2015-2023

RIIO-ED1 **BUSINESS PLAN**

SA-03 Supplementary Annex - Innovation, Smart Grids, Smart Meters, Losses and Climate Change Adaptation

June 2013 (updated April 2014)

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

SA-03 Innovation, Smart Grids, Smart Meters, Losses and Climate Change Adaptation

Contents

1 Introduction

1.1 This document is a supplementary annex to the Western Power Distribution (WPD) Business Plan for the eight year period from 1st April 2015 to 31st March 2023.

1.2 It describes WPD's approach to innovation and describes how we continue to innovate within our business to improve efficiency and set the foundations for smart grids.

1.3 The document applies to all four WPD distribution licences of West Midlands, East Midlands, South Wales and South West.

1.4 The eight year period aligns with the next regulatory price control review period, known as RIIO-ED1; the first for electricity distribution to be determined using Ofgem's Revenue = Incentives, Innovation and Outputs framework. The Business Plan, supplementary annexes, detailed cost tables and financial models form the submission under RIIO-ED1 to the regulator Ofgem (Office for Gas and Electricity Markets), who will use the information to determine allowed revenues.

Structure of this document

1.5 We appreciate that the readers of the WPD Business Plan suite of documents will range from regulatory experts and well informed stakeholders through to new customers who may have had little previous knowledge of WPD.

1.6 This document is aimed at readers who require a more detailed understanding of WPD's strategies for Innovation, Smart Grids, Smart Meters, Losses and Climate Change Adaptation. A less detailed description can be found in the main Business Plan Overview document.

1.7 This document is subdivided into the following sections:

Chapter	Title	Content
2	**Innovation Strategy**	A description of WPD's Innovation Strategy, including the initiatives we have already adopted, our plans for adoption of LCNF project outputs and steps we can take now to prepare for The Carbon Plan
3	**Smart Grid Strategy**	An explanation of how our network will evolve into a Smart Grid, and the interactions that we will have with customers to make more flexible use of capacity.
4	**Smart Meters**	A description of WPD's involvement in the smart meter roll out and an explanation of how we will make use of smart meter data to manage our network.
5	**Losses Strategy**	An explanation of how losses occur and the actions that we can take to reduce losses on our network in the future.
6	**Climate Change Adaptation**	A description of the effects that Climate Change will have on WPD, an assessment of the key priorities for us and the work we are undertaking to prepare for changes to our climate.

2 Innovation strategy

2.1 The WPD Innovation Strategy is now available as a standalone document that can be found using the following hyperlink: http://www.westernpower.co.uk/docs/Innovation-and-Low-Carbon/Innovation-Strategy-Final.aspx

2.2 For completeness the contents are reproduced on the following pages. Please be aware that the formats and page numbers may be different when comparing the Business Plan and the standalone Innovation Strategy.

Executive Summary

Role of innovation within WPD

2.3 Innovation is core to our business strategy. We always seek to find 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 spans from the implementation of good innovative ad-hoc ideas from staff all the way through to formal innovation projects.

2.4 We look for innovative developments across six broad areas;

- low carbon networks – supporting future electricity demand and generation requirements;
- smart meters – maximising the benefits from more detailed network data;
- smart grids – 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;
- business efficiency – searching out better processes, equipment and technology that ensures we continue to be efficient.

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

2.6 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.

2.7 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 (e.g. the purchase of equipment that is ready for the retro fit of automation);
- share what we learn with other organisations and learn from others.

2.8 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.

2.9 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.

2.10 Our existing portfolio of innovation projects is already shaping 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 projected output from the various projects currently being undertaken and the future projects planned.

Document purpose

2.11 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.

2.12 It will be 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.

2.13 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 2030, yet naturally provides more detail on the shorter term priorities, requirements and proposed initiatives.

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

- evidence of how DPCR5 innovation funding (i.e. IFI & LCN Fund) has been used effectively and resulted in improved outcomes for consumers (paragraphs 2.19-2.127);
- the high-level problem(s) and/or challenge(s) which the sector/company expects to face over the period, and the justification for initiating projects to address these (paragraphs 2.128-2.152);
- the consequences of innovation(s) not occurring (paragraphs 2.153-2.162);
- the process or methodology by which the company will decide the focus for innovation during RIIO-ED1 (paragraphs 2.163-2.179);
- demonstration that the problems/challenges have been identified/prioritised and justified in consultation with stakeholders (paragraphs 2.180-2.189);
- discussion of the relative priorities, risks, benefits, value for money and potential customer impacts (paragraphs 2.163-2.179);
- deliverables and potential deliverables from the research or development or trials, such as defined learning on an issue, revised codes, new charging methodologies etc. (paragraphs 2.191-2.252);
- a description of the business's processes for reviewing and updating their innovation strategies within the price control period. (paragraphs 2.253-2.282);
- a description of the business's approach to ensuring the efficient roll-out of successful innovation into business as usual (including innovation developed by other DNOs) (paragraphs 2.283-2.290).

Introduction

What is innovation?

2.15 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 solutions that are better, cheaper or quicker than the current ways of doing things. The Low Carbon Network Fund 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.

Why do we innovate?

2.16 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.

How do we innovate?

2.17 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.

Stakeholder involvement

2.18 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.

Background

Government and regulation

2.19 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 Energy and Climate Change (DECC) to support their ambitions, targets and meet their and our obligations.

2.20 We also engage with DECC on related matters such as Climate Change Adaptation (CCA) that looks to the longer term effects of climate change on the UK electricity industry.

2.21 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 Ofgem, DECC and other organisations to benefit from our learning.

Innovation funding within the UK

2.22 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.

2.23 In 2010, and continuing through to 2015, Ofgem introduced the Low Carbon Networks Fund (LCNF). The LCNF is 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 contains 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.

2.24 We are undertaking five of the nineteen Tier 2 LCNF projects which have been awarded to date. Similarly WPD is running twelve of the thirty seven smaller Tier 1 projects being developed across the industry.

2.25 In RIIO-ED1 the Network Innovation Allowance (NIA) and Network Innovation Competition (NIC) will replace the current funding schemes. The competitive element will have a greater value and will also be open to the electricity transmission companies. We will continue to develop innovation projects through these mechanisms.

2.26 We have also secured support and funding from the Engineering and Physical Sciences Research Council (EPSRC) and the Technology Strategy Board (TSB).

2.27 Furthermore we are also part of two consortia working on Energy Technologies Institute (ETI) projects.

Benefits from research and development

2.28 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. A definition of technical terms and project assessment methodology is set out in the Electricity Network Association (ENA) standard G85/2.

2.29 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		✓	✓	✓	✓
Condition inspection of overhead primary circuit lines by helicopter	✓	✓	✓	✓	✓
Understanding networks with high penetrations of DG	✓	✓	✓		✓
Impact of climate change and weather analysis	✓	✓	✓	✓	✓
Non- intrusive testing of tower foundations		✓		✓	✓
Control system automation algorithm		✓	✓		✓
Harmonic issues on distribution networks		✓	✓	✓	✓
Electric vehicles	✓	✓	✓		✓
Earthing information system	✓	✓		✓	✓
Generating value from smart meter data		✓	✓	✓	
Condition based risk management	✓	✓		✓	✓
11kV voltage optimisation project		✓	✓	✓	✓

Reference network model

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

2.30 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.

Condition inspection of overhead primary circuit lines by helicopter

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

2.31 The trial evaluated an innovative line inspection and condition assessment process that combined several technology areas such as high resolution photography and new condition categorisation. The learning has advanced inspection techniques and has been fully incorporated into company policies and regular helicopter inspection activities.

Understanding networks with high penetrations of distributed generation (DG)

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

2.32 The project improved our understanding of the effect of increasing output from a cluster of micro generators on a distribution network (in particular thermal rating, voltage rise and fault level). It identified ways to change conventional network design to maximise the penetration of micro generation. The research and modelling activity subsequently led to validation projects through LCNF projects.

Impact of climate change and weather analysis

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

2.33 A DEFRA funded project involving climate projections was used to develop new methodologies and probalistic 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.

Non-intrusive testing of tower foundations

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

2.34 This project evaluated various non-destructive testing techniques to assess the strength of tower foundations. The techniques included: Transient Dynamic Response; Linear Polarisation Resistance; Pulse Velocity Measurements and Ground Penetrating Radar. The project supported the development of new technologies that are now used during condition assessment of towers.

Control system automation algorithm

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

2.35 The project developed and demonstrated the benefits of self-healing networks using an automated switching algorithm that could carry out real time circuit status analysis and tracing to identify source and alternative supplies. The project led to a wider trial and rollout of the algorithm to the WPD region. The functionality has led to this type of functionality becoming a core offering within Network Management Systems (NMS).

Harmonic issues on distribution networks

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

2.36 This analysis and research project produced a report on the harmonic problems due to converter plant being installed on electricity networks. The learning allowed us to further develop ENA planning guidelines and continues to inform the on-going industry review of the industry standards such as the ENA's Engineering Recommendation G5/4.

Electric vehicles

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

2.37 The project investigated the impact of charging electric vehicles on conventionally designed distribution networks. It demonstrated different connection scenarios and mitigation options. The project confirmed that the impact on distribution network from a modest uptake of small electric vehicles is low. The project learning has subsequently led to further studies into power quality and harmonics caused by larger electric vehicles under the LCNF Tier 1 project entitled Electric Boulevards.

Earthing information system

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

2.38 This project developed a Geographic Information System (GIS) to assist DNOs in the installation of rural ground earthing systems. Carried out in conjunction with UK Power Networks and 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.

Generating value from smart meter data

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

2.39 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. This project helped inform WPD's RIIO-ED1 Smart Metering Strategy.

Condition Based Risk Management (CBRM)

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

2.40 The integrated 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.

11kV Voltage Optimisation project

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

2.41 The 11kV Voltage Optimisation project was able to demonstrate the benefits of wide scale voltage reduction while keeping end point customer voltages within statutory limits. The learning led to further studies as part of the LV Network Templates project and the recent publication of discussion papers along with a proposed further demonstration project in South Wales.

Business innovation during DPCR5

Innovation performance to date

2.42 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.

2.43 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.

2.44 Some recent examples of our day to day business innovation are detailed within the table below, which also identifies the areas where improvements have been achieved.

Business Innovation during DPCR5	Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
ENMAC Mobile	✓	✓	✓	✓	
Condition inspection of overhead primary circuit lines by helicopter	✓	✓	✓	✓	✓
LV monitoring	✓	✓	✓		
Pre-installed LV monitoring	✓	✓	✓		
Stakeholder engagement			✓		
Dynamic line ratings		✓	✓		✓
Customer "call backs"	✓	✓	✓		✓
Text backs	✓	✓	✓		✓

ENMAC Mobile (operational innovation)

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

2.45 We were the first DNO to use hand held devices in 'real time' to control and manage high voltage switching operations. The hand held devices are in constant communication with our network management system ENMAC.

2.46 Our operational staff use the hand held device to receive operational instructions and confirm completed action back to control. This has enabled us to reduce the volume of voice traffic into our control centres. Staff in the field are able to be more efficient as the number of jobs that can be processed concurrently by the Network Management System (NMS) is significantly improved. This is of particular benefit at peak times of the day when operational staff in the field are starting or finishing planned works at similar times.

2.47 Real time communications also allow the operational status of the network to be updated as soon as alterations occur on the system. These immediate updates improve the information available for our contact centre staff and High Volume Call Taker (HVCT) systems, which in turn improves the information we can provide to customers.

2.48 After the successful implementation of the high voltage switching element we added a low voltage incident management system to the package. This addition allows field staff to take details of faults and incidents directly on the device and provide updates from site that previously relied upon voice updates being provided after completion of work.

2.49 As with high voltage operations the low voltage updates from the field are used to keep the operational status of incidents up to date and to ensure that customers receive accurate messaging and good information from our contact centre or HVCT about what is happening.

2.50 This system has been in use in South West and South Wales since 2007 and became business as usual in West Midlands and East Midlands during 2013.

11kV network automation and automatic restoration (operational innovation)

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

2.51 Remote control of the network is not new, with DNOs generally having remote control and indication down to the level of 11kV equipment at major substations since the 1980s.

2.52 Installing remote control capability beyond major substations and onto the 11kV network was a logical next step to improve performance in remote rural areas where customers are supplied by long overhead lines. Being able to operate switch points remotely, without the need for a person to be on site to do so, significantly improves restoration times.

2.53 We have taken this technology one step further and extended its use into urban areas where large numbers of customers can be affected by faults.

2.54 We have linked the remote control switching devices with our NMS to operate the network automatically when a fault occurs. In most cases this can be achieved in less than a few minutes of a fault occurring, which significantly reduces the impact on customers.

2.55 This system can operate with pre-written scripts or by using dynamic network assessment to learn the status of the network and operate the most appropriate sequence of switching to restore supplies.

2.56 We are now investigating even more flexible methods of automatic network management to ensure that we can meet the requirement to operate the network more dynamically in the future. Our Project FALCON LCNF trial will further develop this application incorporating real time power flow analysis and load management into network reconfiguration decisions.

Pre-installed LV monitoring capability

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

2.57 LV cabinets are normally supplied with relatively simple peak demand indicators built into them. We specify cabinets that have high quality current transformers installed so that, if required in the future, more accurate monitoring equipment can be fitted without interrupting customer supplies or replacing the cabinet.

Pre-installed automation capability

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

2.58 Switchgear for our distribution network can be pre-wired to accept automation equipment and can have current transformers (CTs) fitted to detect the passage of fault current. Pre-wiring all of our new switchgear allows us to provide flexibility in placing automation equipment as our networks develop. Automation can be fitted where it is needed without replacing the switchgear.

Stakeholder engagement process

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

2.59 Our Stakeholder Engagement process has used a selection of interaction methods, from group sessions through to individual telephone interviews. At our group sessions we have made use of electronic voting systems to allow each individual participant to register specific views. We have worked with various customer groups and have included sessions with university students to capture the views of our future customers.

Dynamic line ratings

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

2.60 The success of the Registered Power Zone project, RPZ1, showed that we can establish dynamic line ratings on our 132kV overhead line network. This allows us to accommodate more demand or generation when the network or environmental conditions allow it.

Customer 'call backs' and texts

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

2.61 We have implemented processes where we ask customers who have reported faults to us if they would like us to call them back once the fault is repaired and the network is restored.

2.62 This call back allows us to confirm that the customer is back on supply, provide guidance to the customer where the power has been restored but they are still off supply (such as guidance on resetting a trip switch) and to allow us to take feedback from the customer to learn where our service can be improved in the future.

2.63 We also offer text messaging as an alternative method of contacting customers.

DPCR5 Smart Enablers

Continuing with plans set in place during DPCR5

2.64 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.

2.65 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 2050 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.

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

Pre-installing LV monitoring capability

2.67 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.

2.68 When the cabinets are manufactured it is a simple 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.

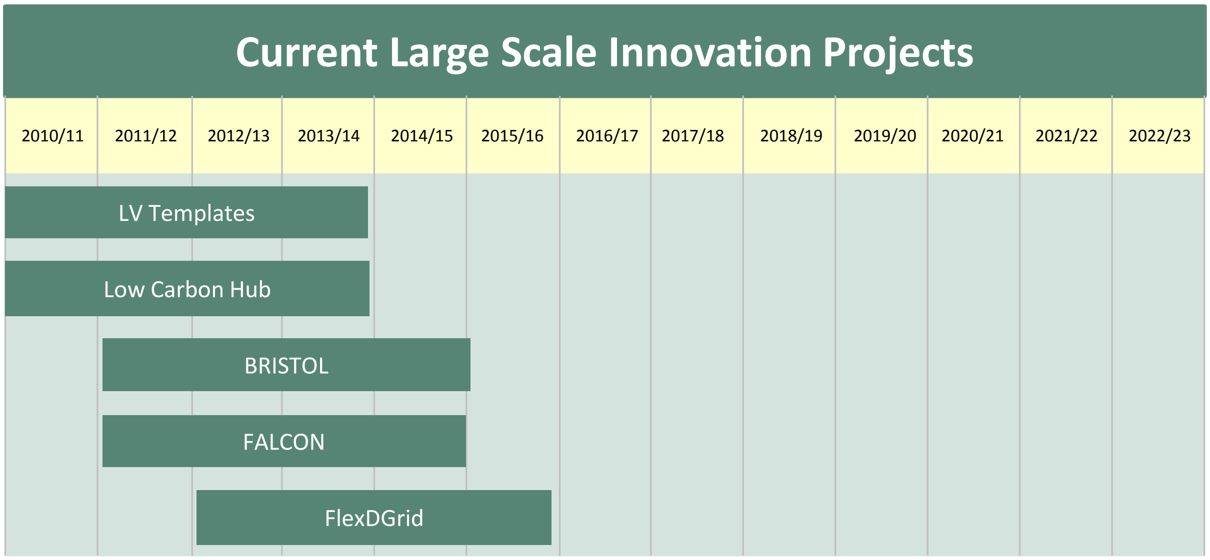
HV switchgear automation

2.69 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.

