Project Code/Version No

Low Carbon Networks Fund
Full Submission Pro-forma

Section 1: Project Summary

1.1 Project title

BRISTOL (Buildings, Renewables and Integrated Storage, with Tariffs to Overcome network Limitations)

1.2 The Lead DNO

Western Power Distribution (South West)

1.3 Project Summary

The UK's transition to a low carbon economy will require significant changes to the way we supply and use energy. Electrification of transportation and heating, combined with dense deployments of photo-voltaic panels, will give rise to additional constraints on electricity networks, particularly at low voltage (LV). These constraints cannot be ignored, and will ultimately adversely affect the customer and their own low carbon aspirations. To address this, networks can be strengthened using conventional reinforcement or by developing novel approaches.

The BRISTOL project is an innovative combination of energy storage in customer's premises, coupled with new variable tariffs and integrated network control to overcome generation or load related constraints at key times of the day. It will explore the use of direct current (DC) power in customer premises in conjunction with battery storage shared virtually between the DNO and customer, providing benefits to both parties. Through batteries, the LV network will be operated more actively with additional capacity to manage peak load, control voltage rise and reduce system harmonics. The techniques trialled will, through reduction in constraints and need for network reinforcement, facilitate the connection of low carbon devices at reduced cost at over 40 locations in a range of premise types including homes, schools and a business.

1.4 Funding

Second Tier Funding request (£k)	£2,204

DNO extra contribution (k)	£0	**External Funding (£k)**	£280

1.5 List of Project Partners, External Funders and Project Supporters

Partners: Siemens, University of Bath (with RWE npower) and Bristol City Council.

Project Supporters: Moixa Energy

1.6 Timescale

Project Start Date	1st December 2011	**Project End Date**	15th January 2015

1.7 Project Manager contact details

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Section 2: Project Description

2.1 Aims and objectives

The UK Low Carbon Transition Plan sets out a national strategy for climate and energy, alongside challenging environmental targets. Currently published pathways (e.g. DECC 2050) predict increasing amounts renewable generation, with the electrification of heating and transportation. Whilst there is some uncertainty as to the timing of large-scale deployment of Low Carbon Technologies (LCTs), it is clear that this transition will accelerate in the run up to 2020.

The Problem

Technical constraints occurring on the Low Voltage (LV) distribution network will intensify as the UK adoption of new LCTs accelerates. There are a number of projects currently evaluating the impact on LV local grids, but less work investigating the role customers, homes and businesses can play in alleviating network constraints.

Integrating LCTs into new houses as they are built is relatively easy; however two thirds of the 2050 housing stock has already been built today. The UK faces the challenge of incorporating microgeneration, heat pumps and electric vehicles into all types of existing housing stock and the UK Distribution Network Operators (DNOs) must incorporate LCTs into the existing distribution network in the most cost effective manner.

Many of these emerging technologies along with existing consumer electronics operate using Direct Current (DC) through an AC/DC power adaptor. Generators and increasing numbers of appliances that use DC have a detrimental effect on the network power quality, adversely influencing the power factor and increasing voltage distortions. Homes and businesses have multiple items of equipment that require DC power. The AC/DC power converters used can be very inefficient generating excess heat, and are a contributing factor to consumer energy inefficiency.

An unintended consequence of promoting LCTs is the additional strain that they place on the LV distribution network. Electric vehicles and heat pumps will draw large volumes of power, and create significant potential increases in peak demand. Microgeneration installations can create two way power flows and change the voltage profiles along cables. If left unmanaged, these additional effects on the network can begin to affect the overall quality of supply for customers and in some circumstances lead to network restrictions, constraining customer activity until the network is reinforced. There is a risk that this potential inability of networks to fully accommodate new LCTs could impede the transition to a lower carbon economy and hinder the attainment of government targets.

Enhancement of the LV network will increasingly be required to maintain a secure, efficient distribution network. Conventional reinforcement (such as laying larger cables and installing greater capacity substations) will allow greater penetration of LCTs, although such schemes can take significant amount of time to plan and construct. Alternatively emerging smart grid solutions may offer a quicker and more cost effective response in addressing network constraints.

Western Power Distribution (WPD) does not under present arrangements utilise smarter grid solutions such as flexible demand to reduce peaks or to accommodate a rapid take up of generation on the LV network. This is due to a lack of deployed suitable technology, unproven operating procedures and unknown costs.

The Methods

The BRISTOL project seeks to address the Problem by developing the following three methodologies.

- **Battery Storage with Demand Response** will be installed in customers' premises, and shared virtually between WPD and the customer to limit the need to reinforce the network. It will be used through a LV Connection Manager device to reduce the impact of LCTs on the distribution network and improve the operation of the system.
- **Direct Current Networks** will be retrofitted into selected homes, schools and offices to connect PV panels and DC appliances together. These DC networks will then be integrated via their LV Connection Manager devices with the LV local grid through LV Network Manager device sited at distribution substations.
- **A number of Variable Tariffs** will be trialled using the domestic element to incentivise customers to alter their demand profile, flattening their demand, reducing their peaks using the automated LV Connection Manager, battery storage, micro generation or lifestyle changes or a mixture of the four.

2: Project Description cont.

The coordination of these methods will be controlled through two Siemens devices, the **LV Network Manager,** located at distribution substations, and the **LV Connection Manager** located at customers' premises.

Further technical details associated with these methodologies and devices will be outlined more fully in section 2.2 and Appendix C.

A number of Trials
Bristol City Council has already secured funding for energy efficiency measures which provide an opportunity to test the methods in a real operational scenario. Photo Voltaic (PV) panels will be connected to homes, schools and an office through several projects including a European Regional Development Fund scheme, Solar PV for Bristol Schools Project and through a grant from the Energy Management Unit. WPD will work with Bristol City Council to develop a highly innovative solution to integrate this generation into the distribution network.

The BRISTOL project is proposed to operate for 18 months and will trial the methods at 30 domestic properties, upto ~~10~~ 5 schools and an office as follows.

Domestic

- 30 homes from Bristol City Council social housing stock, all located in one area of Bristol. Homes will be modified to include:
  - o Up to 4.8kWh battery storage
  - o 2kWe PV panels connected to the DC Network (funded by Bristol City Council out of an European Regional Development Fund)
  - o Lighting converted to operate using the DC network
  - o Computing converted to operate from the DC network
  - o ~~Central Heating Pump and controller converted to operate using Direct Current~~
  - o Smart appliances controlled through the LV Connection Manager
  - o Variable Tariffs

Schools

- ~~10~~ upto 5 schools all connected at Low Voltage with PV panels connected. Schools will have an ICT suite converted to include:
  - o 19.2kWh battery storage
  - o ~~PV panels connected to the DC Network 3.6kWe – 10kWe (funded through Solar PV for Bristol Schools Project with a value of £1m)~~
  - o Up to 40kWe connected to the AC network (funded through Solar PV for Bristol Schools Project)
  - o Lighting converted to operate using the DC network
  - o Computing converted to operate from the DC network
  - o Three phase balancing

Office

- A section of an Office with PV panels connected will be modifies to include:
  - o 19.2kWh battery storage
  - o ~~PV panels connected to the DC Network 10kWe (funded through EMU's renewable energy funds)~~
  - o Lighting converted to operate using the DC network
  - o Computing converted to operate from the DC network
  - o Three phase balancing
  - o Supplemented by a feasibility study on a large office or IT centre using the learning generated by the BRISTOL project.

The above three demonstrations and feasibility assessment on homes, schools and office, are based on the same technical methods, to produce learning in different environments.

2: Project Description cont.

2.2 Technical description of Project

Through BRISTOL, we will investigate the concept of DC premises with Photo-voltaic generation and other LCTs. They will be connected to the local grid and managed through LV Connection Managers and LV Network Managers, intelligent devices, situated in the home and local substation as an alternative to conventional network reinforcement. **A comprehensive technical document has been included in Appendix C written by our project partner, Siemens. This provides greater technical detail of the methods being deployed and how the trial components fit together.**

The **LV Connection Manager** is an in home energy management system device performing many functions including monitoring the network voltage profile and battery storage with demand response. They will be coordinated by the LV Network Manager to maintain network voltage profiles and reduce network peaks locally while taking into account variable tariffs. The LV Connection Manager will integrate the capabilities of the PV, battery storage and the electrical demand to minimise the financial cost of energy used, minimise the carbon impact of energy used, actively manage the real power profile to support the distribution network (demand response), and provide reactive power support to the network. The LV Connection Manager will:

1. Forecast electricity demands of the home for the next day, including any LCT demands.
2. Estimate any microgeneration output for different periods of the day, storing excess energy at periods of low demand in the customer's section of the battery.
3. Move flexible demand (Smart Appliances) to periods of microgeneration output.
4. Calculate if customers require any additional battery charging using off peak or lower carbon intensive generation.

