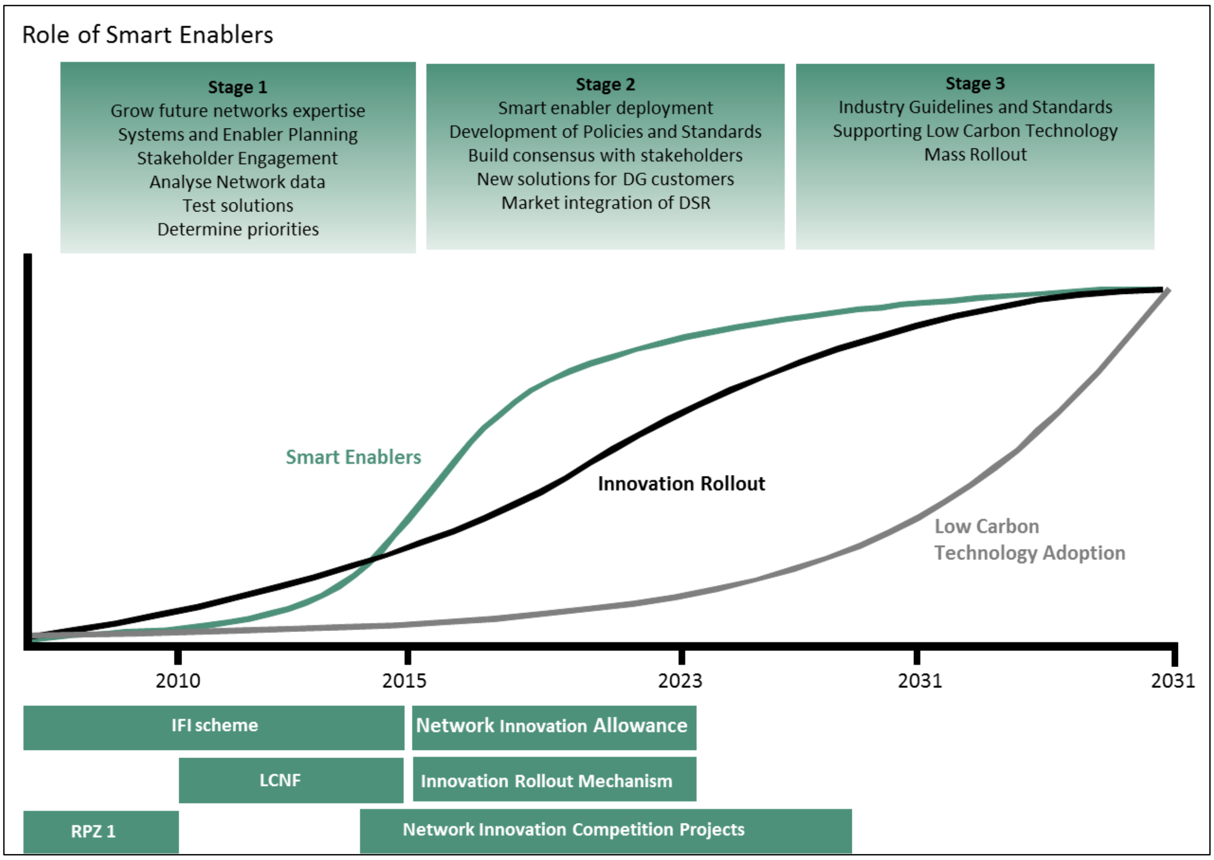
7.4 Preparing for the future with smart enablers

We have been assessing the scale of future network investment requirements by modelling different scenarios. CSE compared the output from the Smart Grid Forum Transform model to socio-economic and house stock information that they held. This refined our plans to make them more specific to local circumstances. For example, forecasts of heat pump installations were reduced in areas where the housing stock is not suitable for their installation and electric vehicles demands were increased in those areas where early adoption is likely. We will compare the CSE forecasts with the activity levels that we are actually observing to update our forecasts.

Using this detailed analysis we are increasing the size of selective transformers and cables where there is greatest likelihood of demand growth.

We are investing in communication infrastructure to improve our understanding of the real time status of the distribution network, utilise metering data and enhance the sophistication of control of the network.

Investment in these enabling solutions will provide an essential foundation for the rollout of many smarter solutions supporting the transition to a DSO. Deploying such "smart enablers" and having individual innovative solutions fully developed will allow us to be ready for the mass adoption of LCTs by customers. This three step approach is illustrated in the diagram below, annotated with how we make use of regulatory innovation incentives.



7.4.1 Selectively increasing the size of distribution transformers

Once installed, transformers are a very simple asset with no moving parts and a long life span. It is more cost effective to increase sizes when transformers are initially placed. Installing increased capacity will avoid the expense and possible customer supply interruptions of transformer changes at a later date.

The additional purchase cost of the next largest transformer is around 12% for the transformer itself, but when all the costs of installation are taken into account the actual additional cost of oversizing is 6%.