2.70 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.

Major DPCR5 low carbon and smart grid projects

2.71 During DPCR5 we have been successful in receiving funding for five Tier 2 projects. The projects investigate a range of network issues from 132kV active network management to rewiring of customer homes with DC systems (as opposed to standard AC).



LV Templates

2.72 The electricity network was designed to carry power from large, centralised power stations and major grid infeed points to distant load centres in town and villages. Historic load profiling data for network design used this basic operating model.

2.73 The shift to distributed low carbon generation such as from wind or solar sources has already moved a significant amount of generation closer to the customer load. At the same time homes are being made more energy efficient through better insulation. These changes require an overhaul of the basic planning assumptions that have been used when assessing power flows and energy consumption.

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

2.75 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.

2.76 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.

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

2.78 We have 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.

2.79 We have already 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.

2.80 We will use the results from the LV Templates project to change the way we design networks. We are initially implementing a templates based planning approach in South Wales that will make relevant changes to network planning tools. Once successful we will roll this out to our other licence areas.

2.81 The templates 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. Furthermore we will use more detailed weather and climate simulations to improve our understanding and adjust the templates accordingly. 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.

2.82 Although the project is formally closed we are continuing to collect data and process it under business as usual. This will allow us to identify demand profile changes as customers adopt LCTs and we will 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.

2.83 We have also 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. The consequences and benefits have also been debated at the ENA and with National Grid. We are now progressing the design of controlled trials within the South Wales area. Findings of several Electricity North West (ENW) projects will also help determine next steps.

Lincolnshire Low Carbon Hub

2.84 The Lincolnshire Low Carbon Hub has been designed to test a variety of new and innovative techniques for integrating additional low carbon generation onto electricity networks with limited capacity. The aim is to avoid the costs that would normally be associated with more conventional reinforcement.

2.85 We are exploring how the existing electricity network can be better utilised to accommodate more generation than traditionally would be accepted. The outcome of the project will lead to solutions that can be applied on other parts of the network where a large amount of distributed generation would like to connect.

2.86 We will offer Dynamic Line Rating solutions and Flexible Generation Capacity Agreements on this project. Both of these will improve the utilisation of our assets. The cost of connections and time to connect for generation customers will also reduce as a result of these initiatives.

2.87 The ENW 'Capacity to Customers' project will consult on changes to the engineering recommendation P2/6, relating to security of supply, and we expect this to also lead to an increase in connected generation.

2.88 Using these techniques more widely will require generators to be coordinated so that adjacent systems can operate effectively together. We will develop the systems to achieve this using the knowledge gained from our project and the ENW project.

2.89 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 now expect the solution to be deployed in more locations than originally predicted and we have already identified the following 11 additional sites in WPD where the solution will be deployed between 2015 and 2018. This will increase the amount of generation that can be connected at these sites.

- Lincoln and Horncastle
- Rame
- Northampton
- Truro / Fraddon
- Corby
- Fraddon / St Austell
- Swansea
- Landulph / St Germans
- Camarthen/Haverfordwest
- Hayle
- St Tudy

Project FALCON

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

2.91 It will be used to assess a number of alternative solutions to conventional network reinforcement. Four technical and two commercial intervention techniques are being designed and tested to address network constraints.

2.92 The project will develop modelling tools that use real-time data to inform network planning decisions, rather than traditional indicators such as total demand and generic engineering guidelines.

2.93 The project will deliver a Scenario Investment Model (SIM) planning tool for both 11kV network design and strategic forecasting. The 11kV design tool will be developed into a production model and rolled out during the project. The strategic planning tool will be used for business planning and scenario analysis.

2.94 The FALCON telecommunications solution, based on mesh radio, will become our preferred standard for primary substation to distribution substation communications. It will be developed during RIIO-ED1 and will eventually replace the legacy analogue based systems.

2.95 The uptake of demand side response within the FALCON project has exceeded the planned 9MW target. This has been achieved through a mix of bilateral contracts and services provided through aggregators. Uniquely, the service is being offered as complementary to the National Grid STOR service, meaning that customers can engage with us and National Grid at different times. We are currently working with the other DNOs and National Grid on a common framework.

2.96 The outcomes from the FALCON project will produce an energy modelling simulator that will be used to design and operate the network in a more efficient way. Functionality from this simulator will be used to provide 11kV design templates for planners and provide more real time analysis for control engineers. UKPN's 'Flexible Plug and Play' project will also deliver tools to design and operate networks to allow cheaper and quicker generator connections, and we will incorporate these tools in our design templates.

2.97 The network management functionality trialled in FALCON will be implemented into WPD's ENMAC control system, and the prototype system subsequently decommissioned. The new functionality will become available to be implemented across the WPD networks from 2015, leading to the widespread rollout of load balancing automation schemes as loads grow with the increase in adoption of LCTs.

BRISTOL

2.98 The BRISTOL project aims to provide an innovative approach to operating networks utilising battery storage in a customer's premises. The battery will store output from PV generation and utilise it in many ways. A DC network for lighting and USB type charging, an inverter controlled by the customer and WPD and new tariffs will help manage the PV generation locally. The project will seek to address issues associated with the large-scale deployment of PV generation.

2.99 In this project WPD is working with:

- Bristol City Council which is deploying the technology at its sites;
- Knowle West Media Centre which is coordinating customer engagement;
- Siemens who are providing the technology; and
- University of Bath (working with RWE npower) who are our academic partner.

2.100 The technologies will be implemented in ten schools, one office and thirty homes; all connected to 13 distribution substations.

2.101 The project is testing the coordination of a local micro-grid but has also provided an excellent storage and DC power test bed. The BRISTOL solution will 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.

FlexDGrid

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

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

- enhanced fault level assessment;
- real-time management of fault level; and
- fault level mitigation technologies.

2.104 Recent forecasts by National Grid and ETI point toward an increase in the use of Combined Heat and Power (CHP) in urban areas. This increase in distributed generation will lead to potentially higher fault levels in most of the larger cities in the WPD area during the latter part of RIIO-ED1.

2.105 Even though this project is less than 12 months old, it is already providing data which may change how we calculate fault level and allow us to accept more local generation and CHP onto our network. As this assessment work completes and reports, it will be used to alter design principles.

Low carbon and smart grid small project portfolio

2.106 In addition to the five large LCNF project, WPD has established a portfolio of smaller low carbon projects.

Isles of Scilly Smart Grid

2.107 We have installed advanced communications links between the islands (including power line carrier communications technology). This is used to remotely synchronise generators on each island with the main power station on St Mary's and the single cable link back to the mainland in Cornwall. The project has included community engagement and the development of an energy website for the islands. The project published a final report in December 2013.

National Grid Systems Integration & Security

2.108 Traditionally DNO control systems and those of National Grid have run in isolation. With the connection of more intermittent generation on the system it will become increasingly important for data to be exchanged. This needs to be done reliably and securely. This project has developed data links using "Inter Control Centre Protocol".

11kV Voltage Control

2.109 Working with Hitachi of Japan, we are testing large power electronic devices to control system voltage at remote ends of our networks where renewable generation is connected. The devices have previously been used in Japan and the Far East and we are adapting them for UK networks. We have demonstrated that Static VAR Compensators (SVCs) at 11kV are an effective way of smoothing voltage on rural networks to allow distributed generation to connect.

Early Learning

2.110 We have worked with Merlin Homes on a new housing development in Crickhowell, South Wales. The development of 30-40 homes has solar panels and other low carbon technologies. We installed three parallel low voltage cable networks (small, medium and large). This enabled us to switch between the networks and monitor their performance so that we could establish which one provides the best solution for customers. The project reported in November 2013.

Substation Sensor Trial & "best buy" report

2.111 Our Tier 2 LV Network Templates project involved installing retro fit monitoring equipment in older substations across South Wales. Traditional methods of installing the monitoring equipment require supplies to be switched off. This project developed a solution to substation monitoring, without the need for customers to be off supply. Equipment was tested in the field and in the laboratory. The work was supported by the National Physics Laboratory. At the end of the project we had shown that 98% accuracy is achievable on these units and produced an evaluation report for a range of sensors.

PVs in Suburbia

2.112 Several thousand social housing homes in Nottingham have solar panels and other energy efficiency measures fitted by the local council. We have taken the opportunity to carry out detailed monitoring of the local grid. The objective was to understand how resilient our system is to such a high concentration of LCTs, and identify how we need to adapt the network.

2.113 Our results showed that dense concentrations of solar panels will present some issues around harmonic content, power factor and when the limits of neutral current thermal limits are reached. These findings are helping to advise new planning principles in conjunction with the LV Templates and Early Learning projects.

Smart Hooky – Britain's Smartest Energy Community

2.114 Working with the residents of Hook Norton, and integrated into DECC's Low Carbon Community Challenge initiative, the project has transformed the local grid to a smart grid. All the substations are monitored with data made available to residents via a web portal. We have also developed a power line communications solution, which allows us to communicate to customers' homes directly and understand individual demand profiles. The project concluded in December 2013.

Seasonal Deployment of DG

2.115 This project recognised that network peaks occur generally for a few days per year. It attempted to develop the standards and commercial arrangements to "top up" the local grid with under-utilised mobile generation at times of forecast excess demand. Due to current market arrangements and the greater utilisation of generation than expected, it was found to be uneconomic to make use of mobile generation in this way. The project was therefore halted in the summer of 2013.

Active Fault Level Management

2.116 Generation connections are limited by three network factors; load carrying capability, voltage and fault level. Until now is has not been possible to measure the fault level, it could only be modelled on computer simulations. We have developed a tool, recently tested in Chicago, to solve this problem. The learning has already fed into our Tier 2 FlexDGrid project and a live measuring device was installed on a network in Birmingham in December 2013.

Community Energy Action

2.117 Working with 10 communities across WPD we will attempt to manage network constraints using demand side management (DSM). The project aims to identify the most effective arrangements to engage customers in the modification of their electricity demand and through these initiate practical DSM arrangements.

Electric Boulevards

2.118 Working with partner organisations including Arriva Buses, Wright Bus and ARUP we are transforming one bus route in Milton Keynes by replacing diesel buses with wirelessly charged electric units. WPD is installing and testing the charging equipment and laying the cables to charge the buses. We will move energy around the city to match the bus route. We expect to be able to show that LV connection of these charging units is possible in most urban areas using the existing network. This will assist in the deployment of electric buses in towns.

ECHO

2.119 The ECHO (Energy Control and Household Optimisation) project is testing the effect on household electricity demand from Demand Side Response (DSR) payments (customers receiving payment for modifying their electricity usage). Delivered in conjunction with the Energy Savings Trust the project will provide insight into the financial, technological and behavioural aspects of DSR.

LCNF Tier 1 Small Project Portfolio Budgets

2.120 The expenditure on many of the tier 1 projects is relatively modest, but we are generating a good understanding of many facets of future networks. We will continue to develop new small scale projects that will continue to benefit the industry.

LCNF Tier 1 Project Budgets (£m)	
T1 Isles of Scilly Smart Grid	1.27
T1 National Grid Systems Integration & Security	0.08
T1 11kV Voltage Control	1.07
T1 Early Learning	0.02
T1 Substation Sensor Trial & “best buy” report	0.28
T1 PV's in Suburbia	0.10
T1 Smart Hooky – Britain’s Smartest Energy Community	0.39
T1 Seasonal Deployment of DG	0.33
T1 Active Fault Level Management	0.80
T1 Community Energy Action	0.33
T1 Electric Boulevards	0.61
T1 ECHO	0.35

Smart Grid Forum

2.121 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.

2.122 Two key challenges to the operation of a smart grid have been identified as the use of DSM and the visibility of operating conditions on low voltage networks. To help address these challenges our early LCNF projects have focused on these areas. The FALCON project is demonstrating the effective use of Demand Side Management (DSM) and the LV Templates project has provided profile information on low voltage networks.

2.123 We are represented on the SGF at CEO level, and are active in many of the workstreams that have developed.

2.124 Workstream 3 led to the development of the 'Transform' model; an enhancement of the DECC scenarios developed under workstream 1. We have actively participated and supported the Transform model and have taken it further by including socio-economic and housing stock details to develop a view of future electricity usage specifically tailored to our areas of operation.

2.125 Workstream 5 has developed the Smarter Networks Knowledge Portal, which has recently been launched by the ENA and we are also represented on this group.

2.126 Workstream 6 deals with Commercial and Regulatory Matters. We have recently been involved in a DNO knowledge sharing event for this group, where we explained the experiences of customer engagement that we have seen on our projects.

2.127 A new workstream developed by the SGF is workstream 7 which will consider the future of distribution networks out to 2030.

Why do we innovate?

External factors and trends

2.128 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 likely to be renewable and distributed.

2.129 Creating a 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.

2.130 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.

2.131 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, distribution substation monitoring was bespoke when our LV Templates project started in 2010. By 2012 we were able to test a variety of off the shelf products in a joint project with UK Power Networks.

2.132 The information, communications and technology sector will continue to grow in significance. The trend in “always online” devices is likely to accelerate leading to the vision of an “internet of things” where smart devices interact with one another without the need for human intervention. We will need to ensure that the distribution network can integrate with such devices to meet customer expectations.

2.133 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.

Responding to Government policy

2.134 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.

2.135 The aspirations within the Government's Carbon Plan will increase demand on the network and there will also be more DG. The scale and pace of the changes are uncertain but we need to be ready to accommodate the changes when they arise.

2.136 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 incentive strength is reduced as generator developers seek to maximise their returns from incentive mechanisms. As an example, in 2013 we connected 28 new large renewable generation connections. Another 90 are planned and have accepted connection offers from us.

2.137 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.

2.138 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.

2.139 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.

2.140 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.

2.141 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 interactive and dynamic system.

2.142 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.

2.143 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.

The need for innovation

2.144 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 heat pumps and electric vehicle charging, but also to accommodate the connection of more locally based DG such as photo voltaic and wind.

2.145 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.

2.146 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 'Smart'.

Passive

2.147 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.

Telecontrolled with remote operation

2.148 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.

Semi-automatic / automatic response to specific events

2.149 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.

2.150 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.

Smart (present day onwards)

2.151 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, smart meter data and other information obtained from dedicated monitoring.

2.152 In addition to reconfiguring running arrangements in response to faults, the smart networks of the future will dynamically respond to network loading, output from distributed generators, weather conditions and other parameters to maximise the utilisation of available network capacity, enable the most amount of generation to be exported and reconfigure networks to minimise technical losses.

Consequences of innovation not occurring

2.153 The need for innovation has been set out in the section above. 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.

2.154 If innovations did not continue to be made, our overall performance would suffer and costs for customers would be higher as the volume of LCTs overwhelmed the capacity of the network and increased volumes of more expensive traditional solutions were used.

2.155 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.

2.156 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.

2.157 For the future networks areas of innovation, the consequences relate directly back to the Carbon Plan and the targets set by Government. 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.

2.158 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.

Dealing with uncertainty

2.159 A high degree of uncertainty exists with respect to the uptake of LCTs 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.

2.160 Whilst we are guided by scenarios developed by DECC we also employ organisations such as EA Technology Ltd (EATL) and the CSE to help model these scenarios further and to enhance the levels of detail.

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

2.162 Wherever possible we also ensure that our projects are 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.

Prioritising innovation topics

Scope of innovation

2.163 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.

2.164 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.

2.165 Our innovation developments can be described across six broad areas;

- low carbon networks – supporting future electricity demand and generation requirements;
- smart meters – maximising the benefits from more detailed network data;
- smart grids – 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;
- business efficiency – searching out better processes, equipment and technology that ensures we continue to be efficient.