The **LV Network Manager** is a device that will be situated at distribution substations and will identify limitations on LV feeders by monitoring system parameters including power flows, voltage and power quality. They will identify constraint conditions within the LV network and attempt to resolve them by calling on the capabilities of customers connected to the LV network, managed by LV Connection Managers. Key functions include:

1. Determine if the DNO needs to charge the DNO section of the battery to reduce the voltage rise created by solar PV during periods of low demand. Use the battery storage to meet the conditions of the Distribution Licence, discharging during peak periods to reduce network losses.
2. Determine if the DNO needs to discharge their section of the battery storage to reduce network peaks.
3. Continually monitor the LV network to ensure it meets the voltage and load conditions of the Distribution Licence.

Battery Storage will be installed at trial sites with a virtual split capacity earmarked for customer and network operation use. Customers will use battery storage as a buffer to make better use of PV generation, only selling energy they do not need. This will minimise importing energy from the grid at peak times, reducing their energy bills.

WPD will also utilise specific capacity in the batteries to aid network management. This will include coordinating multiple units along a network feeder to help manage local grid constraints.

Battery storage will be used to:

- Influence network power flows using the battery storage and demand response
- Influence network voltage profiles using the battery storage and demand response, as well as using reactive compensation from the inverter
- Operate a trial with a fixed percentage of the battery for Customers and DNOs
- Operate a trial with a variable percentage of the battery for Customers and DNOs based on the effects of seasonal variations on distribution network assets.
    - Soak up excess PV generation during periods of low demand or voltage stress
    - Transferring demand to different periods of the day by discharge during peak times

2: Project Description cont.

- Provide demand response capability by retrofitting selected appliances.

- Flatten the After Diversity Maximum Demand (ADMD) profile for the properties connected to the network, reducing the network peaks.

There is a scenario where if the battery storage is fully-charged, the PV output may have to be reduced; however this is very unlikely with the BRISTOL solution.

Batteries will allow excess generation to be stored in batteries instead of exporting power into the network. Forecasting and appropriate sizing will reduce the risk of the batteries being fully charged at times when PV couldn't be exported to the network.

If this scenario did occur, the equipment would behave in the same way as conventional PV installations, charge controllers to prevent PV from damaging the battery and the inverter will prevent power from being exported if the voltage is at statutory limits; this is an existing technology.

Customers will not be disadvantages by having the BRISTOL solution installed.

The Variable Tariffs trialled will be aligned to the wholesale market price of energy, with an aim to incentivise customers to reduce consumption when the price of energy is high and increase consumption when prices fall (e.g. when the UK has a significant level of wind generation).
In particular, the effect of automation and home storage on customer flexibility and responsiveness will be investigated, to allow more sophisticated and cost-reflective tariffs to be exercised whilst not confusing customers or compromising their lifestyle.

The roll out of smart metering, discussed in section 4(f) Relevance and Timing, could lead to new tariffs being developed including variable tariffs rewarding customers for flattening their ADMD profile. These tariff changes could alter customers behaviour and either reduce or increase the strain on the distribution network. BRISTOL will provide an insight into how battery storage with variable tariffs could be designed and used if customers change their behaviours.

During the trial all customers will still retain their existing energy tariff which will be levied by their existing retailer throughout the trial. A number of variable tariffs will be developed as part of the project that will be aligned to the wholesale costs of energy; domestic customers could reduce their energy bill through reducing their energy consumptions during peak energy periods by transferring demand to other periods of the day. Domestic customers who reduce their energy consumption during peak energy price periods will receive a payment, reducing their energy bills. Any changes in behaviour will be recorded through the LV connection manager and a payment to users will be made to compensate the difference between their actual energy bill paid by the domestic user to energy retailers and their bill had the variable tariff been implemented.

Variable DUoS rates have been considered during the development of BRISTOL however we are not proposing to alter the DUoS revenue from customers.

It is our aiming to replicate a tariff that may be implemented when smart meters are installed; variable tariffs may increase the business case for domestic storage and alter customers ADMD, altering the impact of customers and Low Carbon Technologies on the distribution network.

DC Connections & Networks: An increasing amount of DC connections are being made to the distribution network. A DC network will be retrofitted into homes, offices and an office using the existing AC lighting circuits and allowed to operate with a floating DC voltage. Batteries and micro generation will be connected directly to the DC network.

The DC Networks will:
- Use the existing wiring in selected Homes, Schools and Office facilities,
- Connect equipment designed to operate using Direct Current to the network through DC sockets
- Transfer selected traditional AC appliances which are significantly more efficient and improve power quality if operated using Direct Current, e.g. lighting, computing and heating controllers.

2: Project Description cont.

- Remove redundant small, inefficient, noisy AC/DC converters
- Incorporate intermittent PV generation directly into the DC network.

New Network Applications: Utilising these Methods, enhanced network applications can be developed including Resilience of Service for customers and Improved Power Quality.

Resilience of Service of the DC network during power outages. During AC network outages customers are unable to operate any of their DC electrical equipment, heat their homes, even if they have gas boilers, use their digital telephones or use their micro generation. The DC network will maintain lighting, computing, telecommunications and potentially heating. Vulnerable customers could benefit through a wider range of devices, e.g. dialysis, stair lifts, alarms etc.

The project will provide vital learning about battery buffer storage located on the distribution feeder. The project will also generate new learning about DNOs sharing assets with customers. A more technical aspect in BRISTOL is to correct the network's power factor when importing and exporting power through a four quadrant inverter. The reactive components of the power flows through the inverter will be used to improve the voltage profile. Through three phase balancing it may be possible to reduce network imbalance and increase the network capacity.

During the trial, the DC network will connected to the customers' consumer unit via a four quadrant inverter on the customer's side of the cut out. The batteries will be funded by the DNO through the LCNF. The learning from this project will demonstrate how a customer's DC network could be integrated into the active management of the Distribution network beyond the customer's cut out using batteries which could be joint funded by customers and DNOs.

The Power Quality supplied through the distribution network must be maintained, within the levels outlined in the European power quality standard EN 50160, so as not to damage customers or network equipment through distortions. Connecting high levels of poorly performing equipment, such as AC/DC converters, to a distribution network could breach licence conditions if not filtered.

2.3 Description of design of trials

Many local councils across the UK are currently developing large scale PV Panel installations programmes. However assessing the network impact and reinforcement requirements of such deployments by DNOs requires detailed network analysis on a circuit by circuit basis.

This project has been designed to attain learning relating to such schemes and develop solutions that can be directly replicable throughout many UK Locations. Bristol is an ideal location for this trial for a number of key reasons. The housing occupant compositions are roughly inline with national averages based on Communities and Local Government 2008-based household projections. There is a large base of socially rented and council owned houses that are typical of other common UK property construction types.

To ensure the right location is chosen, we will be working with Bristol City Council to indentify a representative area with typical 3 bedroom semi-detached housing. The selected area will also require a dense rollout of PV panels to ensure maximum opportunity to acquire learning. The trial will last for 18 months to ensure at least one winter and summer period with an additional six month overlap to aide verification of findings. This is also seen as a suitable period to learn how effective the technical solutions are and quantify any behavioural changes. Initial power analysis shows that thirty households will provide sufficient information for aggregate changes in behaviour to be reliably measured.

Why BRISTOL will produce reliable data
As well as the statistical considerations of this study, we need also to ensure that meaningful data is gathered. To achieve this a combination on quantitative and qualitative measures are proposed.

For example, for assessing behaviour (e.g., energy consumption), we will utilise direct measurements through the LV Connection Manager. This is in contrast with relying on customers to self report results, thereby reducing possible biases from social desirability.

2: Project Description cont.

Network data generated from the LV Connection Manager and LV Network Manager will be recorded and stored in a data archiving PC located in a distribution substation. The raw data will be analysed to generate the DNO network learning.

Less tangible data such as attitudes, which cannot be measured physically, will be studied using existing, validated scales. Where more subjective measures are inevitable, reliability and validity will be explicitly considered and measured. Our approach thereby seeks to obtain high-quality - often numerical - data which minimise the likelihood of measurement error.

We also consider it important to supplement this quantitative work with more open, qualitative work to provide more in-depth understanding of the participants' experiences and feelings about energy use and the LV technologies being employed. As such, interviews and focus groups will form part of the project. In order that the data arising from these are explored carefully, we will seek to use appropriate existing analysis methodologies.