The Centre for Sustainable Energy data forecasts high uptake of LCTs on around 7% of the WPD network. By targeting larger transformers at this 7% we will install around 109 units per year.

7.4.2 Selectively increasing the size of cables

The average cost of excavation in a footpath is around seven times the additional cost of moving to the next size of cable. When these two items are taken together it makes economic sense to upgrade the cable at the time of installation rather than return at a later date. It also reduces the excavation waste and inconvenience to road users.

It is, however, not economic to do this everywhere and must be targeted at areas where we expect future load to increase.

Using the CSE forecasts we will design to the “next size up” on our cable installation and replacement works across 7% of our network and we will install around 74km per year.

7.4.3 Expanding the communications infrastructure

We will establish communications networks as they are needed to support smarter control of the network. We will provide sufficient capacity to take into account future requirements informed by the clustering data we have for LCTs.

Our forecast of load growth will be supplemented by data that becomes available from smart meters. As the smart meter rollout progresses, we plan to make use of this data to model and operate our network. The smart meter data will show us where our network is being fully utilised and where interventions are required.

We will use our own communications links to control assets and will also bring back monitoring data where it is more effective than using smart meter data. Wherever possible we will connect our links directly into our existing secure communications network via scanning or mesh radio systems.

Our FALCON project has provided a radio solution which has provided new learning for us and will help direct the way forward for our new communication systems. We are planning a further NIA project which will look in more detail at the issue of a cost effective communications solution for distribution locations.

7.5 Preparing for Distribution System Operator

Operating an active system will require new DSO capabilities to be developed:

- understanding historic and real time energy flows
- forecasting future energy volumes across the network under different scenarios,
- actively reconfiguring the system dependent on need,
- contracting/despatching DER through commercial arrangements
- coordinating DSO operations with the TSO
- maintaining a platform for energy suppliers, communities and other market participants to have visibility of network congestion

We are using our innovation funding to test a variety of new capabilities. A snapshot of our innovation priorities related to DSO is shown in the following table:

Data Integrity	Market Integration	IT Systems	Customer Propositions	Equipment
Alignment of Data – Common Information Model	WPD regional energy scenarios	Power System Modelling	DSR products by customer segment	Telecommunications readiness
Energy and Utilisation Data – MWh not MW	WPD Operability Framework	Energy Management and Forecasting	DSM tariff structure	Transducers and measurement equipment
Network Connectivity	DSR Shared Service (link to TSO)	Time Series Data Storage and Visualisation	Alternative Connection Agreements	Settlement and metering data for Network Operations
	Visibility Platform (link to aggregators / suppliers)	LV Connectivity / GIS	Managed Connection Agreements	Managed Connection Interface Devices
	Network Charging Methodology	Settlement and Billing		Active Network Management Technology

The new DSO competences must be delivered whilst ensuring sufficient capacity exists to meet customer needs and to guarantee safe asset loadings are not exceeded. Markets have an important role to play in matching demand with generation. DSO tariffs and price signals can encourage energy suppliers or others to help alleviate constraints.

Work that we have already completed to offer Alternative Generation Connections as business as usual and to offer Demand Side Management and Response through projects has helped us understand some of the features of DSO.

DSO actions will need to be coordinated with the Transmission System Operator to ensure the overall electricity system is efficient. Sharing of forecasts and jointly balancing the overall system using a more iterative approach will be required. This is a new area for us as most of our work has been completed in isolation affecting our network only.

7.6 Driving value from smart metering

The smart meter programme will provide every household with the option of having a smart meter fitted. We will be able to use some of the aggregated data from these meters to provide us with some additional information. The aggregated meter will provide us with details of electricity usage that may assist in refining network planning templates.

7.7 Demand side management (DSM) and demand side response (DSR)

DSR is a term used for agreements designed to encourage customers to make short-term reductions in energy demand triggered by an instruction from a DNO. This could include I&C organisations turning off or deferring consumption for a period of time. Alternatively, they could start up on site generation to displace load and potentially export power back to the network. In domestic households DSR may become more prevalent as smart appliances that communicate with the smart meter are developed.

DSM is a subset of DSR and is more passive in nature. DSM can be based on time of use tariffs or time dependent connection agreements. In Industrial and Commercial (I&C) organisations DSM measures include savings made as a result of improvements in the energy efficiency of processes, but can also include predetermined time of use tariffs that influence usage patterns and the scheduling of processes. In domestic households energy efficient appliances will reduce demand but time of use tariffs are likely to provide the bulk of DSM.

We are engaging with domestic and I&C customers to test different commercial arrangements, determine the scope of terms and conditions and understand the practical implications of applying DSM and DSR. Different approaches will be required for domestic and business customers.

7.7.1 Domestic customers

Our innovation project experience suggests that domestic customers are more likely to engage with a supplier than a DNO. We will mainly make use of suppliers or third party aggregators to manage DSR at a domestic level. Working with the Energy Saving Trust (EST) we trialled a system of domestic demand side response which uses plug-in controllers connected to the customer's broadband router which receives the demand control signals.