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

2.167 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.

Innovation objectives

2.168 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.

Approach to innovation

2.169 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 (e.g. the purchase of equipment that is ready for the retro fit of automation);
- share what we learn with other organisations and learn from others.

Generating ideas

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

2.171 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 (e.g. application of gas sniffing technology to identify locations of faults).

Selecting and prioritising ideas

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

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

2.174 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.

Developing plans for innovation

2.175 Innovation in smart solutions will help us to accommodate LCTs without the need for vast amounts of investment being required to reinforce the network in the latter years of RIIO-ED1 and into RIIO-ED2. We forecast that smart interventions have reduced our investment plans and will save around £128m across RIIO-ED1.

2.176 Our innovation plans will also be regularly reviewed against new information from UK industry, worldwide research, learning from LCNF projects and outputs from the Smart Grid Forum.

2.177 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 bodies such as TSB, ETI or EPSRC.

2.178 We also look for ideas which follow on from other LCNF or IFI projects to maximise the benefits of investments already made.

2.179 This includes building on successful projects delivered by other DNOs. One example of this was the research which underpins our FlexDGrid Tier 2 project. This was developed as an IFI research project by SP and was then further enhanced as a measurement technique by one of our own Tier 1 projects. Another example is where we have taken the demand side management customer contract documents from the UKPN Low Carbon London project and are using them in our own Community Energy Action project.

Stakeholder engagement for innovation

2.180 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 the areas.

Stakeholder engagement in developing plans for RIIO-ED1

2.181 In phase 1 of our stakeholder engagement process we asked stakeholders if they supported our plans to facilitate increased volumes of LCTs. They formed the view that we should provide a level of “future proofing” to the network and that our steps should be taken in an incremental way in case the uptake of LCTs is slower than expected.

2.182 They also expressed the view that we should hold a “watching brief” on technologies such as electric vehicles, where the adoption is not yet established.

2.183 In phase 2 of our stakeholder engagement we presented our plans for the levels of “future proofing” that could be applied to our network. In this stage of the process our plans had a financial value so that stakeholders could establish their willingness to pay. Whilst there was high overall support for our plans, the most favoured option was to invest ahead of need in line with a medium level scenario of LCTs.

2.184 We consulted on our Business Plan in phase 3 of our stakeholder engagement process. At this stage our stakeholders asked us to scale back our assumptions for the take up of LCTs, which we did. Stakeholders also made it clear that they expected our levels of service and reliability to be maintained during the transition to LCTs.

2.185 74% of stakeholders agreed with WPD’s draft plans and outputs to facilitate increased volumes of LCTs. 19% of stakeholders want WPD to do more to identify LCT hotspots to inform our decision making regarding network reinforcement.

Ongoing Stakeholder engagement

2.186 Stakeholder engagement will remain a core activity through the RIIO-ED1 period and innovation will remain a key element for consultation and feedback. Our latest engagement sessions in February 2014 included discussions on the process for DG connection queues where there are a number of DG customers wishing to connect to the same part of the network. This considered interactivity of connection offers, payments and reservation of capacity.

2.187 Innovation remains a key theme for our Customer Panel. At a recent Customer Panel meeting innovation options were presented. The panel prioritised the options for future projects. In addition to innovation projects the panel support our work to assist the distributed generation community.

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

2.189 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.

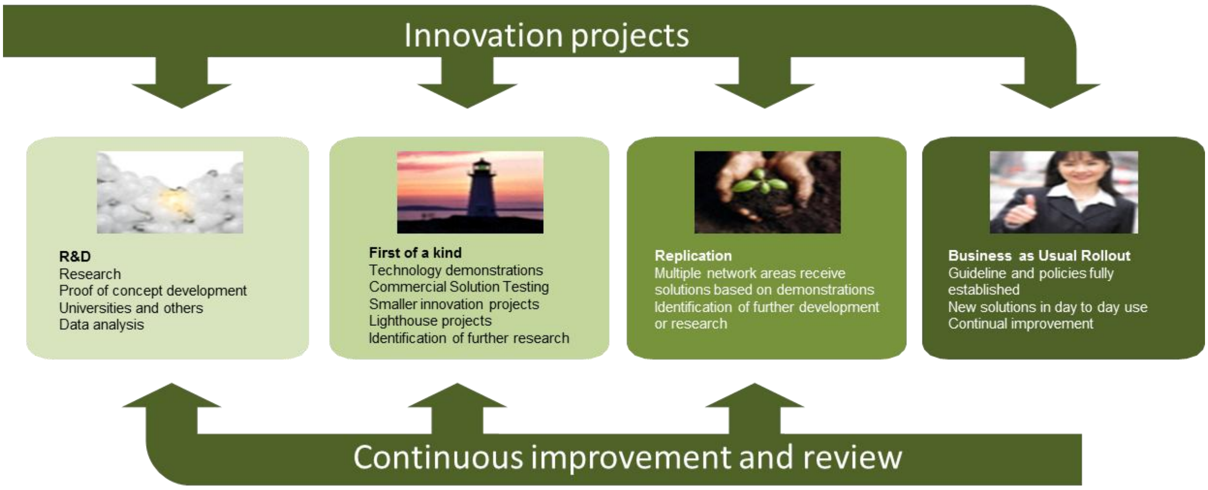
Innovation Priorities for RIIO-ED1

Stages of Innovation

2.191 During RIIO-ED1 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 (in addition to the NIA and NIC) to supplement our own R&D budget.

2.192 Lower TRL projects will generally be carried out by external research partners under limited 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.



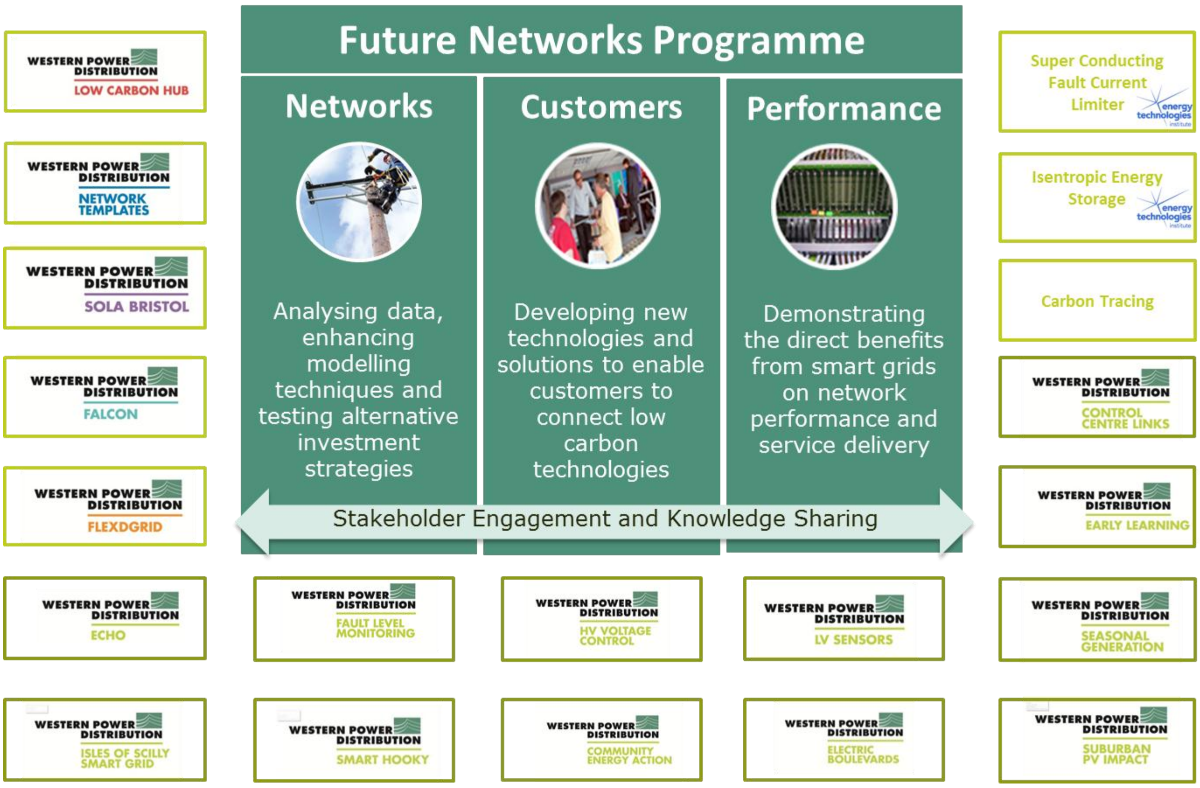
2.193 The full 'research to implementation' timescale can often take 5 to 10 years. That is why we focus internal teams on higher TRL stages, building on knowledge from earlier studies outside our own organisation. This will particularly be the case in RIIO-ED1 in order to rapidly develop new solutions to support delivery of the Carbon Plan.

Forming the innovation programme

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

- Networks – 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. For example the application of battery storage devices to provide additional capacity at peak times.
- Performance – This category of projects demonstrate direct benefits to network performance from the application of technology. For example, the use of phasor measurement units to maintain supplies using local generation in the event of a fault.

2.195 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.



Funding the innovation programme

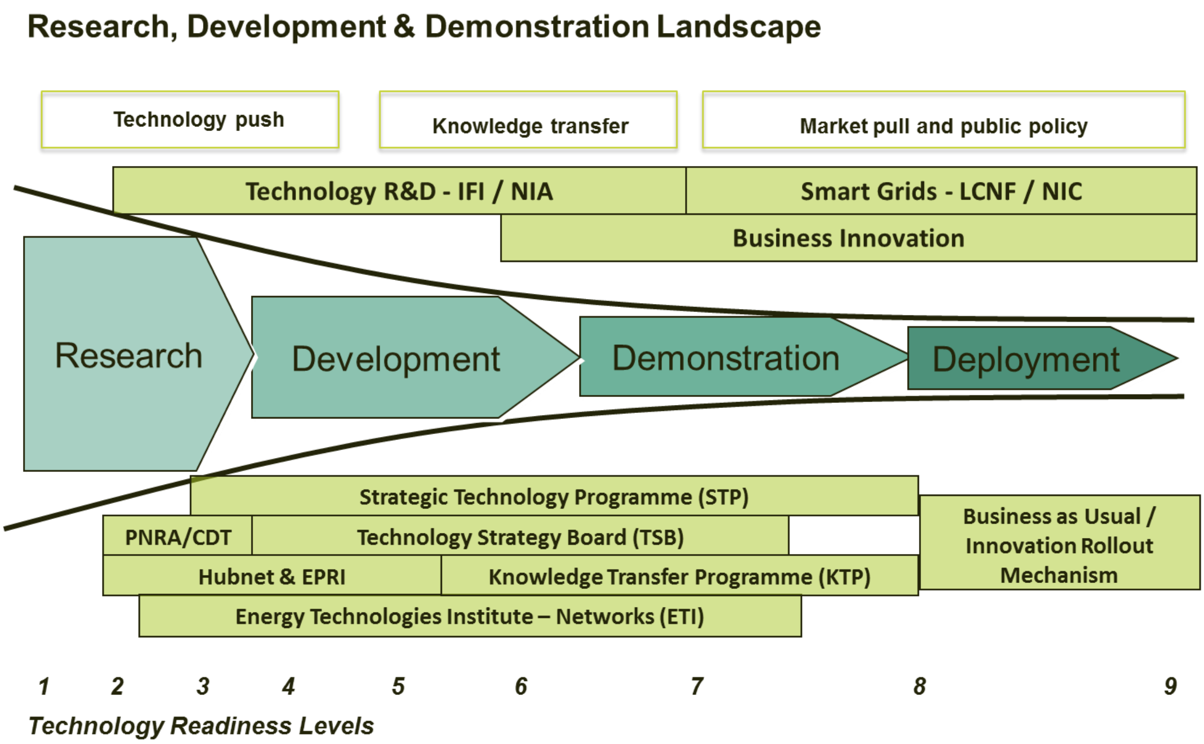
2.196 For RIIO-ED1 we have requested the minimum proposed Network Innovation Allowance (NIA) of 0.5% of total regulated revenue, around £67m throughout the period. We will also work with partners to provide innovative proposals for larger projects to be funded through the Network Innovation Competition (NIC). Together these projects will lead to investment of over £130m in innovation.

2.197 We will also continue to make use of any other available funding sources when appropriate.

2.198 In addition to NIA and NIC projects we will continue to support research and development in partnership with other DNOs. These include continuing to support academic research through Hubnet, the IET Power Network Research Academy (PNRA) and Centre for Doctoral Training (CDT).

2.199 To ensure knowledge is effectively shared with this sector we will continue to make use of the Knowledge Transfer Programme (KTP) initiative.

2.200 The targeting of innovation funding to appropriate TRL stages is illustrated in the diagram below:



Preparing for the future with smart enablers

2.201 We have been assessing the scale of future network investment requirements by modelling different scenarios. The EATL "Transform" model provides future load estimates and potential solutions based on the DECC scenarios using a range of generic network types. This model has enabled us to form a view of loading at distribution transformer level.

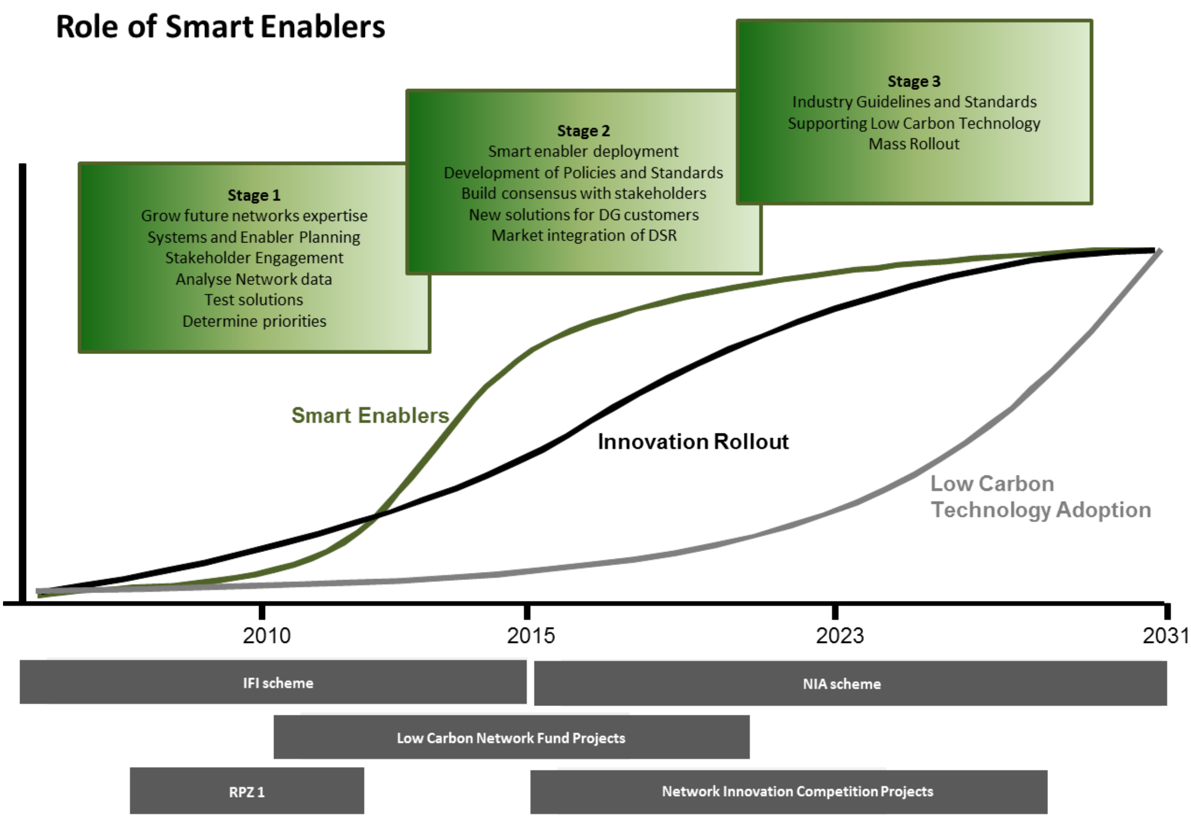
2.202 At our request, the CSE has compared the output from the Transform model to socio-economic and house stock information that they hold. This has refined our plans to make them more specific to local circumstances. For example, forecasts of heat pump installations have been reduced in areas where the housing stock is not suitable for their installation and electric vehicles demands have increased in those areas where early adoption is likely.