Further information regarding our approach is detailed in Section 5, Knowledge Dissemination.

2.4 Changes since Initial Screening Process (ISP)
Western Power Distribution has continued to develop BRISTOL since the initial screening submission with our project partners and project supporters. There have been no substantial changes since the screening submission; other changes are outlined below.

Following the publication of the Initial Screening submission by Ofgem, we have been contacted by Moixa Technology, a R&D company working on the development of Smart DC Energy, and have a solution to shift DC electronics and lighting off grid and off peak. Western Power Distribution, Siemens and Moixa believe that the Moixa smart DC power hub can be incorporated into the LV Connection Manager for the domestic properties trial.

Project Partner

- Siemens
- University of Bath (working with RWE npower as a supplier)
- Bristol City Council

WPD has started to work with:

- Moixa Energy

The Bristol Project requires an investment of £2.20m from the LCNF, the total project costs are £2.78m.

2: Project Description cont.

2: Project Description cont.

2: Project Description Images, Charts and tables.

Project Description images

Project Description images

Section 3: Project Business Case

Background
The Low Voltage distribution network is designed to operate passively. We use an After Diversity Maximum Demand (ADMD) of connected customers to design the network to operate within statutory limits and technical capabilities regardless of time of day or season.

The traditional network designs and operating practices have to date been an efficient method to supply customers. However in the future with much higher distribution peaks and customers exporting generation into the network, it may no longer be the most efficient way to design and operate more complex networks. Innovation may provide improved methods.

The joint Energy Networks Association and Imperial College summary report "Benefits of Advanced Smart Metering for Demand Response based Control of Distribution Networks -version 2.0", April 2010 predicts the reinforcement of GB distribution networks with a like for like replacement strategy using conventional reinforcement will be significantly higher then using smarter network reinforcement techniques. The report highlighted the greatest potential impact of smart appliances is at HV/LV substations and on the LV feeder. With a 50% penetration of electric vehicles and heat pumps by 2030 the predicted the scale of the LV reinforcement will be £21.8bn, compared to £9.3bn using smart grid techniques.

It is therefore appropriate to look at improving voltage profiles, reducing peaks and improving the power quality of the LV network using innovative techniques that allow the connection of significantly more microgeneration and other LCTs to the distribution network without the need for conventional reinforcement.

Design Principles: Networks are designed with three main goals:

> **Voltage profiles:** The LV network's voltage must be maintained. Customers' demand can vary enormously over the day and across the seasons which can cause the voltage to fluctuate. In the future with LCTs voltage management will be even more of a challenge. For example, a distribution network with Low Carbon Technologies connected must operate during a summer's day with very little load and PV panels exporting into the network causing the network voltage to rise. The same network must operate during the winter months with no PV and large loads (e.g. heat pumps) increasing the demand on the network, reducing the network voltage.
>
> **Thermal Limits:** The existing LV network is designed to be big enough to supply the largest peak in demand. If the connection of LCTs increases, and the network is not reinforced, the thermal limits of distribution network could be exceeded. In the extreme, this could result in irreversible damage to the network, disconnecting customers until it is replaced.
>
> **Power Quality:** The quality of power supplied through the distribution network must be maintained so as not damage customers or network equipment. DNOs use advanced engineering modelling to ensure the 50Hz AC waveform is "clean", free from excess distortions and harmonics. Connecting high levels of poorly designed customer equipment, such as AC/DC converters, to a distribution network could cause the waveform to be corrupted, breaching statutory limits.

The proposed BRISTOL projects through the DC network and buffer battery will reduce the impact of LCTs on the voltage profile, reduce the thermal peaks by transferring demand to off peak periods and replace small poorly designed customer AC/DC converters with one efficient AC/DC converter. It is proposed that this will be a much quicker and cheaper solution than conventional reinforcement.

Customer LV Connections
Currently published pathways (e.g. DECC 2050) predict increasing amounts of energy coming from renewable sources, as well as a transition of heating and transport electricity. There is significant uncertainty around the timing of this Low Carbon Transition. However, it is evident that the low voltage (LV) distribution network will be affected by these changes and schemes like the new Feed-in-Tariff are already having an impact.

3: Project Business Case contd.

Small microgeneration is connected to the distribution network under the requirements of Engineering Recommendation G83. Single connections are made under stage 1; informing DNOs upto 30 days after the connection is made. Larger and multiple connections are made under stage 2; DNOs must model the effects to determine if any network reinforcement is required before the generation is connected.

When multiple stage 1 or stage 2 G83 connections are proposed at a particular location, they can trigger network reinforcement, the cost of which is funded by both the developer and the DNO.

- Developers are liable for shallow upfront connection costs which are apportioned relating to the percentage of the increased network capacity being used for their development.
- DNOs fund the rest of network reinforcement.

Stage 1 G83 connections, where reinforcement is triggered, requires the DNO to carry out and fund the network reinforcement.

The BRISTOL solution will help customers connect LCTs quicker and at a lower cost. It will also provide a quicker and cheaper solution to help DNOs connect G83 stage 1 generators.

Alternative to BRISTOL Solution
We have a considerable number of alternatives, however not all are feasible:

1. Do nothing; this is not an option, as the networks would exceed statutory limits, damaging network assets and reduce quality of supply to customers.
2. Conventional Network reinforcement - install bigger cables and change transformers; may not be the quickest or most cost efficient method.
3. Limit / delay the number of LC technologies connected to the network until assets are replaced for condition related reasons. Again, this is not possible as DNOs have an obligation to connect new technologies (providing various technical conditions are met) and new low carbon technologies are required to help the UK meet the Low Carbon Transition Plan.
4. Use a different innovative solution; these will be trialled using the LCNF in our Future Networks Programme.

Western Power Distribution has a portfolio of projects in a strategic Future Networks Programme. These, together with knowledge gained through other projects under Ofgem's LCNF and IFI schemes are designed to help our industry prepare, as the UK makes a transition to a lower carbon economy. We have a desire to be able to offer customers innovative options as well as the conventional option for a range of network scenarios. WPD believe BRISTOL could be a viable solution and should be tested.

Project Benefits
BRISTOL will have a broad range of benefits including Financial, Customer, Learning, Asset Management, Environmental and other benefits that could be demonstrated through a LCNF trial.

Financial benefits
The network reinforcement costs for conventional reinforcement are well known. However the amount of network reinforcement needed for an installation of micro generation or other LCTs varies substantially depending on the location. Networks have a finite capacity to connect LCTs. The learning from the Tier 2 project LV network templates will provide a much clearer idea to the capacity of LV networks. We have examples of micro generation triggering network reinforcement, however the number have been historically low. The increasing connection of microgeneration will increase the number of locations requiring network reinforcement.

A recent example where network reinforcement has been triggered by LCTs has resulted in a quotes of £67,000 for the connection of 27kW PV over three phases.

The cost for a BRISTOL connection for this example, after the proof of concept, is expected to be in the region of £18,100.

A system would include a LV Network manager, £2,400, LV connection manager and batteries £15,700.

3: Project Business Case contd.

Customer benefits

We have identified 4 areas where customers could benefit from the proposed solution.

- **Keeping the lights on:** Through the installation of the BRISTOL system, the batteries will be used to provide enhanced resilience during power outages. Lighting, computing, telecommunications and potentially central heating pumps will be available from the battery storage even during network power outages.
- **Lower energy bills** through a better control of energy; a Variable Tariff rewarding customers for reducing their peak energy demand, passing on the cost savings. Clearer, more transparent energy bills through the LV connection manager using energy efficiency, better use of PV
- **Improved energy efficiency:** Supplying DC equipment using a high quality AC/DC converter and PV panels powering the DC network instead of a large number of inefficient AC/DC converters will reduce electricity losses.
- **Quicker and cheaper connections:** Conventional network reinforcement can not only be costly, but also require significant scheduling; the BRISTOL solution is one that could be implemented much faster and cost effectively.

Distribution Network Operator benefits

There are nine areas where DNOs could benefit from learning as a result of the BRISTOL project.