Domestic DSR and DSM were also trialled through the BRISTOL project where a battery is used to store energy and defer demand at peak times. In the Sunshine Tariff project we used customers' hot water storage to defer demand by storing energy in hot water systems. As more electric vehicles are used, the batteries could also be used for DSR by avoiding charging when there is network congestion. The Connect & Manage and CarConnect projects will test the use of vehicle batteries to alleviate grid congestion.

For large scale domestic DSR to work effectively for a DNO, we will need a standard means of alerting suppliers or aggregators of network congestion. Smart Grid Forum Workstream 6 set out high level requirements for sharing visibility of DSR requirements. We will test such a process as part of the EU funded Local energy market project with partner Centrica.

7.7.2 Business customers

I&C customers are more likely to interact with their DNO. This has been evident on the FALCON project where we found that they are willing to engage directly with us. These customers often already operate in the Short Term Operating Reserve (STOR) markets and are informed on the opportunities that DSR can bring them. In the FALCON project we contracted over 9MW of demand reduction to support capacity on our network.

Our requirement to call on these customers is less frequent than National Grid, as presently we only plan to call against two specific scenarios;

"Pre-fault" scenarios are where the demand is growing to a level where there is potential for the network to trip;

"Post-fault" scenarios are where the network is abnormal as a result of a fault and the demand needs to be reduced.

As these customers operate in STOR, they are already contracted to National Grid to provide a response which may conflict with the response we require. We are part of and ENA Shared Services group that will discuss this in more detail. Our SYNC and Entire projects will further develop and test our DSR propositions for larger customers.

7.7.3 Demand Side Response requests

DSR is managed in two ways, depending on the requirement of the network. For pre-fault scenarios we can schedule the response that we require. We will use load profiles to establish the time that DSR is required and request this in advance from participants. For I&C customers this will be done with a rolling two week notice period. Domestic customers will be scheduled in advance as part of predetermined time of use tariffs. For post-fault scenarios the response will be called for directly from our Control Room. Requests will be made to targeted customers that have agreed to short term demand reductions.

We are at the early stages of DSR so we will initially develop standalone systems to manage requests that we make. For most pre-fault scenarios the requirement will be fulfilled with schedules and tariffs, needing no real time intervention. For post-fault scenarios we will begin with telephone requests and as we make more use of DSR will invest in automated systems. Our long term aim will be to take proven automated systems and merge them into our Network Management System.

7.7.4 Commercial framework for DSR and DSM

The commercial framework for DSR and DSM varies for different customer groups. We will not be in direct contact with domestic customers as they will generally be communicated with via suppliers or other third parties. It is likely that we will aggregate our requirements and trade with the third parties to achieve the required reductions.

I&C customers are more likely to be directly contracted to WPD. Our ED1 Business Plan stated that we will set up a team to deal with I&C customers throughout our area when DSR is ready for deployment. We are testing this as part of Project Entire.

7.8 Identifying and delivering solutions from earlier LCNF projects

To ensure that we learn as much as possible from each of the innovation projects we have assigned specific individuals as points of contact for the other DNOs and their suite of projects. These staff are responsible for ensuring that we capture and apply the knowledge gained from other DNOs and assimilate it, with our own knowledge, into business as usual.

Completed innovation projects provide an excellent source of knowledge to help develop future networks and applications. For example our own projects have delivered solutions for Alternative Connections, Voltage Reduction and Statcoms. From other DNOs we have identified solutions using equipment such quadboosters and large scale energy storage.

7.9 Our plans for smaller scale new innovation projects

Our plans for smaller scale innovation will encompass all of the areas that we have developed in the past, whilst paying particular attention to the establishment of DSO capabilities. We will continue to refine existing innovative solutions across the whole range of business areas and add new innovations as they arise.

We will continue to develop new ideas from a range of sources, including our own teams, our stakeholders, our customer panel, manufacturers, academia, other DNOs, other industries and international developments. As new ideas are developed, we will review and update our project plans.

The ideas we take forward are chosen to support and improve our performance in the broad areas shown on the table below. These areas feed into our main business output headings and will be used to improve our performance in these areas.

Future smaller scale innovation	**Safety improvement**	**Cost efficiency improvement**	**Customer service improvement**	**Reliability improvement**	**Environmental improvement**
SF6 alternatives	✓				✓
LV Connectivity	✓	✓	✓		
Smart meter data for network operations		✓	✓	✓	✓
Reactive power services		✓	✓		✓
Distribution Operability Framework		✓	✓	✓	✓
DSO/TSO Shared Services		✓	✓		✓
Network Analogues	✓	✓		✓	✓
High Voltage Power Electronics Test Lab	✓			✓	
Primary Network PQ Analysis			✓	✓	✓
H2 Energy Balance		✓	✓		✓
Innovative Vegetation Management	✓	✓		✓	✓
Supporting Vulnerable Customers	✓	✓	✓		✓
LV Network Management	✓	✓	✓	✓	✓

The subjects are detailed below.