2.203 As we move into RIIO-ED1 we will compare the CSE forecasts with the activity levels that we are actually observing to update our forecasts and provide feedback into the CSE to refine forecasting techniques. This will allow us to more accurately forecast LCT uptake so we deliver the most efficient volume and mix of reinforcement.

2.204 Using this detailed analysis we plan to increase the size of selective transformers and cables where there is greatest likelihood of demand growth.

2.205 We also plan to invest in communication infrastructure to improve our understanding of the real time status of the distribution network, utilise smart meter data and enhance the sophistication of control of the network.

2.206 Investment in these enabling solutions will provide an essential foundation for the rollout of many smart solutions. 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.



Selectively increasing the size of distribution transformers

2.207 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.

2.208 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%.

2.209 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. This has led to an additional cost of £0.11m per year being included in the plan.

Selectively increasing the size of cables

2.210 The average cost of excavation in a footpath is around £70 per metre, whereas the additional cost of moving to the next size of cable may be less than £10 per metre. 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.

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

2.212 Using the CSE forecasts we will design to the "next size up" on our cable installation and replacement works in these areas. By targeting this 7% we will install around 74km per year at an additional incremental cost of £0.3m per year.

2.213 Cables do not provide the same losses savings as transformers but installing oversized cables will reduce the need to revisit networks and replace cables. Using an average cable replacement cost of around £70 per metre the future cost savings are around £5.1m per year.

Expanding the communications infrastructure

2.214 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.

2.215 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 such as operating adjacent networks in parallel (meshing) and load transfers are required.

2.216 For instance where meshing or load transfers are required we will consider establishing our own communications links to bring back monitoring data and automation control information. This will only be applied where it is more cost effective and operationally effective than using the smart meter data. Wherever possible we will connect our links directly into our existing communications network via scanning or mesh radio systems.

2.217 Our FALCON project is providing a replicable radio solution which will be the way forward for our new communication systems. We are working with the industry, Joint Radio Company (JRC), Ofcom and the EU to identify an appropriate frequency spectrum for smart grid communications.

Identifying and delivering solutions from earlier LCNF projects

2.218 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.

2.219 The suite of LCNF Tier 2 projects will provide an excellent source of knowledge to help develop future networks and applications. The timescales of these projects mean that the majority of the learning and outcomes will be provided in the next few years and into the RIIO-ED1 period.

Driving value from smart metering

2.220 The smart meter programme will provide every household with a smart meter. We will be able to use the data from these meters to provide us with a level of information and customer interaction that we have not previously seen. The meter will provide us with details of electricity usage that will assist in refining network planning templates.

2.221 The increased functionality of the smart meter over the conventional meter provides the potential for us to offer our own tariff signals to manage peaks on our network. The “last gasp” feature will also help us improve our customer service during supply interruptions.

Our plans for smaller scale new innovation projects

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

2.223 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.

2.224 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	✓				✓
Metal theft	✓	✓	✓	✓	
Priority Service Register	✓		✓		
Templates		✓		✓	✓
Smart meter data		✓	✓	✓	✓
Power electronics	✓	✓		✓	
Modelling and state estimation	✓	✓		✓	

2.225 The subjects are detailed on the following pages.

SF6 alternatives

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

2.226 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.

2.227 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.

Metal theft

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

2.228 The theft of metal from our network continues to be a problem whilst the scrap value of metal is high. We are developing a range of initiatives to help prevent and detect theft. We are trialling the monitoring of neutral wire currents to detect theft as it occurs. We are also investigating the analysis of the verdigris on recovered copper to identify the theft location.

2.229 This work will help to deter theft, reduce the disruption caused to customers as a consequence and reduce the safety considerations of network assets being left in an unstable state. It will also lead to lower overall costs of repair, which benefits all customers through lower funding requirements.

Priority Service Register (PSR)

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

2.230 WPD maintains a PSR of customers who are registered as being dependent on electricity due to age, disability or chronic illness. We are looking at further developing ways to help support these customers. We have plans to develop a simple notification system for PSR customers to contact us during a loss of supply. We are also developing a small alternative power supply system for customers who have a requirement to operate certain medical equipment during a loss of supply.

2.231 This helps us provide an excellent level of customer service to our PSR customers who, in times of loss of supply, have the greatest need for our help.

Templates

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

2.232 As new planning templates are developed through innovation projects like the WPD LV Templates projects, we will work to establish them as standard assumptions throughout our planning systems. With each new project completion or learning outcome, we will refine the templates we use.

2.233 Further development of templates will help us optimise the utilisation of our network without the need for expensive monitoring systems, which will reduce costs to customers.

Smart meter data

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

2.234 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.

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

Power electronics

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

2.236 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 LCNF projects will be developed into standard solutions. We will work to develop the standards and establish the rules for wider deployment of these solutions.

2.237 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.

Modelling and state estimation

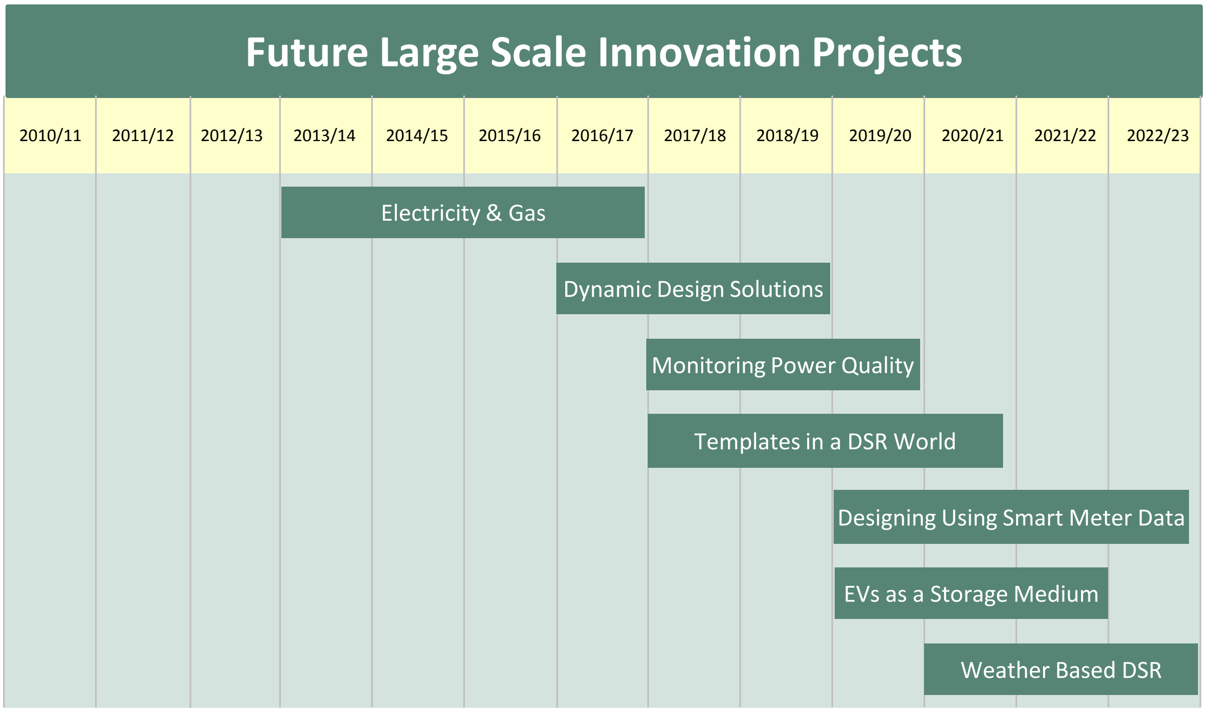
Safety improvement	Cost efficiency improvement	Customer service improvement	Reliability improvement	Environmental improvement
✓	✓			✓

2.238 In our smart grid strategy we explain the interdependencies of monitoring, state estimation and modelling. The estimated and modelled networks will help us develop flexible solutions without the need for specific monitoring points. We will develop the standards to use when applying state estimation and use the results from innovation projects to refine the state estimation assumptions.

2.239 Modelling and state estimation allow us more economically operate our network without the need for expensive monitoring systems, which will reduce costs to customers.

Large scale innovation and the Network Innovation Competition

2.240 The chart below shows the areas we will explore and develop through the NIC up to the end of RIIO-ED1. 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.



Electricity & Gas

2.241 The 'Electricity and Gas' project was been developed as our Tier 2 proposal for 2013. It was to investigate the use of hydrogen as a storage medium. There are parts of the network where there is more generation output than can be accommodated by the network. This means that the output of the generation has to be constrained, limiting the low carbon benefits of the generation capacity. Reinforcement of the network often requires the replacement of EHV or 132kV network at high cost.

2.242 This project sought to use the excess generation output to produce hydrogen which can either be used as fuel to produce electricity when the output from generation is lower or it can be injected as a source of additional gas into the local gas network. The project was not selected for funding in the 2013 LCNF competition. Discussions are now underway to review alternative approaches at a smaller scale and to identify an appropriate funding source for this cross energy sector project.

Dynamic Design Solutions

2.243 Our current methods of designing the network generally assume that the network will operate in a passive way. The move to smart networks and different operating methods means that the network planning tools will also need to evolve and be developed to exploit the new opportunities created. Our 'Dynamic Design Solutions' project will review and create new design solutions to be included in the standard options available to planners. This project will investigate how the existing planning design tools need to change and implement those changes.

Monitoring Power Quality

2.244 The increased range of power electronics and distributed generation that we will see on our network is likely to have a detrimental effect on power quality. The 'Monitoring Power Quality' project will ensure that we understand the impact and develop techniques to continue to operate the network within power quality requirements.

Templates is a DSR World

2.245 This project will build upon the existing LV Templates work. The project will refine the planning assumptions to accommodate the various combinations of DSR and DSM that we will begin to see on our networks.

Designing Using Smart Metering Data

2.246 Smart meter data will become available from all domestic properties by 2020. We will have already incorporated the full set of smart meter data into our business systems as it becomes available during the smart meter roll out. Through our 'Designing Using Smart Meter Data' project we will investigate how this data can be used to model, design and manage our network more effectively. We already plan to provide a geographically based dataset and this project will help develop the detail of that.

EV as a Storage Medium

2.247 More electric vehicles (EV) are also likely to be used in the latter years of RIIO-ED1. This project will investigate how electric vehicles can be used for energy storage when there is excess generation and used to release the stored energy at times of peak demand to smooth load profiles and potentially defer network reinforcement.

Weather Based DSR

2.248 By the end of the RIIO-ED1 period we expect DSR and DSM to be a key part of our network management processes. With this in place, additional weather data and forecasting tools will allow us to more proactively deploy DSR/DSM to smooth load profiles in response to weather conditions and our 'Weather Based DSR' project will develop appropriate design solutions to a variety of constraints.

Our plans for RIIO-ED2 and beyond

2.249 In recent years we have seen a growth of communication technology, taking communications further than our main substations and onto the local distribution networks. Future improvements to the communications networks will increase bandwidth and reliability enabling greater transfer of data and more dynamic operation of the network.

2.250 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.

2.251 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.

2.252 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.

Innovation governance arrangements

Innovation governance

2.253 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.

2.254 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.

2.255 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. Tier 1 LCNF projects are subject to project level approval by the Future Networks Manager. Projects registered in Tier 2 are subject to project level authorisation by the Chief Executive.

2.256 Project progress is tracked through normal monthly business reporting arrangements. For each LCNF Tier 2 project this includes the preparation of a balanced score card detailing progress against milestones, significant issues and summary financial reporting. All Tier 2 projects have a nominated senior management sponsor and progress review group.

2.257 Projects also undergo regular review by the progress review groups of each Tier 2 project and by the Future Networks Manager for Tier 1 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.

2.258 LCNF 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 Tier 2 projects.

2.259 IFI projects are delivered in line with the G85/2 ENA standard as required by Ofgem. Projects are reported annually with copies available on WPD, ENA and Ofgem websites.

2.260 During RIIO-ED1, NIA projects will be reported against a new ENA standard and good practice guide as required by the Ofgem governance arrangements. NIC projects will be reported in line with requirements set out in the Ofgem Governance Document. Most of the requirements are similar to those currently required under LCNF.

2.261 Larger 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.

Research partners and supplier arrangements

2.262 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).

2.263 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. In 2011 we helped prepare papers for the annual conference and in 2013 we presented our own topics based on LCNF learning. WPD chairs session 4 (Distributed Energy Resources) of CIRED’s technical committee.

2.264 To maximise the effect of research and innovation we actively participate in industry wide forums such as EA Technology’s Strategic Technology Program (STP). This program brings together the best industry knowledge in a cost effective way to pool and manage research which is of use to all DNOs.

2.265 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.

2.266 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 LCNF or IFI projects is shared.

2.267 Staff in our Innovation Team review other LCNF and IFI 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.

2.268 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.

2.269 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.

2.270 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.

2.271 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.

2.272 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.

2.273 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.

Managing risk and future uncertainty

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

2.275 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.

2.276 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.

Tracking benefits

2.277 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 such as those delivered under IFI are reported annually in our innovation report. Larger projects report progress including benefits delivery as part of their regular reporting regime.

2.278 All projects delivering against our key outputs have their benefit measured against those outputs. For example the benefits of further developing ENMAC mobile will be measured against the output headings of safety improvements, increased cost efficiency, improved customer service and reliability and also environmental improvements. Benefits tracking is carried out at all stages of the project, from initiation to completion.

Keeping the strategy up to date

2.279 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.

2.280 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 we will assess their suitability for adoption as part of our review process.

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

2.282 The Innovation Strategy is approved annually by the Chief Executive.

Innovation rollout and knowledge dissemination

Rolling out the learning from innovation projects

2.283 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 is part of 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.

2.284 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 LCNF projects.

2.285 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.

2.286 We monitor all the LCNF projects as they develop and make use of learning and outcomes as they are reported. An example of learning that we have used can be seen in our Tier 1 Community Energy Action project where we are using smart commercial agreements from UKPN's Flexible Plug and Play project rather than developing our own agreements.

2.287 Our RPZ1 project has 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. On the circuit where the dynamic solution was developed, we have identified 19MVA of capacity that can be offered using DLR. This is a 20% increase on the static capacity values. Similar values will be achieved on circuits which are operated in a dynamic way.

Knowledge sharing and dissemination

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

2.289 The main annual event for knowledge sharing is the LCNF conference which we actively support, and which we hosted in 2012. We also host specific knowledge dissemination events for individual projects and for our whole portfolio of projects. The audiences for these events are always very broad and include academics, DNOs, Government departments, suppliers, manufacturers and research organisations.

2.290 Often the most important thing that we can share from our projects is data and results. We have two dedicated websites 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. The www.lowcarbonuk.com site is aimed more at the research community and provides more details of the output data and results.

3 Smart grid strategy

Accommodating load on the network

3.1 A smart grid is an electricity network which uses a range of network management techniques to optimise network capacity in the most efficient way.

3.2 The techniques range in complexity from applying standard assumptions (or templates) through to fully automated active networks which respond to real time measurements. As the network becomes smarter, more of these solutions work together.

3.3 We have five options to choose from when deciding whether we can accommodate more load;

Passive accommodation of load

3.4 For many parts of our network, the existing network will be able to accommodate the new demands on it. Nothing more needs to be done for these areas.

Application of Templates

3.5 For some parts of the network, innovative templates and modelling data will allow us to revisit the traditional design assumptions. Using assessment techniques developed in LCNF projects, it will be possible to re-estimate the loadings on the network and model their effect. This more detailed level of understanding will allow us to accommodate additional demands without the need for physical alterations to the network. In addition, the use of dynamic thermal ratings can add flexibility to our design assumptions.

Monitoring and State Estimation

3.6 When templates are unable to accommodate all of the additional demands we will need to make a more detailed analysis of the network. We can use monitoring equipment to accurately measure the status of the network but will also use state estimation techniques to predict the status based on known measurements.