- The project will develop a tool that could rapidly be deployed by DNOs to reduce network hotspots created by the connection LCTs.
- The project will test the benefits of storage located at customer premises, rather then at substations, providing the additional LV feeder load and voltage control support.
- By oversizing the battery in the customers' premises, the project will explore the business case for DNOs operating a virtual partition of distributed storage.
- BRISTOL will test how batteries can be used with demand response by customers to take advantages of variable retail tariffs. From this DNOs will gain an insight into the residual impact of LCTs on the distribution networks.
- The project will provide insight into how customers perceive innovative solutions such as the BRISTOL solution.
- BRISTOL will create an intelligent self managing network linking together the substation with multiple properties with battery storage and demand response to reduce voltage rise and reduced peak demand.
- This project will use intermittent generation and battery storage when making network planning assumptions for the connection of other customers.
- BRISTOL will explore lower harmonic distortions on the network voltage by solving the problem, reducing power quality issues
- The Project will provide better use of the existing distribution assets.

Environmental benefits

There are six environmental benefits through the integration of BRISTOL into properties as they install LCTs in areas with network constraints.

- BRISTOL will increase the ability of the existing distribution network, to accommodate LCTs that can be connected to the network without conventional reinforcement. Through the integration of LCTs the UK will be better set to meet its low carbon targets.
- This project will store renewable generation and off peak lower carbon grid electricity locally for use when customers' demands increase. This will reduce the reliance on the centralised national grid connected generation at peak times.
- Avoiding conventional network reinforcement will prevent the excavation of roads and footpaths, and the installation of additional cables, preventing additional carbon being released into the atmosphere.
- Reduce customers' energy losses, supplying DC equipment with DC power generated locally and efficiently converting from AC/DC with one converter instead of multiple inefficient converters.

3: Project Business Case contd.

- Reduce network losses at peak times, with customers having flatter ADMDs.
- Reduce waste heat from the lossy AC/DC converters on multiple IT devices, reducing the need for air conditioning particularly in offices.

Other energy industry benefits
Energy Suppliers can through this trial increase their knowledge of customers' behaviours and willingness to change energy patterns. It will also improve energy forecasting through the use of the in home intelligence, the LC connection manager.

Great Britain System Operator (GBSO) could benefit through having more flexible demand responding to energy price signals. Customers will become more self sufficient through the use of their battery storage and generation. Battery storage can be used to absorb excess intermittent renewable generation at periods of low demand.

Relevance toED1
BRISTOL has a significant amount of learning that will be collected and shared before the start of ED1 in 2015, where possible early learning will feed into plans and regulatory discussions.

We expect BRISTOL to provide DNOs with a technical solution to increase the capacity of the distribution network when incorporating LCT without relying purely on conventional network reinforcement. This solution will provide an insight into the size of battery required in customers premises, and if a DNO can operate storage with a virtual partition.

This project will provide an insight into how Customers perceive innovative solutions such as BRISTOL and their willingness to participate in smart grid initiatives. If positive, inclusion as an option in the business plan could reduce the funds required to reinforce the network and be used to respond to any quick uptakes in new Low Carbon Technologies.

If successful DC networks with battery storage has the potential to become part of future UK building regulation requirements.

3: Project Business Case contd.

3: Project Business Case contd.

3: Project Business Case images, charts and tables.

Project Business Case images

Section 4: Evaluation Criteria

a) Accelerates the development of a low carbon energy sector

The BRISTOL project is a targeted technical project looking at developing a new tool to help with the integration of PV and other LCTs onto the LV network. If successful WPD believe the solution can be used for a substantial number of new connections. Thereby contributing to the UK Government's current strategy for reducing greenhouse gas emissions through smarter grids, key areas of the electrification of buildings heating and transport to revolutionise the design and operation of networks.

Direct Current Networks & Battery Storage with Demand response

The BRISTOL methods will demonstrate the key elements of the UK smart grid as outlined in the Low Carbon Transition plan, Page 70, Box 10. Through this it will facilitate a higher level of microgeneration and the connection of LCT and change the way customers use energy.

- The LV Network Manager and the LV Connection manager will communicate together in real time to improve the local network operation, maintaining the voltage profile within the statutory limits, reducing peaks, improving the power factor of the network, reduce network imbalance locally using battery storage to facilitate a greater level of microgeneration.
- Providing customers with better information on their electricity use through the LV connection manager. Recording key energy consumption data, PV outputs, battery use and displaying the results in simple format allowing consumers to compare their energy demands over time.
- Feed in Tariffs have already allowed customers to sell unused PV energy back to the grid. Customers will benefit from saving energy for use at different times, only selling the energy they don't need back to the grid and reducing their imported energy.
- Battery storage with demand response will be used to automatically improve customers demand, using PV output and off peak electricity, providing benefits to the distribution network at the same time.

The electrification of buildings heating and transport are a key part of the UK's transition to a lower carbon economy. These energy savings measures will increase the reliance on the distribution network, especially at Low Voltage. High network reinforcement costs may deter energy saving plans.

Variable Tariff

Variable tariffs are likely to be implemented facilitated by the UK roll out of smart meters starting in 2012 and finishing by 2020. This project will provide an insight into the use of batteries, smart appliances, and the network impact of LCTs, in a background of variable tariffs.

Taking the BRISTOL Solution Forward

The Low Carbon Transition Plan shows a rapid uptake of micro generation and LCTs across GB. Without innovation the distribution network may prevent or delay the uptake in microgeneration and Low Carbon Technologies. Innovations like BRISTOL can be used in the most appropriate areas to facilitate this roll out across GB.

BRISTOL could be used as a rapidly deployable tool to increase the network capacity, installed at the same time as a large uptake of LCTs in homes and workplaces. Communities and developers can be offered an alternative to conventional network reinforcement.

We think such a tool could be beneficial because customers have informed us that the conventional reinforcement costs can prevent them from connecting micro generation or heat pumps, sometimes changing the scale of their plans. Creating a localised smart grid instead of relying on conventional reinforcement may allow a more cost effective solution to help facilitate the Low Carbon Transition Plan.

BRISTOL could be rolled out across UK at the same time as the LCT connections. Conventional reinforcement includes excavating roads and footpaths to lay new larger cables, replacing transformers and purchasing areas of land to install new substations. BRISTOL could avoid this.

As well as avoided disruption, conventional reinforcement often requires significant planning, scheduling and installation time requiring long term scheduling with several council departments. Delays can occur in the process (e.g. wayleave permissions).

The BRISTOL method can be used in all locations of UK where Low Carbon Technologies are being implemented. It is suitable when implementing intermittent microgeneration or large DC and AC loads.

4: Evaluation Criteria contd.

We expect the BRISTOL solution may be most suitable in areas of UK with a high penetration of Low Carbon Technologies on the existing housing stock. These will tend to be Urban and Suburban locations with a large housing density supplied by an electricity network with underground cables often over 400 meters with a small cross sectional area. New build properties were considered in the development of the project, but discounted for a number of factors. Integrating Low Carbon Technologies into new houses as they are built is relatively easy; however two thirds of the 2050 housing stock has already been built today. It was therefore considered that the level of learning associated with retro-fit activity would be greater and applicable to a larger number of properties.

It has been estimated that BRISTOL could displace 1,452.3 thousand tonnes of CO_2 by connecting PV generation that would not be connected using conventional network reinforcement methods between 2015 and 2030. The detailed breakdown and calculations are shown in Appendix F. The average aggregated size of 60kW has been derived from the estimation of 30 properties per network connected substation connecting a level of 2kW micro-generation each, totalling 60kW.

The carbon emissions calculations are due to solar PV, the carbon emission calculations do not include carbon savings through heat pumps, EV's or reduced road works. The carbon savings have been based on the DEFFRA's Guidelines -GHG conversion factors document. As with the uptake of EVs and heat pumps, there is a level of uncertainty around the future carbon intensity of the grid.

The view was taken to use the latest accurate figures, the 2008 kg CO_2 per kWh, which is for the final consumer including transmission and distribution losses was 0.54160, to give, what is predicted to be, conservative carbon savings as it is recognised that the carbon content of grid may well reduce.

(b) Has the potential to deliver net financial benefits to existing and/or future customers

We have estimated the net financial benefits using a typical Bristol substation and LV network, (Marwood Road substation, Bristol). This is a typical substation in an area of social housing in Bristol, and indeed many parts of GB.

The voltage rise at key nodes and WinDEBUT network models for the different scenarios when the Marwood Road feeder 5 is modeled using WinDEBUT can be viewed on page 28. These have been used to calculate the limitations of adding LCTs to the distribution network.

The substation modelling shows connecting twenty PV panels spread equally across each phase and equal distances on the feeder is the limit before conventional network reinforcement is required. If the connections occurred at the end of the feeder only on phase L1, three 2KWe PV panels would trigger network reinforcement.

Solution

The conventional network reinforcement tools for the integration of microgeneration and LCTs into the distribution network is LV cable overlay, new substations and replacing existing transformers.