7.9.1 SF6 alternatives

Safety improvement	**Cost efficiency improvement**	**Customer service improvement**	**Reliability improvement**	**Environmental improvement**
✓				✓

Sulphur Hexaflouride is a key gas used to provide insulation in high voltage switchgear. The excellent insulation properties of the gas have helped reduce the size of switchgear, but the environmental impact of the gas is significant as it is a potent greenhouse gas. Alternative insulation methods have been used, such as vacuum, and are now well established at higher voltages. Work continues to develop a solution for distribution voltages and we are very much supporting research. Most recently we have supplied a distribution switch unit for analysis at Cardiff University.

The development of an SF6 alternative will reduce the environmental risk by avoiding the use of SF6 in future switchgear designs. During our normal replacement works, designs using SF6 will be replaced in the same way as oil filled designs have been for many years.

7.9.2 LV Connectivity

Safety improvement	**Cost efficiency improvement**	**Customer service improvement**	**Reliability improvement**	**Environmental improvement**
✓	✓	✓	✓	

The LV Connectivity project will develop innovative methods to determine the connectivity of LV networks. Having connectivity information will be essential to develop network the modelling tools we will need as customers adopt electric cars, heating, home storage and as volumes of solar panels increase. Traditional methods of capturing connectivity involve manual tracing and data entry.

7.9.3 Smart meter data for network operations

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓	✓	✓

The roll out of smart meters will bring about a step change in the level of data that is available in relation to the utilisation of LV networks. The status of the LV network will be known at all times. A system of data mining will be established to interrogate the raw smart meter data that will help to refine planning templates further.

Further developments will enable us to use the data directly creating bespoke solutions for different part of the network.

7.9.4 Reactive Power Services

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓		✓

This project will evaluate and test the provision of reactive power services from customer owned power electronic devices. Emerging grid code requirements will place requirements on DNOs to actively manage reactive power at the TSO boundary, Services can also be used to manage voltage and reduce network losses on the distribution network.

7.9.5 Distribution Operability Framework

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓	✓	✓

The Distribution Operability Framework project will establish an approach to assessing the future trends and priorities for network control and operation. Together with stakeholder engagement, several methods will be tested to determine the most appropriate techniques for presenting result and key findings.

7.9.6 DSO/TSO Shared Services

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓		✓

Our first LCNF project in 2010 developed and tested an Inter Control Centre Protocol (ICCP) link between DNO control systems and the TSO. It has subsequently been utilised by ENW and UKPN. This new project will focus on the business rules which are required to enable TSO and DSO to have visibility of each other’s proposed DSR actions. This visibility was a key finding as Smart Grid Forum Workstream 6. This project will be delivered jointly the National Grid and other DNOs.

7.9.7 Network Analogues

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓	✓		✓	✓

A future DSO will require much improved visibility of network status such as loading and voltage, and at a greater temporal resolution. For example maximum, minimum and average values every 10 minutes. In many cases the necessary transducers and ancillary equipment is not installed. Retrofitting current and voltage transformers can be costly or disruptive. This project will test alternative means of measuring or approximating values.

7.9.8 High Voltage Power Electronics Test Laboratory

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓			✓	

The move to an active network with active power flow management has introduced a new range of power electronic devices onto the distribution network. Devices which are being trialled under NIA/NIC projects will be developed into standard solutions. Using a purpose built laboratory at Loughborough substation we will work to develop the standards and establish the rules for wider deployment of these solutions.

In all areas of new development, the generation of standards helps manufacturers design systems and products which are appropriate for our network and the other DNOs in the UK. This helps reduce costs through bulk manufacture as all DNOs purchase equipment built to the same UK standards.

7.9.9 Primary Network Power Quality Analysis

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
		✓	✓	✓

Power Quality is set to become a much bigger issue as customers power electronic devices and install invertor fed distributed generation. Visibilty of Power Quality on the network (rather than at the point of connection) is currently not possible. This project will establish a network of monitoring equipment for analysis.

7.9.10 H2 Energy Balance

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
	✓	✓		✓

Distributed generation customers are increasingly interested on Alternative Connection arrangements enabling quicker and cheaper connection to the distribution system. At peak times WPD is able to curtail the renewable generation to protect the network. This project will evaluate the potential to use despatchable load instead of curtailing the generation.

Using electrolysers hydrogen will be created. Through a partnership with local government a parallel project will use the hydrogen as a transport fuel in commercial vehicles. A number of companies have indicated they would use hydrogen vans for the duration of the trial including WPD.

7.9.11 Innovative Vegetation Management

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓	✓		✓	✓

This project will address the problem of improving overall vegetation management activities in a 5 to 10 year timeframe. It will test several methods working with a range of partners in universities and other research establishments. Building on earlier research activities topics such as mapping, automated tree identification, aerial and satellite photography and tree growth inhibitors will be explored.