3.7 State estimation is a system which takes data from a measurement point and uses it to forecast conditions on similar networks or at similar points. In some cases the measurement point is not directly related to the estimated point. On our Lincolnshire Low Carbon Hub project we use wind turbine output as a pseudo measurement of wind speed. Such state estimated values will increasingly be used as pseudo measurement points within our control systems and automation controllers, since they are a cost effective alternative to widespread network monitoring via sensors.

3.8 The FALCON and FlexDGrid projects are developing state estimation tools which will be readily deployable within RIIO-ED1.

Active Network Management (ANM)

3.9 In the areas of the network where we see the highest demands and concentration of Low Carbon Technologies, we are likely to require more dynamic solutions.

3.10 In these areas the constraints are likely to be such that the templates and state estimation would still leave unacceptable risk. These areas will need in depth monitoring and coordination of generator control schemes.

3.11 Through an ANM Connections Tier 1 project we will be rolling out an ANM standard and training planners in how to assess solutions for LCT 'hot-spot' areas. The Lincolnshire Low Carbon Hub project is developing an intelligent and flexible control mechanism on the 33kV network which can be used in areas where constraint management is required. We are also developing demand management approaches to alleviate peaks and smooth load profiles by shifting demand to times of the day when the network has capacity

Reinforcement

3.12 Some areas of the network will be required to operate at levels which exceed the capacity offered by the solutions above. In these areas, conventional reinforcement will still be required.

Smart grid connection agreements

3.13 The alternative solutions described above can be applied to customer connections as well as general network reinforcement planning. Customers applying for load or DG connections will either be accommodated, offered an unconstrained reinforcement solution or offered a smart alternative solution in line with the following:

- **Passive –** If a connection can be accommodated without any further network reinforcement then this will be offered to customers in line with current processes.
- **Templates** – If a connection can be accommodated but it requires to be constrained to be able to operate within the parameters defined in the local network template design, then a variable capacity offer will be made. We will require the customer to implement an automated solution to ensure their connection does not affect other customers. In many cases this may be a simple timer based device. WPD will reserve the right to audit a customer installation, but compliance monitoring will largely be done retrospectively using metering data. We are currently negotiating the first such arrangement with a hydro generator based in the South West.
- **Monitoring & state estimation** – Network reinforcement is triggered by a forecast breach in a network constraint. This forecasting is generally done on a "worst case" basis. For this category of connection a customer will be made an offer on the basis of replacing the forecast with a physical or state estimated value. In the event the revised constraint is (or forecast to be) breached then the customer will automatically be limited to a lower capacity threshold. We are currently discussing such a solution with a wind generation customer in the East Midlands.
- **Active Network Management** – The most complex systems will be used mainly with larger new connections, and primarily for generation. Customer control equipment will be integrated into the WPD ANM solutions allowing full dynamic control of network, generation and demand. We are making use of learning from the SSE Orkney Smart Grid project to develop our own ANM solutions.
- **Reinforcement** – The customer will always be offered an unconstrained connection in addition to a smarter option (for comparison purposes)

Flexibility – application of different solutions

3.14 Our work with the CSE has allowed us to model the LCT impacts on our network to a more granual level of detail than the Transform model alone. However it is still not certain as to the overall uptake of LCTs.

3.15 For that reason it is essential that our plans remain flexible and we will deploy systems which can be re-used if the network changes. For example, a network which is experiencing load growth may be able to defer conventional reinforcement, such as the replacement of a transformer, by accommodating the load using Templates or Demand Side Management (DSM).

3.16 If the load continues to grow and the transformer is eventually changed, this network will also change from one at the highest level of smart grid intervention back to one which can be managed by template. The DSM systems which have been utilised can be switched off when they are not required. We will ensure that our agreements with customers include notice periods to cancel the agreements.

Templates and modelling

Low Voltage Networks

3.17 Data is being provided from our LV Templates LCNF project which shows us how low voltage networks operate and the effects that low carbon technologies can have on them. We will use this data in our design tools to ensure that the impact of LCTs is not over-stated in planning calculations and maximum use can be made of the available network capacity.

3.18 The collection and analysis of data from the LV Templates project and other monitoring initiatives will become a business as usual function. This will allow us to track changes after the completion of the LCNF project. As more customers adopt Low Carbon Technologies the data will be used to modify and create new templates which can be applied across WPD licence areas and the wider DNO community.

3.19 We will make use of smart meter data from all of our customers to build a detailed understanding of the LV network. The smart meter data will complement the data from the LV Templates project and provide a check that the templates correctly reflect network usage. Our work with the CSE has helped to develop a data mining system to allow us to extract pertinent network information from smart meter data.

3.20 Smart meter data is key for us as it will give us an indication of the status of low voltage feeders without requiring us to add monitoring systems. We can use this data when we make our planning decisions regarding the connection of distributed generation. When this data shows that the network is nearing capacity additional substation monitoring can then be added ensuring the efficient deployment of that equipment and resources.

3.21 At present a lot of network planning data in WPD is provided in a tabular form. Using smart meter data we will develop a diagrammatic representation of the data to allow our planners quicker interpretation of the data. We plan to continue the low voltage network connectivity modelling which was started in DPCR5. This will allow us to reference smart meter data to our network easily and automatically.

3.22 We will establish a 'Smart Grid Planning Laboratory' in conjunction with Bath University which will assist us in the research and development of new templates and models.

Higher voltage networks

3.23 We have already implemented learning from the RPZ1 project. This has allowed us to use dynamic thermal ratings on our 132kV overhead lines to allow us to operate the asset more flexibly.

3.24 Data from the Lincolnshire Low Carbon Hub project will show that we can extend dynamic thermal ratings onto our 33kV overhead network.

3.25 In both of these projects, multiple weather stations are used to collate data that can be correlated with load. As our knowledge of weather effects increases, we will reduce the number of weather stations we use on each project and develop weather templates.

3.26 FALCON is implementing a full nodal power flow model for the 11kV system across Milton Keynes. The project system (called the "SIM") will benefit strategic planners making long term investment decisions and 11kV planners carrying out more day to day and near term studies.

Network automation

3.27 Our LCNF projects include the investigation of network reconfiguration or meshing networks by operating adjacent networks in parallel. Meshing networks allows us to make use of capacity where adjacent networks have load profiles which are different and load can therefore be shared. The automated switching required to mesh networks is provided using the standard automation devices installed on our switchgear. Control of meshed systems is provided through our NMS using either automated algorithms or manual switching in response to trigger points.

3.28 We manage the network to provide supplies within the statutory limits for voltage and quality. Active voltage monitoring schemes can be used to allow generation to run when the voltage conditions allow it, or suppress the generation when voltages would exceed limits. Subject to commercial agreements with customers many forms of generation can also be used to control system voltage. In particular wind turbines and invertor fed PV are ideal sources of voltage control ancillary service. We are testing these arrangements as part of the Lincolnshire Low Carbon Hub project. We can also use static compensators (STATCOMs) to deal with situations where the reactive elements of the supply are approaching statutory limits, allowing generation to be online for longer. Our LCNF Tier 1 project with Hitachi is testing these solutions.

3.29 Demand Side Management and Demand Side Response will also be used to actively manage our network. The amount of response that can be provided varies for different groups of customers. Domestic customers are likely to provide scheduled demand shifting. Commercial customers will provide demand shifting but are also likely to provide targeted demand response, both at times of high load and when the network is being operated abnormally as a result of network fault.

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

3.30 DSM is the generic term associated with energy management activity that customers connected to the distribution network can undertake. 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.

3.31 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.

3.32 We will engage 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.

Domestic customers

3.33 Our experience suggests that domestic customers are more likely to engage with a supplier than a DNO. We will make use of suppliers or third parties to manage DSM at a domestic level. Working with the Energy Saving Trust (EST) we are already trialing a system of domestic demand side management which uses plug-in controllers connected to the customer's broadband router which receives the demand control signals. The EST are communicating with customers, arranging supply of the equipment, operating a helpdesk and delivering the demand response signals to the equipment. The trial will show how effective domestic DSR is, and what level of customer take up will be achieved.

3.34 Domestic DSM is also being trialed through the BRISTOL project where a battery is used to store energy and defer demand at peak times. In the RIIO-ED1 period we will investigate how this can be achieved through other methods. For example we may be able to use 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 DSM by charging when there is spare capacity in the network and using the batteries to provide energy to the network when demand is high.

3.35 For large scale domestic DSM to work effectively for a DNO, we will need a standard set of terms and conditions with suppliers, so that a customer's choice of supplier does not hinder the use of DSM.

Business customers

3.36 I&C customers are more likely to interact with their DNO. This has been evident on the FALCON project where we have 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 will contract over 9MW of demand reduction to support capacity on our network.

3.37 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.

3.38 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 working with National Grid to amend their standard terms and conditions to allow customers to operate in both markets. We have set up the DSR Forum, where DNOs, Ofgem and National Grid are represented, to discuss this in more detail.

Demand Side Response requests

3.39 DSR is managed in two ways, depending on the requirement of the network.

3.40 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.

3.41 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.

3.42 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.

Commercial framework for DSR and DSM

3.43 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. In our domestic trial we are offering units as low as 2.5p/kWh for agreed reductions (representing around a quarter of a standard tariff).

3.44 I&C customers are more likely to be directly contracted to WPD. We will set up a team to deal with I&C customers throughout our area. In our I&C trial we are offering a tariff of £300/MWh for reductions.

Agreement periods and terminations

3.45 To provide the security that we require from DSR & DSM systems, we will contract with customers for 12 month periods with the ability by mutual consent to then roll these periods on where there is an ongoing requirement for the service.

3.46 To allow customers the ability to opt out of the system, we will allow 3 month terminations at the end of the initial fixed period. We will make the termination available to either party so that we could also terminate if our network changes and the solution is no longer required in a specific area.

4 Smart meters

Introduction

4.1 The Government has mandated that by 2020 every home in Great Britain will have a smart electricity and gas meter. This vision represents the world's largest mandated dual fuel smart metering programme. The deployment of the meters is due to be undertaken by the electricity suppliers with a mass change programme that is due to commence in the autumn of 2015.

4.2 The majority of meters currently installed in properties require a manual reading to be obtained periodically by the site visit of a meter reader. In addition the existing meters have no capability to provide anything other than a total energy consumed reading. For that reason it is only ever possible to determine an average consumption over the time period between meter readings.

4.3 The new smart meters will have a whole host of additional functionality. As well as being capable of being read remotely via an independent communications path they are specified to be able to record the energy consumed for each 30 minute period and to store this data until it is periodically downloaded by a new organisation called the Data and Communications Company (DCC).

4.4 This 'time of actual use' data provides much better information with respect to the actual consumption behavior of each customer. This opens up many opportunities for Suppliers to provide new and innovative time of day tariffs for customers. Ultimately customers should be able to take advantage of cheaper electricity at times of the day where supply is high and demand is low.

4.5 This ability to provide this accurate 'time of actual use' consumption data also provides the mechanism for a number of benefits to be derived for DNOs.

4.6 The installation of smart meters allows WPD to gain much greater visibility of the operational state of the low voltage (LV) network compared to our current limited view. The LV system was designed to work passively with a level of spare capacity and inherent robustness. Our network planning is undertaken using established traditional operational assumptions.

4.7 However these assumptions are now being challenged with the introduction of low carbon technologies such as heat pumps and electric vehicles. These technologies have the potential to significantly increase the loading on parts of the LV network. In addition greater amounts of distributed generation need voltage regulation and management of two way power flows.

4.8 By taking information aggregated at the LV feeder level we are able to see actual LV network demands over each half hour. These can be used to make informed decisions as to the availability of capacity and the ability to connect new load or generation.

4.9 The additional functionality and information available from smart metering therefore represents a significant opportunity to deal with these challenges. We will be able to make use of the monitoring functionality embedded in each meter to increase understanding of the network and improve our service to customers in existing activities, while looking to more effectively facilitate the low carbon transition.

4.10 This opportunity however comes with its own set of challenges. In order to meet the mass rollout requirements within the agreed timescales (2015-2020) the Suppliers need to undertake an accelerated meter installation programme. This is approximately four times quicker than the current meter replacement and recertification program. In turn this is likely to result in an increase in associated WPD visits to properties in order to deal with issues associated with our equipment at customers' premises.

4.11 To ensure the data from smart meters can be used effectively, additional IT systems will be required. These will include systems to interface with new and amended industry processes, along with connectivity models and data storage to allow network data to be collated and evaluated. Further costs will also be incurred through a mix of fixed and variable charges associated with provision of data via the DCC.

Benefits for WPD

4.12 For WPD, the Smart Meter programme has the potential to provide data to enhance existing core business activities such as fault management, network planning and asset management. There are also potential benefits which can lead to future applications that will help the deployment of low carbon technologies and move to actively managed networks. With many of these applications, the benefits increase as the density of smart meters on the system increases.

4.13 To take full advantage of the benefits we will need to ensure that we have established compliant interfaces with the DCC, established data storage systems and have created detailed network modelling tools with full LV connectivity.

Fault Management

4.14 Smart metering will provide a number of functions to support fault restoration and reporting activities. When there is a power cut, ‘last gasp’ functionality will trigger a message to notify a loss of supply. This will provide a level of visibility down to the individual premise that has not been available before.

4.15 Additional functionality will allow the ’energisation status’ of meters to be checked remotely, gaining a clearer understanding of which customers are off supply and allowing us to determine what kind of fault has occurred (blown fuse, open circuit fault, single premise). This will help ensure that we dispatch the correct restoration response first time and improve our restoration times. In the case of a call regarding a ‘single premise’ it will also help to remotely identify if the issue is on the network or on the customer’s own equipment.

4.16 On completion of the fault it will be possible to check that all supplies have been restored. This is particularly useful in storm scenarios where faults at High Voltage (HV) can mask additional issues at Low Voltage (LV). The ability to check will reduce the possibility of teams leaving the area whilst customers are still off supply.

4.17 The smart meters will record interruption and restoration times which could lead to automation of fault reporting. They will also allow additional visibility of short interruptions, power cuts lasting less than 3 minutes, to indicate developing issues on overhead networks, such as intermittent faults due to tree contact.

4.18 Fault management applications will become more effective over time as the density of installed smart meters increases and more information becomes available to provide a comprehensive view of the network.

Network Planning

4.19 Existing network planning assumptions are already becoming challenged due to the volume and type of distributed generation on the LV network.

4.20 At present the majority of load data is derived from measurements at source 11kV circuit breakers at primary substations. At LV, maximum demand indicators provide a limited view of loads at distribution substations but no load duration is collected. Smart meter data can provide increased visibility on aspects of network activity that inform load-related investment decisions. Data on half-hourly power flows (real, reactive, import, export) and maximum demand (both for individual meters and aggregated for network sections) allow us to determine load profiles, which can be used to:

- check that loading is within operational and thermal capacities of network components;
- determine thermal capacity headroom to gauge the scope for accommodating additional (LCT) loads;
- inform the prioritisation of load-related network investments;
- avoid unnecessary reinforcements or network issues from demand over or underestimation;
- identify reverse power flows, which might require us to take measures;
- Identify where power factor correction is necessary or can act as an alternative to network reinforcement;

4.21 The data collected will provide a more comprehensive understanding of where there are issues on the network and where there is adequate capacity to accommodate additional connections or more LCTs without the need for network reinforcement.

Connections

4.22 As with load related network investment, increased visibility of voltage levels and power flows can help reduce the time to connect new loads and generation. It can also provide benefits to new connectees via lower connection charges and the ability to assess options for the use of smart solutions to reduce or avoid upstream reinforcement.

Asset Management

4.23 A wide range of data will be available from smart meters to support asset management activity. Each meter will be able to act as a voltage monitoring point and be capable of issuing alarms relating to voltage anomalies (under voltage, over voltage).

4.24 Aggregated load data will create a more detailed profile of the loads experienced at points on the network. This can support the identification of overloaded sections of network and aid in the prioritisation of network reinforcement where load issues have been identified.

4.25 Aggregated load data can also ensure that network reinforcement is avoided where it is not necessary. For example maximum demand indicators may suggest that a substation is overloaded based on a momentary high load whereas aggregated metering data may demonstrate that this this was of very short duration and in line with design parameters requiring no intervention.

Future Applications

4.26 It is recognised that electrification of heating and transportation, along with the adoption of distributed generation will present a number of challenges to the operation of the LV network.