The estimated conventional network reinforcement for integrating PV into one feeder on Marwood Road substation is £21,240 based on LV overlay and harmonic filtering.

- LV overlay 120m including - £11,240
- Harmonic Filtering - £10,000

It is envisaged in the future BRISTOL type installations would be jointly financed by customers and DNOs leading to significant customer benefits with quick pay back periods. If battery storage is jointly financed between DNOs and customers each funding 50% of the battery storage, the estimated DNO costs are £17,900 based on 10 homes having battery storage and DC networks.

- Domestic property costs -Batteries, LV Connection Manager and enclosure £1,550 per property.
- Substation costs - LV Network Manager, sensors, communications and enclosure, £2,400 per substation

4: Evaluation Criteria contd.

Using the same assumptions as detailed in the carbon savings, if BRISTOL was used across GB, the method could save £36,753,000 between 2015 and 2030 compared to conventional network reinforcement. The detailed breakdown and calculations are shown in Appendix F. It is expected that 2480 locations will have the BRISTOL solution installed by 2030. These are a very conservative number and anticipated to be across the whole of the UK. This does not include the potential roll out of the solution to incorporate the connection of heat pumps or electric vehicles.

There are no costs for customers' for the BRISTOL trial. For future uses of BRISTOL it is assumed £700 per customer for a 50% ownership of the 4.8kWh batteries. We believe the trends of battery storage will continue. There is significant evidence that these costs could fall to £100/kWh by 2020; reducing the customer and DNO costs considerably.

During the project the most appropriate mechanism for funding will be evaluated. This may include storage being funded through green deal, being treated as a registered asset and funded through customer DUoS payments or being purchased outright. All other project costs including the LV Connection Manager and communications have been included within the DNO finances.

The BRISTOL solution does not require all customers to have battery storage installed. BRISTOL it is a modular solution that will allow increasing numbers of customers to connect microgeneration and other Low Carbon Technologies to the network when its headroom has been reached. In situations where customers requested further connections which would cause the distribution network to operate beyond its limits, who do not wish to have a BRISTOL solution the appropriate conventional network reinforcement would be used to complement the network controlled battery storage on the same substation.

(c) Level of impact on the operation of the Distribution System

BRISTOL directly impacts the substation load and demand on cables. It will help DNOs in Planning, Developing and Operating of an efficient distribution system by providing the following new knowledge:

Fundamentals of DNO coordinated buffer storage

- If the voltage profile can be managed using BRISTOL methods, the existing LV cables can be utilised with large number of microgeneration and LCT demand connected.
- Can DNOs use battery storage and demand response, whilst sharing assets with customers?
- Is there evidence that Variable Tariffs, customer owned storage and changes in customer behaviour can be used to naturally smooth demand, reducing the impact on the distribution network.

Through use of LV Network Manager

- Monitor the voltage headroom and load profile of each feeder when storage is located on a LV feeder.
- Learn and predict behaviours at the distribution substation level, determining when storage is required and how much.
- Understand the thermal limits of the LV system
  - How much peak demand can be shifted to the base load?
  - How much storage is needed for differing levels of substation control?
- Understand the harmonic levels over a long period of time
  - How the harmonic distortions can be reduced using the BRISTOL project and if consequently conventional filtering can be avoided?
- If network peaks can be smoothed using BRISTOL, the existing LV cables and distribution transformers can be utilised with increased levels of demand.

Design Rules - all DNOs

- Generates new ADMD knowledge of domestic homes, schools and offices with PV and battery storage.
- How the actual performance of BRISTOL compares with the modelling software WinDEBUT and if assumptions made are accurate.

4: Evaluation Criteria contd.

Others

- Will BRISTOL result in reduced customers bills using a variable tariff with storage compared to the existing single rate socialised tariff with a single energy price, resulting in a business case for storage when used with a variable tariff?
- Does increased knowledge of customers' response behaviour improve supplier energy forecasting?
- BRISTOL will explore if customers reduce their energy demands through their installed PV and energy efficiency savings.
- Can customers share integrated storage with DNOs to make better use of PV and off peak energy?
- Does BRISTOL maintain resilience of supply during short outages; is this a service customers appreciate?
- The project will measure if a building's carbon footprint is reduced
- Can the storage support Great Britain System Operator (GBSO), (e.g. Distributed storage absorbing excess intermittent renewable generation).

(d) Generates knowledge that can be shared amongst all DNOs

BRISTOL will generate new knowledge that will be shared with UK DNOs through out the project. The successful delivery rewards 1-7 outlined in section 9 are very closely linked to sharing incremental learning. The four sections below show key areas and the incremental learning that will be shared.

1. The effect of DC network installation in schools, homes and offices

The power quality at the trial properties will be recorded. The LV feeder characteristics will be monitored before the property installations, and at different stages of testing, to measure the effects of a DC network on the distribution network. (Particularly the network power quality and phase imbalance)

- Successful Delivery Reward Criteria 2
- Successful Delivery Reward Criteria 4
- Successful Delivery Reward Criteria 5
- Successful Delivery Reward Criteria 6
- Successful Delivery Reward Criteria 8

2. The effect of both battery storage and PV on import / export

The import and export profiles of properties will be collected. Information will be captured and analysed on battery discharge rate and daily profiling; Battery charge / discharge profiles; Customer / DNO use of battery; the availability of smart appliances; and the PV output profile.

- Successful Delivery Reward Criteria 2
- Successful Delivery Reward Criteria 4
- Successful Delivery Reward Criteria 7
- Successful Delivery Reward Criteria 8

3. Economics and demand side management of DC networks

The project will assess the value of battery storage for control of distribution substations (11,000V / 230V) and LV feeder for DNOs, the availability of smart appliances for DNOs; the potential for customer savings when using variable tariffs and battery storage.

- Successful Delivery Reward Criteria 8

4: Evaluation Criteria contd.

4. Communications, Sensors and ICT

We will evaluate the communication used between the LV controller manager and the LV network manager; the sensors used at substations and the ICT used. The learning will be relevant to all DNOs.

- Successful Delivery Reward Criteria 3
- Successful Delivery Reward Criteria 5
- Successful Delivery Reward Criteria 8

(e) Involvement of other partners and external funding

Western Power Distribution and our project partners Siemens, University of Bath with RWE npower and Bristol City Council have continued to develop the project since the Initial Screening Submission. We can now confirm individual roles and responsibilities for their involvement.

Siemens

- Siemens are a global technology provider with a strong proven record of delivering innovative solutions.
- Project partner with UKPN in the 2010 LCNF project Low Carbon London.
- Strong knowledge of domestic home energy solution

LCN funding required £1,136,198
Contributions - £129,600

Siemens have committed to providing the LV Connection Manager and LV Network Manager and associated equipment. If Siemens feel there is an advantage to integrating Moixa's technology into the LV Connection Manager they will form a contractual arrangement with Moixa. Siemens are continuing their discussions with Moixa. Any subcontractor arrangement will be approved by WPD as outlined in the terms and conditions of the contractual arrangement with Siemens.

University of Bath

The University of Bath have already demonstrated a DC network on one floor of their campus library to power ICT. The demonstration is continuing to evolve and will feed learning into the BRISTOL project. The University are leading the learning on Smart Tariffs and have strong links with RWE npower. The University of Bath have excellent knowledge capture and dissemination history.

LCN funding required £357,500
Contributions - £150,000

The University of Bath and npower will enter into a written agreement in respect of their interaction on BRISTOL. The variable tariffs will be developed by the University of Bath with input from npower.

Bristol City Council

- Have won £1m for installing PV in schools, funding through an ERDF bid for installing PV on domestic properties.
- Support of Low Carbon Living, partner in a €3m awarded for 3ehomes. Bristol City Council is trialling an innovative energy savings demonstration in 100 domestic properties.
- High volume of social housing stock
- Desire to reduce fuel poverty through new initiatives.
- Will work with WPD to identify 30 homes in one location, installing PV (funded through a secure external funding source) and BRISTOL.

4: Evaluation Criteria contd.

(f) Relevance and timing

Developments in the Low Carbon Economy: The majority of the impacts associated with the transition towards a low carbon economy will have a substantial impact on the LV distribution network. The requirements to reinforce the LV distribution network will need to be factored into future price controls (ED1) in order to maintain a safe and efficient distribution network. BRISTOL could be used to increase the ability to connect LCTs when added to the distribution network.

- There has already been a large increase in the installation of PV panels, DNOs have evidence that PV and other micro generation technologies will continue to increase during this and the next price control period.
- Areas of the Renewable Heat Incentive and Electric Vehicles will compound any LV network issues, the early learning from this project will identify if BRISTOL can be used to improve the voltage profile, reduce the peak demand and reduce the network harmonics.