7.9.12 Vulnerable Customer Solutions

Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓	✓	✓		✓

This project will address the problem of improving vulnerable customer support activities in a 5 to 10 year timeframe. It will test several methods working with a range of partners in universities and other research establishments. Topics will include temporary power supplies from storage, innovative customer technology alerts and use of non-conventional data sources to alert us to issues.

7.9.13 LV Operational Monitoring and Control

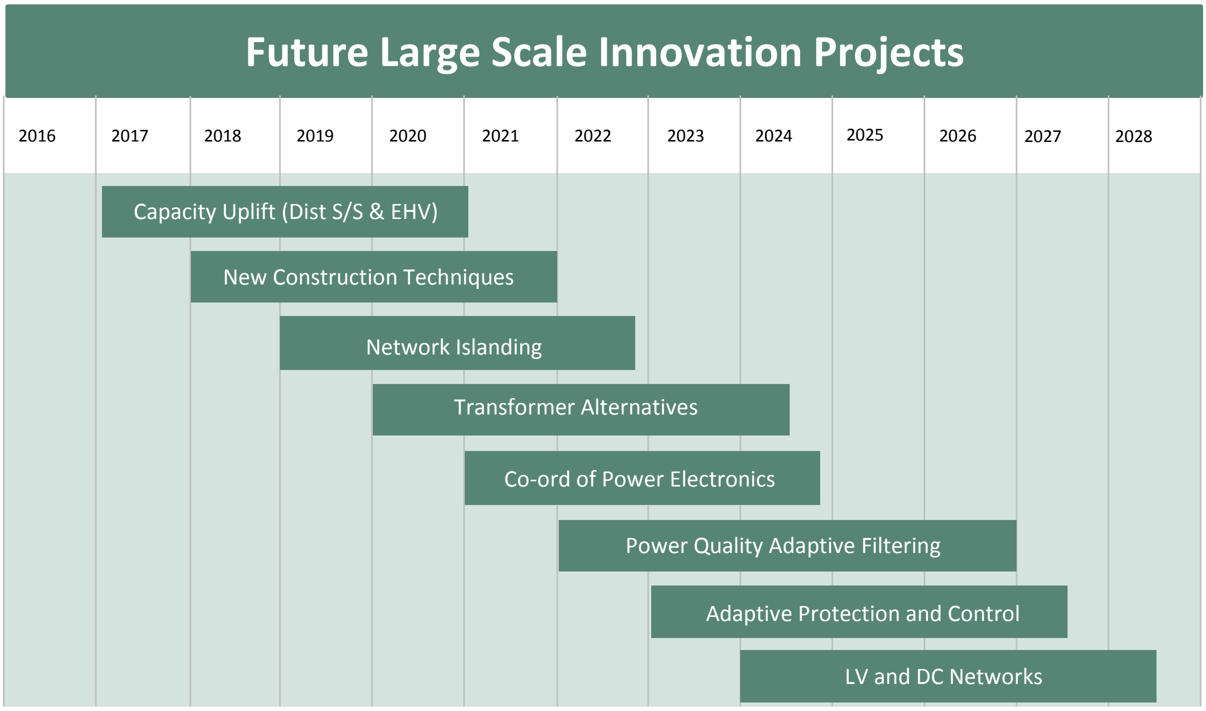
Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓	✓		✓	✓

This project will address the problem of improving LV operational activities in a 5 to 10 year timeframe. It will test several methods working with a range of partners in universities and other research establishments. In particular the project will identify the potential for very low cost substation monitoring solutions. It will also demonstrate simple and low cost network technology to reconfigure the network or isolate faulted sections.

7.10 Our plans for Large scale innovation projects

The chart below shows the areas we will explore and develop through the NIC. Many are still at a conceptual stage and build upon anticipated learning from existing projects. The scope of each project will become clearer as current knowledge learned in WPD and other DNOs is revealed. This may also lead to different projects that have not yet been conceived.

These areas specifically focus on technology solutions to support the changing needs and requirements of a distribution network. Technical and commercial developments to support such changes as to transition from a DNO to a DSO are captured in our NIA project portfolio.



7.10.1 Capacity Uplift (EHV)

Increasingly we are witnessing specific areas of our distribution network that are either experiencing large peaks of either load or generation power at certain, particular, times of day or extensive general growth due to significant connection of generation, principally on the extra high voltage (EHV) network.

This project will look to utilise new and innovative technologies to suitably mitigate these short term peaks of power, whilst also investigating and trialling solutions to uprate our existing EHV networks, to allow additional power transfer through novel solutions. Such trials could allow us to significantly expand our existing network capacity without the need for a considerable asset replacement programme.

7.10.2 New Construction Techniques

The building of new substations, overhead lines and cable installations is becoming increasingly difficult due to several factors such as planning restrictions, public opposition and escalating costs. Therefore, it is important that new and alternative techniques for construction are considered.