4.27 Smart metering functionality has the potential to support future network operations through a number of applications. Increased amounts of data will help to identify where issues are appearing on the LV and 11kV system. Applications will be developed to support load shifting, scheduling using variable tariffs and other demand side management techniques. This will lead to a more active network management approach compared with the passive 'fit and forget' approach historically used by the industry.

4.28 It should be noted that functionality for load control does exist within the smart metering specification however this is currently unavailable to the DNOs due to security restrictions and access to critical commands.

4.29 Network losses are particularly difficult to identify and measure in part due to the current lack of visibility of the LV network. Two main types of losses are encountered;

- non-technical losses - smart metering data will help in the identification of non-technical losses as part of ongoing revenue protection activity where electricity is being extracted illegally.
- technical losses - as the volume of smart meters installed becomes significant the load profile and voltage data will be used to help model the LV network more accurately allowing an improved estimation of the technical system losses throughout the network. This can be used to support investment decisions to improve the efficiency of the system by installing assets that provide for lower losses.

4.30 We have used socio-economic information to predict where LCTs may connect and have then analysed the consequential impact on the network. During RIIO-ED1 we will use data from smart meters to build up a better view of areas that become LCT 'hotspots' i.e. those areas with a high probability of requiring additional capacity in the near future.

4.31 We will integrate knowledge of LCT hotspots into WPD network planning tools to ensure that the information is readily available for team planners dealing with customer load or generation enquiries or where developing routine asset replacement projects. This will ensure that planners are presented with timely information about hot-spots rather than having to access and interrogate separate data systems.

Quantification of benefits

4.32 The benefits from smart metering can broadly be split into two categories; existing business functions and future applications. From an existing business function perspective there are a number of benefits relating to outage management and capital investment. Future applications include functions relating to active network management and demand response.

4.33 In March 2012 the Energy Network Association (ENA) produced a smart metering benefits paper that outlined the DNO benefits associated with the smart meter roll-out programme. This has been revised by the industry and a summary report was published in June 2013. It details the expected benefits available based on the latest smart meter specification and the functionality available to DNOs. This also reflects the changes in availability of direct load control to DNOs that has been removed as part of the smart metering security review.

4.34 In summary, it is expected that over RIIO-ED1 the total gross benefit that WPD would expect to see from smart metering would be in the region of £9m to £12m, with £7.5m relating to benefits associated with applying smart metering to existing business functions.

Smart metering benefits for business as usual activities (£m)								
	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23
Efficiency saving on load-related reinforcement	0.00	0.00	0.00	0.00	0.00	0.43	0.70	0.85
Efficiency saving on connections-related reinforcement	0.00	0.00	0.00	0.00	0.00	0.50	0.80	0.98
Savings from last gasp functionality	0.00	0.00	0.08	0.23	0.38	0.60	0.75	0.75
Savings from restoration confirmation	0.00	0.00	0.01	0.04	0.06	0.09	0.11	0.11
Total per annum	**0.00**	**0.00**	**0.09**	**0.26**	**0.43**	**1.62**	**2.36**	**2.69**

Smart metering benefits for demand side response and active network management (£m)								
	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23
Total per annum	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.5-1.5**	**0.5-1.5**	**0.5-1.5**

4.35 A number of different techniques have been used to establish the scale of smart metering benefits, including the use of engineering assumptions and scenario analysis with the Transform model.

4.36 Smart metering data can greatly increase the visibility of the network, and in particular inform decision making processes related to load and connections related reinforcement. WPD will have access to half-hourly power flows (including real, reactive, import, export) along with detailed voltage data. This data can be used to check asset loading, thermal capabilities and voltage performance. Informed decisions can then be made as to the headroom for additional loads such as low carbon technologies and to set priorities for targeted network reinforcement. Such processes should also help avoid unnecessary reinforcement due to demand over or underestimation.

4.37 It has been assumed that improved knowledge will lead to an eventual 5% reduction in load and connection related reinforcement as the population of smart meters increases. This is based on current levels of activity and does not take into consideration the introduction of LCTs. Modelling the network with smart metering data improves with an increased density of meters, hence an increasing benefit as the programme completes.

4.38 The assessment of benefits associated with power management has focused on last gasp and restoration confirmation functionality. It has been estimated that last gasp functionality could reduce the duration of LV outages by 5% due to having a clearer picture of the fault at the time of dispatch. This has then been applied to the underlying value of a CML of £0.17 based on Ofgem's 'Willingness to Pay' valuation.

4.39 'Pinging' meters (sending a signal to the meter) on completion of fault restoration activities will ensure that no customers are inadvertently left off supply when teams leave site. The estimation of benefits has been calculated based on reducing the amount of GSOP payments due to improved energisation status information for customers.

4.40 The future network benefits associated with DSR and Active Network Management (ANM) have been developed by using the Transform model. A number of scenarios have been run by EA Technology as part of this work looking at a range of electric heating and transportation cases. A number of network techniques were then applied that relied on the smart metering data to instigate such as network reconfiguration and voltage regulation.

4.41 It should be noted that the values from this work are significantly less than the initial estimates produced by Imperial College in 2010. This is primarily down to the scaling back of LCT deployment rates and the removal of direct DNO control over loads from the smart metering programme. Whilst it is envisaged that load control signals could be produced by DNOs, the current market model would require messages to be passed through electricity suppliers. It is currently unclear as to how this would work in practice.

4.42 The benefits associated with DSR and ANM is intended to show the range of savings possible. There is some uncertainty around the scale of these benefits due to the uncertainty associated with the deployment of low carbon technologies and the consequent need for innovative network solutions.

Cost benefit analysis

4.43 Using the benefit analysis work undertaken by the ENA, a number of WPD specific scenarios have been established to complete cost benefit analysis for the smart metering programme. There are number of cost items that will be incurred as part of the smart metering rollout programme. In some circumstances these will be required to facilitate industry process and support the programme such as IT development and service position defect rectification.

4.44 The smart metering cost benefit analysis has been completed based on the costs related to receipt of data through the DCC. This approach has been adopted because WPD has some choice as to the level of data to be purchased and therefore costs.

4.45 The DCC costs can be broadly split into two categories, fixed costs and variable costs. The fixed costs are directly related to the establishment and running costs of the DCC and the infrastructure required for the communications. The variable costs are also included and relate to the amount of data that is purchased.

4.46 Three data cases have been considered for the cost benefit analysis:

- Base Case – Fixed data costs only and receipt of no data;
- Option 1 - Optimal Data Collection;
- Option 2 - Real Time Data Position.

4.47 The base case scenario is based on WPD satisfying industry requirements and gathering no further data to support network operations.

4.48 Option 1 represents an optimal level of smart metering data collection to support network planning and operations. This case has been created using data forecasting work that represents our best estimate as to data requirements and has previously been submitted to DECC to support the DCC procurement process. The requested data includes scheduled half hourly load profiles, and voltage data. It includes a small percentage of half hourly load profiles being returned in near real time. With this data set it is envisaged that WPD could achieve all of the forecast benefits including enhanced network planning, outage management and some level of active network management.

4.49 Option 2 is based on Option 1, but with an increased proportion in near real time data collection for half hourly load profile data. This scenario has been developed to represent enhanced active network management techniques and would be supported by voltage and load profile data being returned for 0.5% of our customer base in near real time. This would then allow operational decisions to be made on the network based on this data either through a control center or with system automation.

4.50 Individual cost benefit analyses have been undertaken for each of WPD's 4 licence areas. The table below shows the summary net present value (NPV) of Option 1 and Option 2 for the whole company.

Cost benefit analysis	Option 1	Option 2
Term (years from first out flow)	NPV (£m)	NPV (£m)
16	£8.62	£1.82
24	£16.47	£4.78
32	£25.16	£8.55
45	£38.97	£14.93

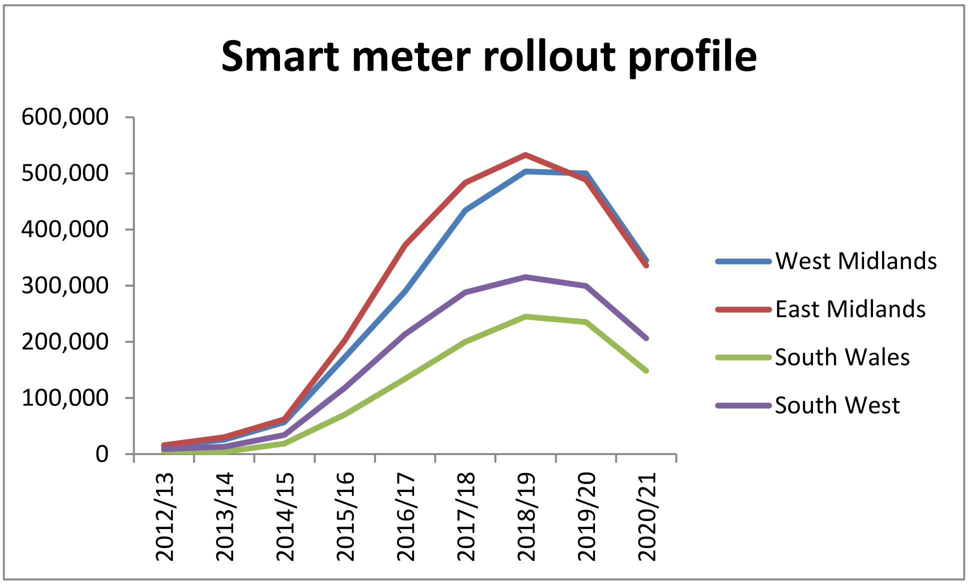
4.51 While Option2 delivers a positive NPV, this shows that Option 1 delivers a higher level of benefit over both medium and long term periods.

Service defect rectification

4.52 The installation programme for smart meters is being controlled by suppliers in liaison with their meter installers. Whilst in the majority of cases the meter operators will be able to proceed with the meter change, there will be situations where DNOs will need to carry out remedial work to service equipment to allow the installation of the smart meter.

4.53 At present, WPD already attends a number of premises in response to meter exchanges. This activity can be in response to a range of situations, including damaged or faulty cut-outs, damaged cut out boards or other defects relating to the service termination.

4.54 The graph below outlines the latest information available of the predicted rollout profile of smart meters across the four WPD licence areas. At its peak, this represents over 4 times the existing level of activity normally associated with the meter exchange programme.



4.55 At the peak of the rollout (in 2018/19), it is anticipated that over 1.6m meters per annum will be installed across the WPD licence areas.

4.56 The actual number of defects is unknown, but for the purposes of forecasting work volumes and resource requirements it has been assumed that remedial work will be required for 2% of smart meter installations. Over the roll out programme this equates to 148,000 service issues in total. It is calculated that 4,500 of these would have been identified ordinarily as 'business as usual' over the period and so there will be an additional 143,500 issues to resolve. The rectification costs are shown in the table below.

Smart meter related cut-out change expenditure in RIIO-ED1 (£m)					
	West Midlands	East Midlands	South Wales	South West	WPD Total
Cut-out changes	**8.4**	**9.1**	**3.9**	**5.4**	**26.8**

4.57 These costs will cover normal in-hours work where WPD attends site to rectify a defect. Any additional costs incurred out of hours or for wasted visits will be recovered directly from suppliers.

4.58 WPD systems have already been updated to cater for the anticipated workload and data flow requirements. This has included the functionality to receive new industry data flows including the information as to the type and classification of the faults. However processes to report on actual service levels and to charge suppliers for out of hours and abortive calls will need to be developed based on the outcome of on-going industry discussions.

4.59 A better indication of the likely volumes of defects will be derived during 2014/15. We will analyse the smart meter related work within the foundation phase to identify the actual percentage of meter operator visits where subsequent DNO visits are required. This will be possible by analysing new industry information as to the volumes of smart meters currently being installed that became available during 2014.

Installation visit - resource management

4.60 In order to support the additional site visits required within the accelerated roll out period approximately 60 FTE staff will be required to be assigned specifically to the smart meter programme.

Work-flow management

4.61 In order to process all installation defect requests in a timely way additional activity will be required to manage requests and programme work. This falls into two major areas of responsibility:

- Call centre indirect activity. An additional three staff at each of WPDs two call centres. Total cost of £200k per year
- Work scheduling indirect activity. Nil cost. The current assumption is that this activity would be absorbed by existing team support staff.

Establishing a cut out survey

4.62 As smart meters are installed in domestic and small commercial properties, we have an opportunity to gain information about the service position and cutout in the customer's premises. To install a meter the incoming service will be made dead by removing the cutout fuse. By working with the Suppliers we can make use of this visit and supply interruption to greatly improve the quality of our data on cut out population.

4.63 We will establish agreements with suppliers to capture information about the cut-out, its condition and location at the time when a meter is changed. This will help to influence condition based decisions.

4.64 We will establish a record of this data in our asset register and will supplement it with data provided when new cutouts are installed and when cutouts are visited as a part of our works. Our register will include details of cutout type, fuse size, age, service type and earthing.

4.65 We can start to establish the cutout condition using condition assessment points related to the fuse and the fuse holder. Working with EA Technology and the ENA we will establish a condition based replacement regime for cutouts which takes into account age, type and environment.

DCC charging arrangements

4.66 A new regulated organisation called the Data and Communications Company (DCC) will manage the systems for communications between the meters and users of smart meter services.

4.67 In order to fund and support the operation of the national smart meter infrastructure the DCC will levy charges for use of their network. These charges will cover the full end to end process covering the costs of three discrete elements:

- the communication network from the smart meters to the DCC - provided by the Communication Service Provider (CSP);
- internal DCC processing provided by the Data Service Provider (DSP);
- the communication network from the DCC to user's processing centres.

4.68 It should be noted that there is uncertainty about the level of charges since the DCC, DSP and CSP have not yet been appointed.

4.69 However DECC has produced indicative figures that have allowed an initial assessment of the fixed and variable cost elements of the smart metering communications charges. It is anticipated that these costs will be confirmed following the award of contracts for the different roles in August 2013.

Fixed costs

4.70 Following the award of the contract in August 2013 the DCC licensed entity will recover its own costs and governance costs via a fixed charge per meter. This will be levied at a rate of £0.02 per meter for all domestic premises irrespective of whether a smart meter is fitted.

4.71 From July 2015 the DSP and CSP can also begin to recover costs. The level of costs for these services is currently unclear but DECC has indicated the charges could rise to about £0.20 per meter.

4.72 During RIIO-ED1 Ofgem has determined that DNOs can pass through DCC fixed costs up to the end of 2019/20. This time period should be extended by Ofgem to reflect the one-year delay to the programme announced by DECC. At present we are unclear as to the level of the DCC fixed costs but fully expect, based on the indications from DECC, that these costs will be £0.20 per MPAN. It is currently assumed that the fixed charge element will encompass all the DCC licenced entity charges and smart meter alert notifications.

Variable costs

4.73 Through the ENA, a number of 'use' cases have been developed and used to generate a set of business process flows – currently defined within the DECC "Networks Framework Document" (NFD). This document lists the service request and a description of the service plus information on the typical volume of flows and usage over time.

4.74 In order to establish the potential volumes and costs incurred by the variable cost elements a review of the data flows was completed based on the NFD. Each flow was allocated to the appropriate WPD business processes and, from this, volumes and frequencies estimated. Indicative costs for small and medium message types have been supplied by DECC at 0.2p and 0.8p per message respectively.

4.75 Ofgem proposes that none of these variable data costs will be funded, stating that they should be covered by the benefits gained in network management.