The UK government is planning to begin the rollout of smart meters in 2012 and complete the deployment by 2020. The rollout will cover 27 million homes and DECC's latest impact assessment (07/10) estimates that the cost will be £10bn. This introduction of smart meters will provide customers with greater visibility of their energy use and thus increased control which could result in reduced customer bills. It could result competition in Britain's energy markets through development of new suppliers, services and tariffs.

The LCNF BRISTOL trial is fully independent of the smart metering rollout. Any customer taking part in the BRISTOL trial will be able to switch to a smart meter if so offered by an Energy Retailer.

The LV Connection Manager has many features that could be simplified if integrated with smart meters.

BRISTOL will address Developments in the Low Carbon Economy
The existing distribution network has a finite capacity available for connecting microgeneration and LCTs. BRISTOL could use the available capacity, in an innovative manner to allow substantially more connections to be made to the existing networks.

As there is still significant uncertainty as to which developments associated with a move to a low carbon economy are more likely to happen, BRISTOL will facilitate the connection of microgeneration feeding power into the distribution network, large DC and AC loads drawing power from the distribution network or multiple combinations connected to the same distribution network.

Without an innovative, lower cost solution there is a risk that the network reinforcement costs will prevent customers from achieving their low carbon aspirations and the UK's move to a lower carbon economy.

The BRISTOL method can be used by DNOs in several ways:

Quick Fix tool
BRISTOL can be used to solve problems that occur very quickly, If successful WPD believe the solution can be used during DR5 as a solution to integrate LCTs into the distribution network quickly and efficiently.

Longer Term Planning
If successful, BRISTOL can be used as a long term planning solution to be used in ED1 when offering developers an alternative to conventional reinforcement when integrated microgeneration and other LCTs into the distribution network.

In both cases both DNOs and developers could jointly benefit from reduced network reinforcement costs and quicker connections using innovation.

The early learning either positive or negative will be collected and analysed before the fast track DNO's ED1 deadline. The project will be completed before the non fast track DNO deadline.

4: Evaluation Criteria contd.

If successful BRISTOL project could be offered to customers as an alternative to conventional reinforcement, with the aim or reducing the costs and time it takes to reinforce distribution networks for Low Carbon Technologies.

The knowledge captured though this demonstration will highlight how likely it is that customer's and developers will chose BRISTOL over conventional reinforcement and its inclusion in future Price controls as a viable network reinforcement model.

4: Evaluation Criteria contd.

4: Evaluation Criteria contd.

4: Evaluation Criteria contd.

4: Evaluation Criteria images, charts and tables.

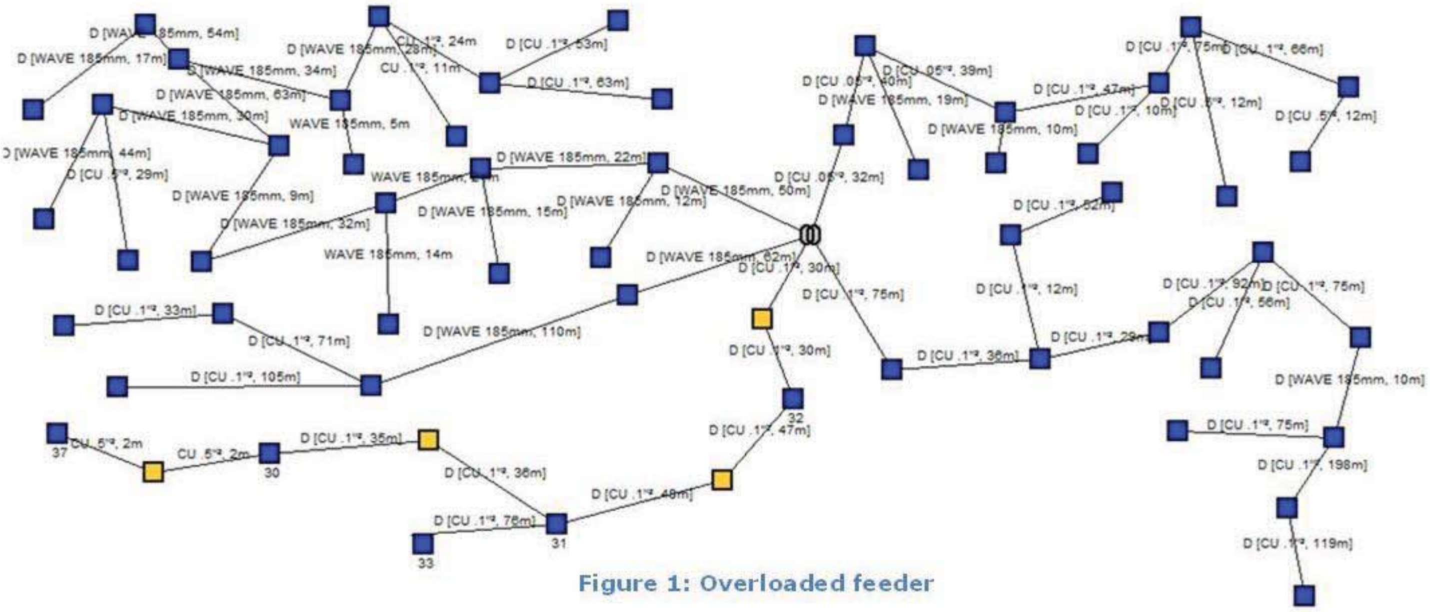

Figure 1: Overloaded feeder

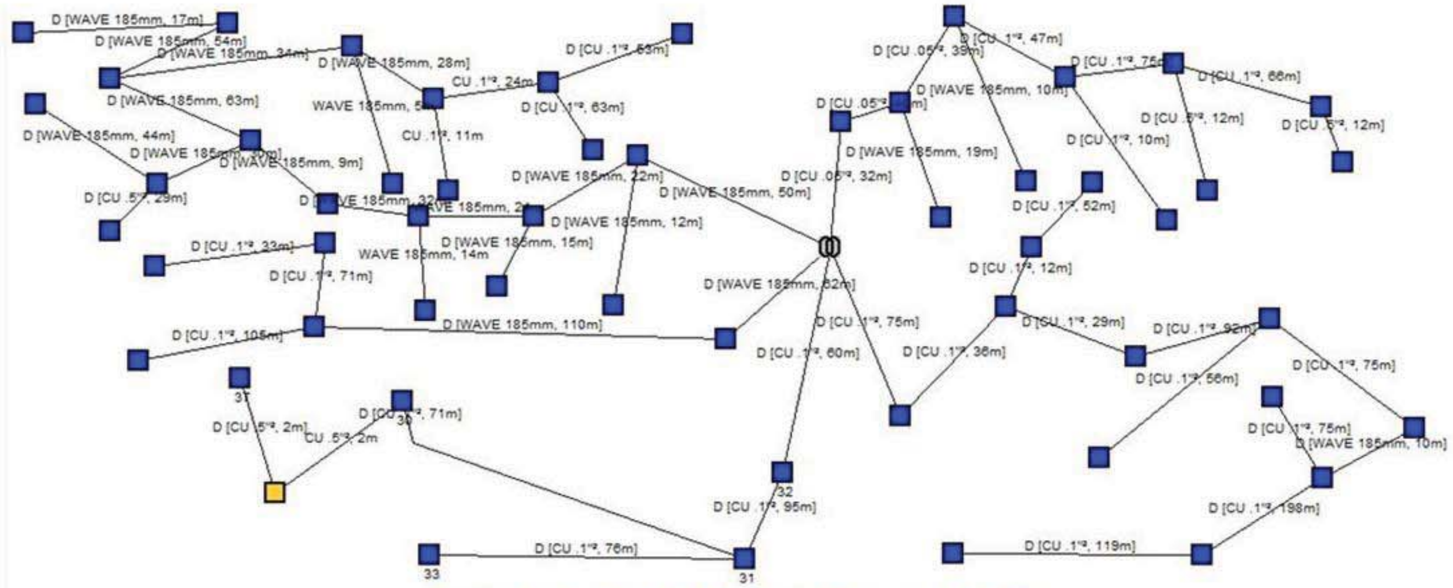

Figure 2: Overloaded feeder – L1 connected PV

	Minimum Demand without PV		Figure 1 – 19 PV panels across 3 phases in 4 locations		Figure 1 – 3 PV panels on phase L1 in 1 location	
Name of Node	**Voltage Drop (%)**	**Voltage at Node (V)**	**Voltage rise (%)**	**Voltage at Node (V)**	**Voltage Rise (%)**	**Voltage at Node (V)**
37	0.33	249.2	1.22	253.05	1.10	252.75
30	0.33	249.2	1.22	253.05	1.10	252.75
31	0.3	249.25	1.16	252.9	0.99	252.475
33	0.32	249.2	1.25	253.125	0.98	252.45
32	0.15	249.625	0.56	251.4	0.50	251.25

Table 1 - Feeder Voltage Profile

Section 5: Knowledge dissemination

☐ Put a cross in the box if the DNO does not intend to conform to the default IPR requirements

Knowledge Capture and Dissemination

The BRISTOL project will produce new knowledge about how local DC networks and battery storage systems can benefit both DNOs and Customers. It will also reveal how these technologies can be used for local network control and how they are perceived and employed by end-users. However, new knowledge of this kind is of little value unless it is properly recorded, stored and shared. In particular, the issues explored in BRISTOL concern the whole of the UK, not just the specific partners working on the project. For these reasons, it is vital that a robust plan exists, in advance, for capturing new knowledge arising from the project, and for sharing that knowledge with interested organisations.