Under this area, the opportunity to develop and trial new construction techniques, which look to minimise the cost, time and disruption to install new network assets will be explored. Such trials will include new infrastructure installation techniques along with new types of asset that facilitate expedited installation.

7.10.3 Network Islanding

With an increasing level of generation on all voltage levels of the network; the opportunity to utilise this generation to provide supplies to customers in outage and fault conditions must be explored. This project will investigate and trial the engineering and commercial elements associated with safely operating an islanded network.

Facilities will be developed to allow an isolated area of network to be maintained through the continuation of operation of distributed generation. This will involve producing and updating existing generation protection philosophies and developing appropriate commercial arrangements to suitably manage the process.

7.10.4 Transformer Alternatives

Utilising learning to be generated as part of Network Equilibrium and the installation of a 33kV Flexible Power Link (FPL), alternatives to traditional voltage transformation will be developed. It is forecast that the ability to provide greater levels of network interconnection will be required to support the future needs of the distribution network, not only where there are two voltages at the same network but also at points where geographically close networks of different voltage levels are present.

Throughout this project alternatives to traditional transformers will be developed, trialled and tested. As the interconnection of two or more distinct networks can have significant engineering challenges, the use of alternative solutions aims to eliminate these connection constraints. Greater levels of network interconnection will provide significant increases in network flexibility, operability and security to existing and proposed customers.

7.10.5 System Co-ordination of Power Electronics

All DNOs are currently developing and trialling power electronics such as static synchronous compensators (STATCOM), batteries and FPLs. Many of these devices provide apparent and reactive to the system or from one section of network to another. As the number of these power electronic devices increases so will the need for them to be carefully considered and co-ordinated.

In order to ensure that power electronic devices connected to LV, HV and EHV networks can successfully co-ordinate the project will aim to develop a co-ordination and operation architecture for these technologies. Their performance and hierarchy of operation will also be investigated. This project will look to deliver industry learning on how to successfully integrate multiple power electronic devices in a single, connected, network effectively.

7.10.6 Power Quality Adaptive Filtering

It is well understood that the addition of power electronic devices at all levels of the distribution network contribute, to a greater or lesser extent, harmonics to the system. Technology such as inverters connected at generation sites, STATCOMs, batteries and other technologies all produce harmonics that are then distributed along the system. As these devices increase in their density of network installation the cumulative harmonic effect will become significant.

This project will assess different options to mitigate the harmonic distortion on the network, which will involve the design and trial of specific harmonic filters and also the utilisation of existing power electronic devices to operate specifically to destructively interfere with pre-existing network harmonics. The project will assess the effectiveness of each harmonic limiting option as well as the effects of potential harmonics on the system.

7.10.7 Adaptive Protection and Control

National Grid has released evidence to show that fault level in all areas of the UK is likely to fall, due in part to large rotating centralised generation plant being replaced by localised distributed generation.

We will investigate, through the trialling of a variety of technologies and solutions, the ability to support existing HV and EHV networks for the instance that there are significant variations in fault level. The focus of this project will be the network ‘strength’, where key consideration will be the future requirements of system wide protection and harmonic network effects.

7.10.8 LV and DC Networks

This project will investigate the future requirements of new and replacement LV networks to ensure that they’re designed with suitable futureproofing for the advent of further low carbon technology connections.

This project will build on learning from other areas to understand the future needs and requirements of the LV network and trial solutions. The aim is to remove any potential barriers to future domestic and light commercial low carbon technology integration. Particular focus will be given to the required current carrying capacity, system interconnection and flexibility of LV connections. A comparison of AC and DC network topologies will be evaluated.

7.11 Our plans for RIIO-ED2 and beyond

In RIIO-ED2 the transition detailed in the Carbon Plan will be well underway and there will be more certainty over the eventual levels of Low Carbon Technologies. This will help us improve our forecasts for demand growth and distributed generation connections.

By RIIO-ED2 smart meters will have established a new communications link to each customer. Customers will have developed a deeper understanding of their energy consumption and will be more receptive to participating in initiatives that reduce their energy consumption. This will provide future options for more DSR when the volume of LCTs is anticipated to grow further.

By the end of RIIO-ED2 some of the domestic LCTs installed during RIIO-ED1 will be coming towards the end of their useful lives. Future generations of these technologies will provide additional services for customers and by working with manufacturers we will encourage the development of features that will also enhance our ability to manage the network.

Whilst no-one can be certain about the way that electricity usage will develop over this long period, we will continue to review our plans with our stakeholders to ensure that we have the best informed view available. Our plans will remain flexible and we will monitor developments and react appropriately to address changing requirements.

8. Innovation governance arrangements

8.1 Innovation governance

All smart grid innovation projects are delivered as part of the Future Networks Programme. The Programme is the delivery mechanism for the Innovation Strategy detailing ongoing and new projects.

All business innovation projects are delivered from the area of the business that has the specific expertise to also be able to develop the idea.