4.76 The following table summarises the DCC related costs:

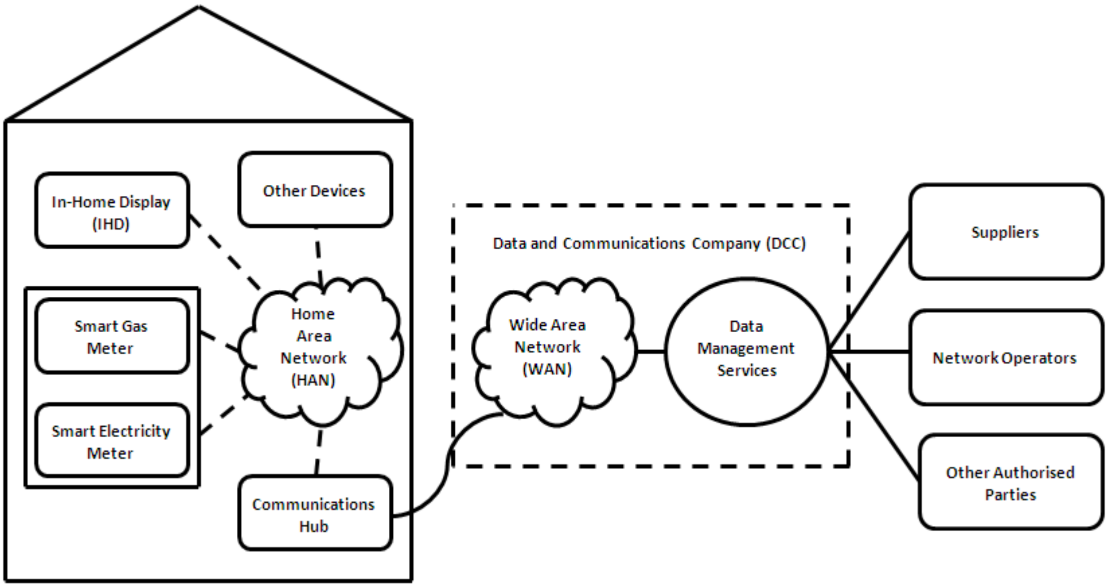
Smart meter related DCC expenditure in RIIO-ED1 (£m)					
	West Midlands	East Midlands	South Wales	South West	WPD Total
DCC licence fee	**2.4**	**2.4**	**1.2**	**2.0**	**8.0**
DCC fixed transaction costs	**5.4**	**5.7**	**2.6**	**3.9**	**17.6**
DCC variable costs	**1.0**	**1.1**	**0.5**	**0.6**	**3.2**

Development of WPD systems

4.77 In order to benefit from the services to be provided by smart meters the users, such as DNOs, will need to communicate to and receive updates from the meters on a regular basis.

4.78 The ownership and management of the communications to and from the meters to the various users of smart meter services will be managed via the DCC. The DCC will be responsible for all end to end communications from the meters at customer properties to the user's processing centres.

4.79 The diagram below provides a simple high level overview of the DCC communication environment and shows that users such as WPD access smart meter information via a link to the DCC.



Source DECC First annual progress report on the roll-out of smart meters (December 2012)

4.80 The DCC will provide a common framework through which users are able to communicate to smart meters. Users can include Suppliers, DNOs or other authorised parties. Each user group has a unique set of requirements that will need to be satisfied by the DCC.

4.81 WPD has been active in working groups that have been establishing the overall smart meter development programme. We have input into the smart metering specification, the user service catalogue which defines the flows to/from the smart meter and the Network Framework data volume assessment which defines, for each flow available to WPD, the potential volume and frequency of use. This has enabled us to start to develop the specification for data and IT systems requirements for smart metering.

Business processes and data flows

4.82 The scope of smart meter process and systems development work in WPD has been divided into the following key areas:

- business processes;
- alerts;
- common processes;
- legacy system changes;
- licence changes;
- industry testing.

4.83 From a business process perspective all smart meter flows available to DNOs have been reviewed and assigned to either amended or new WPD systems. We will build systems to receive meter installation set-up information, hold standard set up criteria and send appropriate flows to configure meters to meet WPD requirements. The ability to reconfigure meters will also be provided.

4.84 Routines to process meter readings, both scheduled and ad-hoc, will be developed along with data stores to hold this information for analysis purposes. This data will be used for day to day operations and network planning activities. Access to this data will be strictly limited to enquiries which comply with WPD data aggregation rules.

4.85 Ad-hoc enquiries will be made available to review the status of the meter. This will enable real-time checks to be made on energisation status to support off-supply processes and, where appropriate, to subsequently check successful restoration. In addition meter log/site details will be available for review so checks can be made on outage history and installed devices.

4.86 WPD will receive a number of alerts from meters which are generated by events within the meter that are relevant to DNOs. These alerts, such as last gasp (off supply), voltage fluctuations and tamper messages will be routed on a real time basis to allow prompt action to be taken. A final list of alerts and their volumes have yet to be defined so further analysis will be required once this information is available.

4.87 To support flows and alerts a number of common processes including data validation and security management will be required. This may be facilitated though joint development at an industry level and work is currently being undertaken by the ENA in this area. The output will be used to produce a standard set of requirements and used in detailed design discussions with the DSP. Regardless of how this functionality is developed WPD will have to ensure systems are in place and as such provision has been made to resource this work either on an internal or joint-development basis.

4.88 There are a number of existing core industry processes that will require amendment. These include Meter Point Registration Services (MPRS), reporting of meter technical details and receipt of installation information. Changes to cater for the smart meter programme are under development by the industry and will be available to support mass roll out. We will incorporate these changes into our legacy systems which will be updated accordingly. This work will also include the population of the Unique Property Reference Number (UPRN) into Meter Point Administration Service. Ultimately it is intended that MPRS will eventually migrate to the DCC during the later stages of the smart metering programme and a provision for the work to be undertaken to support this move has been included in the Business Plan costs.

4.89 At a licence level, smart metering will have an impact on a number of areas including Ofgem reporting, data aggregation and IIS reporting. Systems will be required to process data received from the additional smart meter data flows. In particular we will develop processes for data aggregation and for making sure that data is anonymous to meet the data privacy requirements as agreed with DECC/Ofgem. This will be in accordance with current best practice work that is being developed by the ENA.

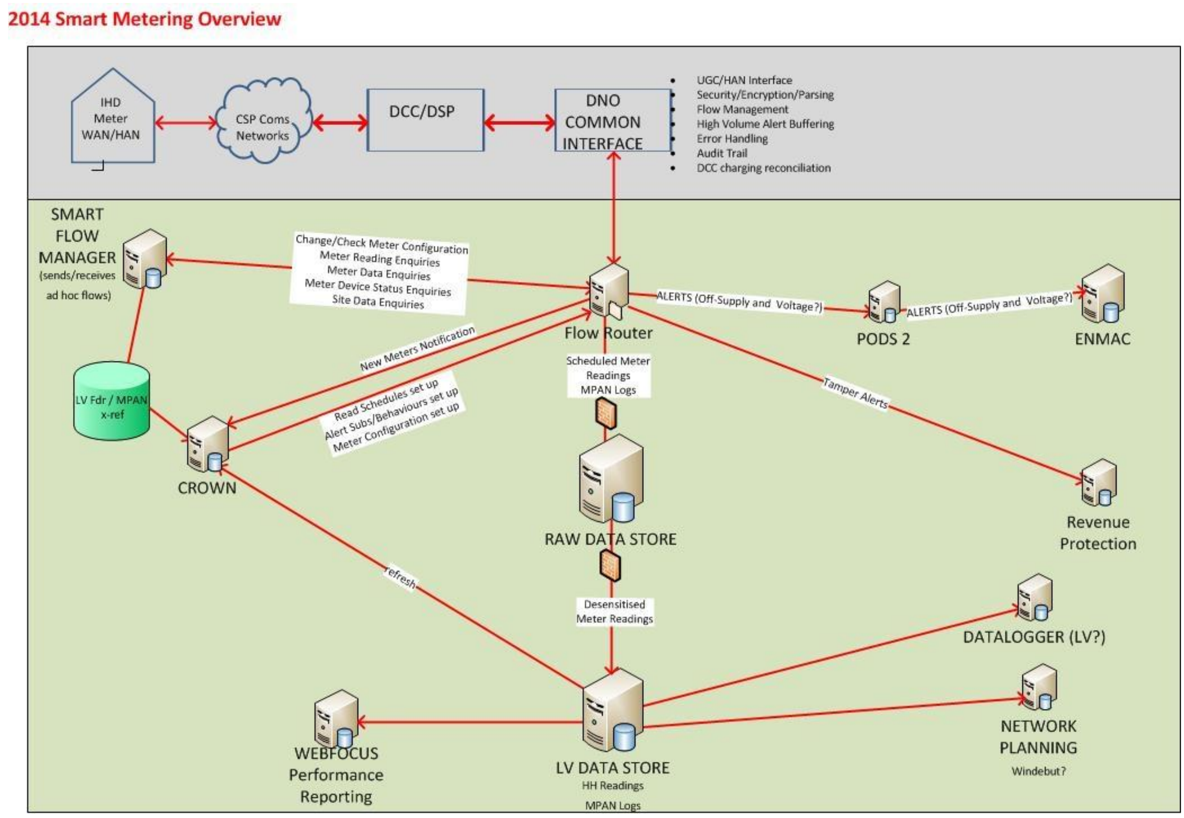
4.90 Before being able to implement the system changes we will have to undertake industry testing to verify that our systems and processes work correctly within the national arrangements. The exact makeup of the qualification and testing requirements necessary to prove this have yet to be defined, however provision for this effort has been made based on experience of previous industry implementations.

IT Environment

4.91 Each of the smart metering requirements have been analysed to estimate IT application and infrastructure costs. This includes costs for:

- servers;
- data storage (phased growth);
- 3rd party software (flow routing and management, reporting analytics);
- software licences (Oracle, Tivoli Storage Manager);
- implementation (consultancy, contractors);
- on-going hardware and software maintenance;
- hardware technology refresh costs .

4.92 The following diagram provides an overview of the current thoughts on the WPD computer environment required to support smart meter processing.



WPD Smart Meter Environment Diagram

4.93 In the diagram the grey area at the top represents the DCC environment and potential common processes with the green section being the WPD internal environment.

4.94 Communication with the DCC will be via a new flow routing system which will link to a communication path provided by the DCC. Details of this link have yet to be agreed however it is assumed that this will be via a standard communications media and as such will not provide any significant technical barriers. In addition resilient disaster recovery measures will be adopted to minimise the impact of any loss of the primary communications link to the DCC.

4.95 The DCC communications link will in turn be plugged in to an internal WPD flow routing system. This is likely to be an upgrade of the current “off the shelf” package employed within WPD. From the WPD flow routing system, smart meter information will be transferred to the systems required to support the new smart meter business processes. These systems can be broken down into three broad categories:

- systems supporting processes to configure, and request information from meters – Smart flow manager, CROWN;
- systems to hold data received from meters for on-going investigation and analysis – Raw Data Store, LV Data Store, Webfocus Performance reporting, Datalogger, Network Planning;
- systems to handle alerts raised by the meter – PODS, ENMAC and Revenue Protection.

4.96 Initial IT systems changes will be made to facilitate and test core industry processes prior to the start of mass rollout in autumn 2015. It is anticipated that initial IT capital costs in DPCR5 will amount to £2.7m with an additional £7.3m in RIIO-ED1.

5 Losses strategy

5.1 The WPD Losses Strategy is now available as a standalone document that can be found using the following hyperlink: http://www.westernpower.co.uk/docs/Innovation-and-Low-Carbon/Losses-Strategy-Final.aspx

5.2 For completeness the contents are reproduced on the following pages. Please be aware that the formats and page numbers may be different when comparing the Business Plan and the standalone Losses Strategy.

Background

What are losses?

5.3 The amount of energy that enters an electricity network is usually greater than the amount that is delivered to customers. The principal reason for this is that an electricity network uses energy in the process of delivering power to customers. This is known as a technical loss.

5.4 Another reason for electricity losses is where there is no meter or supplier at the final connection to record the usage. There are situations where a connection has been made to our system without authority. The energy used in these connections is not metered and does not feature in volumes that suppliers register. As a result it is shown as a loss on our network. This is known as theft in conveyance or illegal abstraction.

5.5 All Distribution Network Operations (DNOs) are obliged to run an efficient and economic system as a condition of their Distribution Licence. Losses are one measure of this efficiency. In addition to the requirements of the Licence, reducing losses is also a key part of the WPD strategy to help us manage our carbon footprint.

Technical losses

5.6 Of the amount lost a fixed amount is lost dependent upon the network itself, irrespective of the usage of the network and then a further amount is lost depending on the level of load on the network. The energy lost as a result of the network and its usage is usually called “technical losses”. This can further be categorised into fixed losses and variable losses. Variable losses will change as load alters on the network and is further impacted by the effect of network imbalance or power factor.

Fixed losses

5.7 The fixed element of losses is made up of the energy which is required when transformers are energised. As transformers require electrically produced magnetic fields to operate the energy used creating these fields is essentially fixed while they are switched on.

Variable losses

5.8 The variable element of losses is created due to the heating effect of energy passing through cables and wires. These conductors all have a small resistance and when currents are passed through they heat up. This heating effect is logarithmic and the effect of high load (when an item of equipment is running near or at full capacity) is very much more significant than in an item which has a low or part load.

5.9 The resistance of a cable reduces as its cross sectional area increases so the effect of losses is reduced in larger cable sizes.

5.10 There is a very similar variable element created through the wires and windings which are found in all transformers.

Imbalance

5.11 A network which is not balanced across all three phases will have higher currents than expected in at least one phase. Due to the logarithmic relationship to variable losses, these higher currents can have a significant effect on losses.

5.12 Imbalance is found on all parts of the network due to customers using one or two phases having different load consumptions. In order to rebalance the network there are physical actions that are required on the network. For example, a rural high voltage overhead network could be rebalanced relatively simply by moving the overhead service connection to a different phase of the overhead main. This is more difficult on an urban underground low voltage network which requires existing service joints to be excavated and new joints made to move customer supplies to different phases.

Power factor

5.13 Another characteristic which will increase losses by increasing currents on the network is the power factor. Where the power factor is less than unity the current has to increase to deliver the required amount of power. This has historically been an issue for installations used by industrial and commercial customers where most motor loads or power electronic loads were seen. Developments in domestic power electronics and the adoption of heat pumps means we will start to see this issue on our domestic networks.

Theft in conveyance

5.14 The detection of situations where there is no registered supplier at a final connection point or no meter installed is very difficult. Often detection comes as a result of investigations for another reason. In many cases theft in conveyance is connected to other illegal activities, which prompt investigation and detection.

5.15 The normal routine of our visits to premises and the routine of supplier visits to collect meter readings will often expose cases of theft.

Which parts of the network produce the most losses?

5.16 The distribution of electricity at low voltage produces the most losses on our network. The local network supplying electricity to properties and the transformers which support it at 11,000 volts (11kV) account for around 50% of our total losses. The 33,000 volt network (33kV) which sits behind this accounts for another 44% of losses and the higher voltages (EHV) make up the remaining 6% of the total.

The benefits of reducing losses

Societal losses reduction benefits

5.17 Electricity losses for all elements of the electricity network; distribution, generation and transmission, are included in the settlement processes and form part of a customer's electricity bill. Distribution losses currently account for around 7% of an average domestic customer's bill. Therefore any initiatives that are taken to reduce losses will have a positive effect on these bills.

Cost benefit analysis (CBA)

5.18 We have undertaken cost benefit calculations for specific areas of our network. In section 5 we discuss the implementation of specific actions to help reduce losses and these are underpinned by CBA calculations. Our CBAs have been calculated using the Ofgem provided CBA value of losses of £48.42/MWh.

5.19 In general terms we have found that actions to reduce losses do not deliver favourable CBAs when considered in isolation. Actions taken in conjunction with other work tasks on the network do show a benefit. For example, whilst it is not beneficial to actively replace underground cables to reduce losses it can be beneficial to oversize them when they are replaced as a part of other works. To avoid stranded assets we have targeted these uprating actions in areas where there is a likelihood of early adoption of Low Carbon Technologies (LCTs).

5.20 The increasing impact of LCTs such as heat pumps and electric vehicles will affect our low voltage networks. These networks generally operate in a radial fashion and are sized to accommodate the load seen during normal running conditions. In this operational configuration the uprating of assets is beneficial and is unlikely to lead to stranded assets.

5.21 CBAs show this and have produced favourable outcomes for the following areas:

- Uprating existing low voltage underground cables in conjunction with other works
- Uprating existing 11kV/LV ground mounted distribution transformers in conjunction with other works

5.22 CBAs did not produce favourable outcomes for the uprating of pole mounted 11kV/LV transformers due to the relative replacement cost of these units.

5.23 When we consider the uprating of assets on the High voltage (HV) network (11KV and above) we do not see the same conditions of operation or LCT impact. The HV network cables are generally sized to accommodate the load seen during normal running conditions and also support adjacent networks in times of fault. The CBAs for the uprating of HV underground cables do not produce favourable outcomes.