Knowledge capture

Because knowledge capture and dissemination are so important to this project, we recognise the importance of having a comprehensive plan for capturing new insights as they arise. Knowledge will begin to be generated very shortly after the start of the project; it is therefore vital that our plans allow for early capture.

Systems and processes for knowledge capture

The knowledge that will be captured during BRISTOL breaks down into two broad areas: **End-user** knowledge, about the likely demand for and use of DC networks in the future, and knowledge about the **engineering** involved. The scheduled reports and workshops are included in the Gantt chart and the successful reward criteria.

Knowledge about the engineering of DC networks

BRISTOL will install a LV Connection Manager device in homes, schools and an office and a LV Network Manager device in substations. Knowledge will be generated during design, installation and operation of BRISTOL at both the premise and substation level.
Within homes, offices and schools we will capture knowledge from:

- Data recorded by the LV Connection Manager and its integration with smart appliances, variable tariffs / pricing signals and battery storage.
- Customer use of the DC network - this can be captured through the LV Connection Manager and linked back to data captured at the substation. This will be recorded graphically and will provide an engineering based assessment of potential behavioural change. This will be captured in reports and disseminated through the ENA LCNF conference and Workshops.
- The battery storage discharge rate, PV output to battery and the use of battery storage by the DNO and the customer within the premises. This will be captured by the LV Connection Manager and through householder interviews.
- In the homes only, we will capture knowledge in relation to the application of the variable tariff and its overall effect on householder bills.

At the substation level, knowledge will be captured from:

- The effect of DC network and battery storage on power flows, voltage profile, current, harmonics, load, thermal output, with and without battery storage through pre and post monitoring at local substations using panel meters for each different feeder.

- Frequency of data transfer and communications backhaul at the substation contributing towards the final data requirements of the DC network system.

Knowledge captured will be disseminated through technical reports, papers, workshops and presentations at the ENA LCNF conference.

5: Knowledge dissemination contd.

Knowledge about end-users

We need to learn more about the general public's attitudes, beliefs and preferences concerning the specific low-carbon technology of local DC networks and battery storage because these underpin the need for such an engineering solution. Moreover, we need to estimate how likely the end-users of the distribution network might be to engage with related technologies in the future.
Knowledge will be captured through:

- In-depth qualitative research to generate information on people's perceptions of their energy supply and how they use it. This will be collected through workshops and questionnaire based surveys.
- A large-scale survey of relevant attitudes, perceptions and behaviours. This will be captured through questionnaires and from workshop feedback.
- Field trials of DC networks and local storage. Knowledge will captured from the LV Connection Manager, interviews with participants and comparing / contrasting participants with control groups.
- Modelling work to combine the above findings and provide a method for estimating the extent to which demand can be predicted from measurable constructs such as attitudes.

The groups to be studied in this part of the research will be householders, businesses and schools. It is probable that different results will be found in each of these groups; in particular it is likely that different motives, perceptions and behaviours will be found in individual and corporate decision-makers.

Knowledge captured will be disseminated through reports, workshops through the project website and if suitable, in academic papers.

Systems and processes for customer engagement

The core recipients of Project BRISTOL's knowledge output will be DNOs and energy suppliers. Although these bodies are likely to have some interest in the raw information from the knowledge capture process they are likely to have more interest in processed information, in which all our learning is reduced to concrete conclusions, recommendations and action plans. We envisage a variety of methods for providing members of this audience with such outputs from BRISTOL, including:

- Regular stakeholder/team meetings
- Workshops and symposia, including an early workshop to elucidate links and learning opportunities between the various LCNF projects in which these partners are involved (Project FALCON, Project BRISTOL, other LCNF Tier 1 and 2 projects, etc.)
- The project wiki
- Technical reports
- Project Advisory Board
- Presentations at the annual ENA / LCNF conference
- Progress and final reports
- A DC Networks LinkedIn group
- Website - with technical and public faces containing audience relevant material
- Academic journal and conference papers
- Articles for in-house newsletters and magazines
- E-Newsletters
- Press releases

Other recipients of the knowledge generated by BRISTOL are the end-users of the power network who might be offered DC networks and technologies in the future (and who therefore need to understand what these are, the benefits they offer and how they can be implemented). The members of this group are important as ultimately it will be their uptake of DC networks and local storage devices that allow low-carbon technologies to be implemented and better network load balancing to be achieved. We see various methods by which insights and messages from Project BRISTOL can be shared with these end-users, including:

- Press releases and briefings
- Leaflets (e.g., delivered with energy bills)
- Discussions with developers and local authorities
- Notices on energy companies' customer websites
- Public face of the BRISTOL website
- A major programme of school student engagement to be run by GalloManor, a proven provider of science education and engagement schemes at school level
- Teaching materials, which allow science teachers to integrate information on low-carbon technologies and behaviours relating to these into their lessons

5: Knowledge dissemination contd.

- Teaching materials which feed into undergraduate and postgraduate education at each participating university (especially into student research projects)
- Through the development of joint research projects related to BRISTOL such as through the Bath MSc in Electrical Power Systems
- The outputs of the project could be developed as course materials for use in undergraduate, postgraduate and CPD teaching
- Energy Savings trust
- Green investment bank

Systems and processes to evaluate knowledge capture and customer engagement

Over the course of this project, it will be important to check that the above knowledge capture and customer engagement processes are working. This process breaks down into various areas: auditing the knowledge capture process regarding the engineering of DC networks and related technologies, and then auditing the customer engagement process for this information; plus auditing the knowledge capture process regarding end-users' perceptions of DC networks and auditing the customer engagement process for this information.

Track record

The knowledge capture and dissemination will be led by the University of Bath in conjunction with their partners. Bath is a leading research university with a long-standing track record with WPD. It is currently participating in, and will lead, the dissemination of the 2010 LCNF Tier 2 LV Network Templates project; Bath is also the nominated dissemination partner for WPD's 2011 LCNF Tier 2 FALCON project. The university plans to co-ordinate dissemination across these three projects to provide a single channel for communication to stakeholders and so maximise value-for-money. Similarly, the BRISTOL project will benefit from the stakeholder database, secure server, workshop models and the experience gained from the dissemination activities currently underway in the LV Network Templates project. Consequently, dissemination activities for BRISTOL can be developed more efficiently and cost effectively than if starting from scratch.

As one of the UK's leading research institutions, the University of Bath has outstanding expertise of gathering knowledge and sharing it with varied audiences. Bath has a long history of industry collaboration and knowledge gathering that will inform this project; of particular note is the learning gained from its many previous energy projects, not least Dr Furong Li's Ofgem-endorsed work. Bath has organised knowledge sharing events for a wide range of stakeholders, including the power industry, academics and the broader public. Dr Ian Walker, an award winning science communicator, who will co-ordinate knowledge gathering for this project and who was recently invited to mentor a knowledge capture project for the Department for Transport. He will be assisted by the university's experienced research management and financial oversight teams.

The other partners in this project also have established track records for knowledge capture and sharing. Siemens, who have also worked in the BritNed interconnector project, the ETI Joined Cities plan and the LCNF Tier 2 funded Low Carbon London project, have experience of sharing information with various audiences, both technical and public. RWE npower similarly have established and tested channels for internal and external communication, with the means to reach both industry and customer audiences. Bristol City Council, who will have an important role in reaching householders, naturally have multiple channels through which they can reach do this, including established websites and hard-copy publications distributed to homes across the city. Gallomanor, who will assist with engaging the school audience, are leaders in citizen and school engagement using new media.