On an individual basis projects are approved in line with our financial approvals process. All projects and works are subject to the same controls and authorisations as other engineering projects in the business. NIA projects are subject to project level approval by the Future Networks Manager. Projects registered in NIC are subject to project level authorisation by the Operations Director.

Project process is tracked through normal monthly business reporting arrangements. For each major project this includes the preparation of a balanced score card detailing progress against milestones, significant issues and summary financial reporting. All major projects have a nominated senior management sponsor and progress review group.

Projects also undergo regular review by the progress review groups of each major project and by the Future Networks Manager for smaller projects. Reviews include an assessment of the risks that exist to the overall success of that project. These risk assessments allow appropriate decisions to be made to mitigate their impact.

Innovation projects are delivered in line with regulatory governance requirements and regular reports are provided to review the progress of individual projects against their targets. Six-monthly reviews are made publicly available for all our LCNF/NIC projects.

Major projects are managed in accordance with recognised project management methodologies. There is a suite of standard documents and templates which are tailored for the specific requirements of each project.

8.2 Research partners and supplier arrangements

We have links with a wide range of universities, research establishments and manufacturers, both in the UK and across the world (e.g. Hitachi in Japan and the Electric Power Research Institute in the USA).

We monitor UK and worldwide research to identify concepts and developments that may provide benefits to us in the future. We are active members of CIRED, the forum where the international electricity community meets. To maximise the effect of research and innovation we actively participate in industry wide forums. These forums bring together the best industry knowledge in a cost effective way to pool and manage research which is of use to all DNOs.

Through the ENA, the DNO trade body, we also actively participate in a variety of groups and panels which review and develop industry wide learning. The issues and challenges facing WPD are the same as those for other network operators and we share knowledge wherever possible.

We proactively support knowledge sharing and the development of best practice guides which can benefit the whole industry. It is important that we learn from others and do not spend time or energy duplicating effort on topics which have been well researched. Benefits for the industry and society can be more effectively applied when the specialist experience gained from running innovation projects is shared.

Staff in our Innovation Team review other DNO projects in tandem with their own work to deliver our projects. They become our key contact to other DNO dissemination events and ensure we learn as much as we can from the other projects which are being undertaken. We have allocated one person as the key contact to each other DNO group.

We support research that is led by suppliers and manufacturers and share our knowledge and experience to help them develop solutions. Providing this support enables us to influence the research so that it provides a benefit to us.

We work with UK based Small to Medium Enterprises (SMEs), who are playing an increasingly important role in the delivery of new technologies and solutions.

We also provide feedback on the limitations of existing products so that they can be improved. Partners can also trial products or solutions on our network which generates useful practical experience for the developer and allows WPD to understand how the products can be integrated into existing systems.

Our academic partners enable us to draw on the specific expertise which they have which enables us to cover a wide range of topics and specialisms with people who have in depth knowledge.

Some projects include technology which is not from the electricity industry and we work with partners who might not be obvious choices but provide us with the best resource.

We choose product suppliers using our well established procurement systems. We use the Utilities Vendor Database system, Achilles and have worked with Achilles to develop new product codes to cover elements of network innovation.

8.3 Managing risk and future uncertainty

We identify and control project specific and generic (programme wide) risks. Dedicated project management processes periodically review and control risks for individual projects.

Generic innovation risks such as the application of new technology to the distribution network are controlled through close liaison with our Policy Team. This means that new technologies either fit into existing policies and standards or the team develop new policies and standards as a part of the innovation process. The diligence of setting policies at this stage also ensures the long term operation of new technologies by ensuring that new innovations are ready for business as usual deployment at an early stage.

In some cases the risks are associated with uncertainties such as the take up of LCTs or the Low Carbon Transition. Future uncertainty risk is mitigated by regular review of forecasts and identification of tipping points for wider application or a commitment to higher volumes. An example of a tipping point for transport would be a motor manufacturing devoting a whole factory to the production of electric vehicles.

8.4 Tracking benefits

All smart grid projects are regularly reviewed to ensure the benefits they deliver are in line with those predicted at time of approval. Smaller projects are reported annually in our innovation summary report. Major projects report progress including benefits delivery as part of their regular reporting regime.

All projects delivering against our key outputs have their benefit measured against those outputs. Benefits tracking is carried out at all stages of the project, from initiation to completion.

8.5 Keeping the strategy up to date

Our innovation plan is subject to review to ensure that it continues to provide solutions in line with business requirements. We review our plans with our stakeholders to ensure that we allow them to challenge our proposals and shape what we do. Our plans will remain flexible so that we are able to address changing demands.

External factors will influence our plan and feature as part of the review process. We will take account of results from our trials and other DNO projects. Manufacturers will often develop products through DNO trials and will we assess their suitability for adoption as part of our review process.

Our review will also take into account existing Government incentives and potential changes which may impact on customer behaviour.

The Innovation Strategy is approved annually by the Operations Director.

9. Innovation rollout

We deliver innovation through an in-sourced model with a small team of specialists using the resources of our operational teams to deliver tools or products onto the network. The Innovation Team works alongside the company's Policy department where they interact with equipment specifiers and technical experts of the wider business. Once trials are successfully completed, the outputs are taken forward and replicated across our network.