5.24 33kV/11kV Transformers are generally sized and operated in pairs to provide the same level of fault support. With this configuration it is not possible to achieve the same level of benefits by replacing these transformers with uprated units. The CBAs for the uprating of these transformers do not produce favourable outcomes.

5.25 An extrapolation from the HV network can be made onto the EHV and higher voltage networks. In general terms these networks are sized for normal running and fault support and do not operate in a radial fashion. Whilst we have not completed specific CBAs, the costs also outweigh the benefits in following areas:

- Uprating of EHV transformers (33kV and above)
- Uprating of EHV cables (33kV and above)

Understanding losses

Analysis of the Impact of LCTs

5.26 We are working on a major study of network losses which builds on previous research. It will assess the impact of the changing power factor of LCTs on our losses. The outcomes of the project are likely to include the targeted replacement of some assets, the balancing of phases in areas where we see imbalance and the use of power electronics to improve power factor.

Modelling Power Flows and Losses

5.27 'Carbon Tracing' is a project that we are undertaking to model power flows and better understand the effect of different network configurations on losses. Variable losses will increase with the increased demand seen from LCTs and we are using the model to target where losses can be reduced. The Carbon Tracing project also researches the effect of customer engagement and behaviour on reducing losses.

Use of Monitoring and Automation

5.28 Where automation and monitoring is fitted to substations to accommodate the additional loads brought about by LCTs, these new data and control points can also be used to help target our plans for loss reduction.

Stakeholder input and review

Stakeholder engagement

5.29 Losses reduction activities will be reported annually as part of the WPD Stakeholder Report. This will set out improvements achieved in the year; actions planned for the following year and any longer term programmes.

Losses strategy review

5.30 Our losses strategy will be reviewed on an annual basis throughout the RIIO-ED1 period. We expect knowledge to be gained from the range of LCNF projects that will help us to better understand the profile of customers' load and the effect this has on peak demands and peak losses.

Present policy

Equipment selection

5.31 Distribution transformers are a major contributor to the overall level of losses on our network. When we tender for transformers we take into account the lifetime cost of the units. This cost includes the purchase price and the effect of losses during normal operation.

Design

5.32 Our design software takes account of losses when modelling network designs. The majority of losses on the network occur on the low voltage system, and our WinDebut LV design programme automatically designs with reference to losses.

Asset replacement

5.33 Our normal programme of asset replacement has an effect on losses. Changing older transformers for newer models will reduce overall losses as new transformers have lower losses than old ones.

5.34 Where overhead lines are replaced we aim, where possible, to replace small diameter aluminium conductors of smaller sizes first. The replacement conductors have a larger cross sectional area and therefore a lower level of variable losses.

Future changes

Ecodesign

5.35 We are aware that the EU is considering a regulation to implement Directive 2009/125/EC regarding the Ecodesign of electrical equipment and, if introduced, this would lead to an obligation for us to install more efficient transformers. The additional cost of these units is considerable and, at larger distribution substation level, can lead to a doubling of the cost of a transformer. We will continue to monitor changes to obligations, assess their impact on substation design and determine whether there is a cost benefit to adopt them early for loss reduction.

5.36 To comply with the Ecodesign directive manufacturers will have to find ways to reduce the level of losses inherent in their products. To reduce the variable losses in a transformer the resistance of the wires needs to be decreased, which can be done by increasing the cross sectional area of the wires or by using materials with a lower resistance. To reduce the fixed losses the efficiency of the magnetism needs to be improved, which can be done by using materials with better magnetic properties.

5.37 Improving both of these elements can often result in a transformer with a larger physical size. As many of the transformers that we use are installed as replacements for existing units it is not always feasible to make the sizes larger due to the size constraints of existing distribution substations and GRP housings. We have worked with manufacturers to develop more efficient transformers that retain the same footprint and dimensions as existing units.

Smart meter loads

5.38 The smart meter roll out will replace existing passive gas and electricity meters with more dynamic meters that will incorporate a communications device. This additional functionality, combined with domestic customer in-house displays, will increase the network load that is attributable to metering. It is likely that the load will increase by around 2W per customer. Taken across our customer base of 7.8 million customers this will increase the overall load by over 15MW.

Electrification of heating and transport

5.39 The Government Carbon Plan places more emphasis on using electricity to provide energy for heating and transportation. The effect of this is that our network will see a higher utilisation and, as a result, higher levels of losses. The electrical loads due to heat pumps and electric vehicles have the potential to be time managed. We may be able to schedule this demand to help with the control of the total load on our networks and therefore will have the effect of filling in gaps in our load profiles. However such technology will also increase the utilisation of our network and therefore increase losses.

Distributed generation (DG)

5.40 Traditional centralised generation sources are mostly connected to the National Grid network. This requires energy to be transported through both the transmission and distribution networks.

5.41 Distributed Generation sources are often connected directly to distributions networks. Whilst this eliminates transmission losses it can lead to higher losses on the distribution network. This occurs when the generation exceeds local demands and there is a need to move the energy across the distribution network.

5.42 Distributed Generation can create the opportunity to use the generation characteristics to manage losses through load balancing and power factor correction.

Our plans for losses reduction in RIIO-ED1

Improved understanding of losses

5.43 Most of the work undertaken on losses to date has been to better understand network losses rather than the practical options for reducing losses. During the RIIO-ED1 period we will reach a stage where we can apply this knowledge to ways that we can actively reduce losses. In order to see the effect of reducing losses we need to be able to set a baseline of current losses. We plan to do this by using the established highly monitored network in South Wales which supported the Low Carbon Network Fund (LCNF) LV Templates project.

5.44 The LV Templates project provides us with a monitored network covering a wide area of South Wales. It can measure the power supplied into this network at HV and also measure the power delivered from the LV substations. The losses in this section of network will be due to technical losses, as inaccuracies caused by illegal abstraction or meter data issues generally occur at LV. We will investigate ways of extrapolating this data to provide reliable loss baselines for different network types.

Transformer sizes

5.45 The variable losses in a transformer are much lower when the unit is partially loaded and increase greatly as a unit becomes fully loaded. It is therefore possible to reduce the overall losses by oversizing transformers when they are installed. Whilst it is not appropriate to do this in all cases, as not all transformers will become significantly loaded, there is a case for oversizing transformers in a targeted way.

5.46 Using data from the Centre for Sustainable Energy (CSE) we can forecast that there will be approximately 7% of our network where the up-take of LCTs would most likely occur and the investment in oversized transformers can be justified. We would aim to oversize on average 109 transformers per annum at a cost of around £0.11m per annum.

5.47 Older designs of ground mounted transformers have much higher losses than new designs. Whilst it is not efficient to replace transformers early simply to reduce losses, we do ensure that these older transformers are not refurbished for re-use when retired from the system.

5.48 Pole mounted transformers are relatively small size and there is little justification in replacing them to reduce losses.

5.49 We will install larger size transformers on targeted networks in the RIIO-ED1 period. At an additional cost of approximately £0.11m per year.

Cable sizes

5.50 To reduce the variable losses in a cable the cross sectional area of the conductor needs to be increased. Once a cable is laid and the ground is reinstated, it becomes expensive to make alterations to the cable. Our opportunity to reduce losses exists at the time that the cable is initially installed. The resistance of a 185mm^2 LV cable is around half that of its 95mm^2 equivalent. The additional cost of the cable is less than £10 per metre which is a marginal cost when compared to the excavation costs that can be between £50 and £100 per metre.

5.51 Whilst this cost is marginal, it is not appropriate to oversize cables in all cases. Using CSE data we would aim to uprate around 75km of network each year.

5.52 We will install the next size up for all our cable designs on targeted networks in the RIIO-ED1 period. This will add around £0.31m per year at current costs.

Network design

5.53 We have completed research into losses with Imperial College and SOHN Associates. The “Management of Losses on a Distribution Network” project will shortly be finalised. The early indications are that we can address losses on new developments by reducing the number of customers per substation and also by increasing the size of the service cables.

5.54 This will increase the total fixed losses by adding more transformers to the network, but this increase is outweighed by the reduction in copper losses achieved with the reduced loads per transformer.

Asset replacement

5.55 The majority of our network is already established and there is no cost benefit in replacing it wholesale purely as a method of reducing losses. When we add new assets to the network or replace existing ones we do have an opportunity to consider the effect of losses and take them into account. Using the Ofgem provided CBA value of losses of £48.42/MWh it is not possible to justify a blanket investment in larger assets to reduce losses alone, but when considered in areas where network demands are expected to increase the proposal has more merit. We have used research from the CSE to show us areas of our network that are highly likely to see an increase in demand as a result of LCTs.

Demand side management (DSM)

5.56 Due to the logarithmic nature of variable losses, assets working at their maximum capacity will lead to significantly more losses than those with a reduced loading. The scale of variable losses can therefore be reduced by simply reducing the demand on the network or by reconfiguring networks to transfer loads from highly loaded circuits to lower loaded circuits.

5.57 In our Lincolnshire Low Carbon Hub, FALCON and FlexDGrid LCNF projects we are demonstrating methods to monitor and automatically reconfigure networks. Where these networks can be meshed (operated in parallel) and loads transferred it will be possible to reduce the overall losses. We will identify areas of our network where the techniques can be replicated.

Imbalance and power factor

5.58 We are developing a project with a solar generation customer that will investigate the feasibility of addressing imbalance and power factor issues on the 33kV network. The project will use the customer’s inverter equipment to alter the phase angle of the generated power. It will also use local storage to set the generated power per phase to reduce overall network imbalance. The storage can also be used to manage the overall utilisation of the network.

5.59 The Solar Storage project, which will shortly be registered under LCNF Tier1, will establish how a DNO can interact with a generator to improve overall network losses.

Theft in conveyance

5.60 Theft of electricity from our network adds to the level of recorded losses, but is difficult to detect exactly where it is occurring.

5.61 We are currently working with partners on an IFI project to establish if it is possible to fit monitoring equipment at a substation which can detect the presence of heat lamps used for the cultivation of drugs such as cannabis. The detectors look for the specific electrical harmonic signature created by the heat lamps. If this project is successful we will use it to assist with detection and share the findings with other DNOs.

5.62 The majority of methods available to detect theft in conveyance relied on visits to the premises to establish the theft. It has not been easy to complete a desktop office based survey of our network to establish which properties were connected to the network and had a registered electricity supplier and those which were not.

5.63 We plan to use the "addresspoint" standard which is provided by Ordnance Survey that applies a unique property reference number to all properties on the mapping background. Our records hold a reference for all known connections which include grid reference details. Comparison of these two systems will produce a list of premises which do not have an electricity supply registered to them. By starting from the assumption that most premises in the UK have an electricity supply, we can use this list to establish a subset of premises without a registered supply and which would require a physical inspection. This desktop analysis will make the targeting of potential theft a much more efficient system.

Options for losses reduction beyond RIIO-ED1

Superconductors

5.64 The variable losses in a network are directly related to the resistance of the current carrying conductors. A superconductor has a very low resistance which significantly reduces the losses generated. Most superconductor technology, which is available at present, relies on processes which cool the conductors as a method of reducing their resistance. There are no practical solutions available which can cool conductors in a low voltage distribution setting, but we will continue to monitor developments in this area.

Energy storage

5.65 Our LCNF project, BRISTOL, is showing the benefits of energy storage at a customer's premises. The project was designed to show the benefits of reducing the effect of local distributed generation on the LV network by managing the peaks of generation it creates. A secondary benefit of the energy being stored at the premises is that there are no losses created through the further use of the LV network.

Active network management for losses

5.66 One way to reduce the fixed losses on the network is to switch assets off. An asset on "hot standby" (energised but not actually supplying electricity) will continue to produce fixed losses. Disconnecting duplicate or reserve assets will reduce losses but will also affect supply security and therefore has to be carefully considered before being adopted.

5.67 Developments in network management systems beyond RIIO-ED1, and the increased level of monitoring and control will provide a platform for the reconfiguration of networks to reduce losses without the current concerns over supply security

6 Climate change adaptation

6.1 The Government's Carbon Plan has been developed to reduce greenhouse gas emissions which are believed to contribute to climate change. This proposes the electrification of heating and transport and the move to more distributed electricity generation.

6.2 The growth of these low carbon technologies poses a challenge for the electricity networks to accommodate them without significantly increasing costs to customers. To enable DNOs to develop and trial lower cost solutions Ofgem introduced the Low Carbon Network Fund to stimulate innovation.

6.3 In addition to the innovation being carried out by WPD and other DNOs to develop networks of the future, there is a requirement to ensure that the assets we use are suitable for the conditions that will arise due to climate change. The following sections describe the work WPD has done for climate change adaptation (CCA).

Risk assessment and reporting to DEFRA

6.4 In response to the Department for the Environment, Food and Rural Affairs (DEFRA) direction to report under the Climate Change Act 2008 WPD submitted the 'WPD Climate Change Adaptation' (CCA) report which contains details of WPD's risk management process and describes how this process identifies, assesses and manages the implementation of control measures for climate change adaptation.

6.5 Many risk and mitigation areas are common across the whole electricity industry and we reference the ENA Engineering Report 1 (ERep1) – May 2011, which identifies climate change impacts on electricity distribution and transmission network operators. The ENA report also proposes mechanisms for monitoring and actions to respond to these probable climate change impacts. Our CCA report describes our analysis of the risks associated with future climate change impacts and how we have used available projected climate data to assess these risks. It details how our risk management system leads to control measures being developed and implemented.

6.6 We are supporting research and development project work to gain a better understanding of the impact of climate change on our assets.

6.7 Our strategy for CCA is reviewed annually to take into account any changes and new climate risks. For example, as there has been an increased incidence of surface water flooding we are now working with the ENA and the Environment Agency to assess the risks posed by pluvial flooding.

Extreme weather events

6.8 We have used data from the UK Meteorological Office to assess the impact of severe weather events on our network. Lightning activity is predicted to increase across the WPD area. By the end of the RIIO-ED1 period we expect activity to increase by up to 11% in the South West and East Midland areas.

6.9 Lightning strikes can damage equipment, but the effects can be mitigated by adding lightning protection devices to the network. Arc gaps allow the lightning energy to bypass the equipment and surge arresters allow the lightning energy to be transferred to earth via a device that changes its resistance in response to high voltages.

6.10 We will continue to fit lightning protection to cable terminations and pole mounted automatic switchgear across the whole of our area. We will also fit protection to pole mounted 11kV transformers, using surge arresters in the East Midlands and West Midlands and arc gaps in the South West and South Wales. With the increased reliability of surge arrestors, we are assessing the benefit of also adding surge arresters in the South West and South Wales.

Temperature increase impact on overhead lines

6.11 Predicted increases in ambient temperature will mean that additional thermal expansion of conductors will affect the overhead line clearances and that thermal loading limits will be reached more quickly.

6.12 In response we have introduced new overhead design requirements to increase ground clearance and have prepared new conductor ratings for our overhead lines. Our lines are now designed to a minimum rated temperature of 55C to take account of the effects of increases in ambient temperature.

6.13 The effect of this change means that, as a rough average, the height of every other pole used on a new line is increased by 0.5m. This is a good example of a situation where a climate change mitigation measure has translated into a simple change to design which has a very small incremental cost effect on our network.

Flooding

6.14 Using data provided by the Environment Agency we have developed site specific flood risk assessments for our sites. The risk assessments calculate the risks posed by Fluvial or Coastal flooding on our assets.

6.15 Depending on the flood risk assessment, mitigation measures have included the installation of pumping systems, protection of individual items of plant, protection of buildings or protection of the site as a whole.

6.16 Whilst most of our outdoor equipment can continue to operate when affected by flood water, problems arise when the water reaches a level where it threatens to affect wiring and terminations in cubicles which are not waterproof. In many cases the simplest mitigation is to move these cubicles to a higher level above the predicted flood depths.

6.17 Indoor equipment can also be affected and the mitigation here will normally include a system of bunding or protection of the building to prevent water ingress or to allow the water level inside to be maintained at a low level.

6.18 Our flood risk assessments include a site survey with an overlaid flood depth prediction so that we can identify the items at risk and the most prudent steps to take. By taking this approach it is very rare for us to have to protect a whole site or consider relocation.

6.19 This work will continue through RIIO-ED1 and we are now working with the Environment Agency to gain a better understanding of surface water flooding.