As outputs are delivered, they are developed into new learning that can be taken forward and developed as business as usual. Outputs obtained from other DNO projects are fed into this process to ensure that we gain maximum benefit from innovation projects.

All solutions rolled out from innovation follow the same route as our other policies and techniques introduced into the company. Policies are reviewed by the senior network managers before they are introduced. The rollout process includes implementation plans and, where appropriate, training and dissemination sessions. We monitor all the projects as they develop and make use of learning and outcomes as they are reported.

Our RPZ1 project developed a practical application for Dynamic Line Ratings (DLR) on our 132kV overhead lines. The project results have been embedded into business as usual and are documented in a dynamic line rating policy.

Our Lincolnshire Low Carbon Hub project developed a practical application of Active Network Management which is part of our Alternative Connections policy suite. Alternative Connections are available to all generation customers seeking a connection where significant reinforcement is required.

Export limitation devices have been developed by manufacturers to locally balance generation and demand, however due to the lack of an industry standard, the variance in the quality and method of operation of these devices is wide. We developed a policy for acceptance of these schemes which outlines the minimum requirements to achieve compliance with a new WPD policy. This policy was circulated to the other DNOs and following further refinement was developed in conjunction with manufacturers to form a new UK standard, ENA Engineering Recommendation G100.

All projects produce new or revised WPD policies for use during the project lifetime. These policies are always written in such a way that they can be extended to apply beyond the project and in a larger geographic area if the solutions trialled turn out to be successful.

10. Outputs

Our Tier 2 projects registered and completed under the Low Carbon Networks Fund have produced a wide range of outputs in the form of standards and specifications which are replicable within the UK electricity industry. In some areas the knowledge has created a requirement for more research and work in a particular area.

Project	Aspect	Policy/Standard	Note	Further work
LV Templates	Connection of PV	Changes to planning tool parameters	Additional diversity added to enable connection of 20% additional PV	
	Energy Saving	11kV Tap Change Control Settings	Tap changer target voltage adjusted to measure impact on consumption and losses	For DECC to assess the potential for broadening of LV statutory voltage thresholds
	Templates	Ten standard substation profiles	Profiles to enable DNOs to model their networks more effectively.	Comparison with results of other LCNF projects.
Low Carbon Hub	Connection of DG	Active Network Management (ANM)	ANM is one of our Alternative Connection solutions which are BAU	
	Voltage Control		Dynamic Voltage Control (DVC) solution prototyped	DVC will be fully developed for BAU as part of Network Equilibrium
	FACTS	FACTS Policies for I&M and Ops		
	Telecoms	Policies developed for fibre optic installation on wood pole lines		
SoLa BRISTOL	Micro-grid control			Further work is ongoing with universities to study the coordination of micro grids
	DC Installations		Clarification of UK wiring regulations.	
	Export Limiting Devices	Policy on export limiting devices developed. Now BAU.		
	Home Energy Storage standards			Further work under NIA & ENA working groups

FALCON	Engineering Trials	Battery Policies for I&M and Ops at Distribution Substations	Automated Load Transfer, Network Meshing, Dynamic Asset Rating and Energy Storage	
	Commercial Trials	Commercial arrangements with customers	Despatch of Distributed Generation and signalling of demand reduction by I&C customers	Conclusions will feed into business rollout of DSR.
	Telecommunications	Standard for wood pole telecoms masts	Development of Data Network configuration recommendations and evaluation of WIMAX radio links	Conclusions will feed into future Telecommunications for Smart Grids project
	Scenario Investment Model (SIM)		The SIM has been developed as a pre-production software system to advise on optimum network designs involving innovative techniques	Relevant aspects of the SIM will be further developed beyond FALCON under NIA and other sources
FLEXDGRID	Modelling	Fault Level Policies for Application and Connection		
	Measurement	Specification for Fault Level Monitors		
	Mitigation	Specification and policies for I&M and Ops for Fault Current Limiters		
Equilibrium	Enhanced Voltage Analysis		New voltage design techniques in development	
	System Voltage Optimisation		Control logic and software in development	
	Flexible Power Links	Specification and policies for I&M and Ops for flexible power links in development		

11. Knowledge sharing and dissemination

A key feature of the LCNF is the requirement for us, in common with all other DNOs, to share our learning on our projects.

The main annual event for knowledge sharing is the LCNI conference which we actively support. As in 2012, WPD will host the 2017 event be held in Telford. We also hold four specific knowledge dissemination events for smaller projects. These are sometime shared events with other DNOs. The audiences for these events are always very broad and include academics, DNOs, Government departments, suppliers, manufacturers and research organisations.

Often the most important thing that we can share from our projects is data and results. We have a dedicated website where interested parties can find out information on our projects. The www.westernpowerinnovation.co.uk site gives details of all our projects and the results they are producing.