5: Knowledge dissemination images, charts and tables.

Knowledge dissemination images

Section 6: Project readiness

Requested level of protection require against cost over-runs (%).	5%
Requested level of protection against Direct Benefits that they wish to apply for (%).	0%

How Can we ensure a timely start to the project?

Senior Management Commitment

WPD directors have discussed project BRISTOL at board level and have subsequently obtained commitment from the Directors of Pennsylvania Power and Light, WPD's owners.

Throughout the bidding phases and the run up to Project launch our partner organisations have ensured engagement has taken place at a senior level and commitment obtained. We are confident that this level of senior engagement and commitment will continue post bid submission and throughout the project lifecycle. In order to ensure this level of commitment remains we have proposed a Project Forum. The Project Forum will consist of key stakeholders and decision makers in the energy community.

To demonstrate the level of commitment of our project partners we have included letters of support from each of our partners and supporters in Appendix H.

WPD Internal Engagement

The key internal stakeholders have been identified and engaged to ensure the project will be delivered successfully. The WPD local delivery model has already proven our ability to deliver smart grid initiatives and will be used when delivering this project.

Project Readiness Considerations

In planning this project ready for a timely start on the 1st December 2011, the following aspects have been considered:

- Fully developed project scope with our partners.
- Innovation and Low Carbon Networks Department
- Learnings from 2010 projects
- Project Plan
- Risk

Fully developed project
BRISTOL has followed a structured and robust project methodology taking BRISTOL from concept, through development to readiness for LCNF submission. The overall technical solution as developed with Siemens is shown in Appendix C.

The BRISTOL concept was discussed with several companies and organisations before the Initial Submission Pro-forma was submitted to Ofgem. Following the projects' acceptance to the Full submission stage, a detailed Request For Information was sent to the companies involved in early discussions before selecting the final partners Siemens, University of Bath and Bristol City Council.

A multi party Memorandum of Understanding is in the process of being agreed, all partners received the first draft (27/07/11). It is planned they will be completed and contracts will be in place before the project launch.

Within the MoU project partners have their own areas of work with lead and supporting partners defined. There are clear boundaries between the different sections of work, the separate areas with lead project partners is shown in Appendix D.

6: Project readiness contd.

Innovation and Low Carbon Networks Department

Significant resource is already in place ready to start the project on 1st December 2011. WPD have a proven track record of delivering large smart grid projects with all milestones hit. The WPD local delivery model has already shown our ability to deliver smart grid initiatives. WPD aims to continue developing this project between the project submission and the LCN Fund announcement date.

A full time Project Manager was assigned to the project in May 2011, continuing to develop the project in conjunction with our partners, Siemens, University of Bath and Bristol City Council to ensure the project has a robust scope.

During the detailed project development and installation of equipment the project manager is likely to be working full time on project BRISTOL. During the operation phase we have estimated the dedicated project manager will spend two days per week working on BRISTOL.

Learnings from 2010 projects

During the detailed planning of bid, we have fed the lessons learnt from our own LCNF projects and our partners' similar projects into the project plan.

Project Plan

The project has a comprehensive project plan, shared with all project partners. The project will be launched internally on the 1st December 2011 with project partners joining us after the 1st January 2012.

Risk

The project is built on relatively high TRL components and the costs have been built based on quotes from our partners, a significant amount of the project has fixed costs.

The funding for the energy saving initiatives in the City of Bristol has already been secured.

We have included potential risks highlighted from our partners into the risk register and used their expertise in costing non conventional distribution network costs. These have been built up from off the shelf components where available to further reduce financial risk in the delivery stage.

Both Western Power Distribution and our project partners view the risk of failing to complete contracts as a low risk.

How will we minimise the possibility of cost overruns or shortfalls in Direct Benefits?

- The costs have been calculated using a bottom up and top down methodology.
- The project has been broken down into individual areas, to provide a detailed overview of each area.
- Costs for "off the shelf items" have been used where possible to provide a greater level of certainty.
- Our project partners built up the costs, sharing detailed planning with us for each section of the project. We also understand the level of uncertainty within these costs. Many of the external project costs are fixed, preventing cost over runs.
- Appendix C shows the technical design details used to develop accurate costs for the project.

The most significant DNO project benefit is the deferred conventional network reinforcement. The typical substations reinforcement costs have been estimated using network planning software for the business case but are very location specific. Without the project locations, it is not possible to calculate if any network reinforcement will be required.

Management of project finances

- We asked project partners to quote fixed prices for the majority of their sections.
- The scope of the project has been clearly defined and the project partners all understand the boundaries within each area.
- Small areas of the project with residual cost uncertainty have an appropriate level of contingency built into the costs. This is shown transparently in our project financial plans.

6: Project readiness contd.

Accuracy of information

- The proposal has been written by Western Power Distribution with information being provided from the project partners.
- We have a full time project manager preparing the bid, working with our partners.
- The BRISTOL proposal has been peer reviewed internally and sent to all project partners to ensure accuracy.
- Information provided from partners has been reviewed by WPD to ensure accuracy.

Project Governance

- The project will be managed using PRINCE2 Methodology.
- Project will form part of the Future Networks Programme, using established governance and processes.
- A project forum made up of partners and senior stakeholders will be formed.

BRISTOL has a comprehensive project plan, risk register, mitigation plan and contingency plan as found in the Appendix D. These documents will be used continually throughout the project to ensure successful delivery.

6: Project readiness contd.

6: Project readiness contd.

6: Project readiness contd.

6: Project readiness contd.

6: Project readiness images

Project readiness Images

Section 7: Regulatory issues

☐ Put a cross in the box if the Project may require any derogations, consents or changes to the regulatory arrangements.

We do not see a need for regulatory derogations as a result of this project. As part of this project we will deliver new regulatory learning.

For BRISTOL, we will ask retailers to accept an uncertified DC meter rather then an AC meter for customers' microgeneration, we expect them to request that any necessary regulatory restrictions be lifted for the purpose of the trial. We've already spoken to OFGEM and DECC about this issue.

Domestic customers will see a variable tariff to incentivise changing their ADMD; their actual tariff will remain the same. We propose to protect domestic customers from cost over runs; their energy bills should not increase as a result of the technology interaction. Customers could receive up to £200 off their actual energy bill per year as a result of changing their energy profile.

7: Regulatory issues contd.

7: Regulatory issues images, charts and tables

Regulatory issues images

Section 8: Customer impacts

Customer Impact
Through the BRISTOL project we will interact with customers, supported by experienced external companies to investigate the mutual benefits of DNO's working with customers and suppliers. Battery storage, DC networks and new variable tariffs will be trialled in domestic homes, schools and an office with the customers fully involved in the project.

Domestic properties

- Through Bristol City Council and a trial recruitment company, customers in key areas who already have or will have PV panels installed will be contacted:
  - We will target residential locations with a high level of social housing near to the schools involved in the BRISTOL trial. We will inform residents in these areas about the project and ask for expressions of interest.
  - From the interested parties, we will sign up homes and select 30 properties in one location.
  - The installation of equipment and the modification to homes, schools and office will be carried out by Bristol City Council.
  - The installation team will receive training on the equipment being installed and will have supporting technical information from Siemens and the University of Bath.
  - The in home equipment will be supported and maintained by Bristol City Council.
  - The University of Bath will conduct appropriate interviews with home owners to capture knowledge.

Bristol City Council is participating in a European commission funded project called 3ehouses, installing energy reduction measures. Bristol City Council is identifying 300-400 social housing units where tenants wish to work with innovative technology. Lessons learnt from this project will feed into the customer impact plan for selecting 30 properties for BRISTOL.

Schools

- We will invite schools already receiving PV panels through the Solar PV for Bristol Schools Project to participate in the project
  - We have determined through a desktop study that 24 of the schools already selected to have PV panels installed are appropriate for the BRISTOL project.
  - These schools will be invited to a participant's workshop where the project will be explained.
  - The installation of equipment and modification to schools will be carried out by Bristol City Council.
  - Equipment will be installed and decommissioned during school holidays to minimise the disruption to children and teachers.
  - The installation team will be trained on the equipment being installed before visiting site, and will be supported by Siemens and the University of Bath.
  - The school equipment will be supported and maintained by Bristol City Council.
  - Each school will take part in our outreach program. Children will be taught about energy and why the BRISTOL project is happening.

Customer engagement and key aspects
Through this trial, we will:

- Not interfere with any smart meter roll-out in the area,
- Not change customers primary electricity meters,
- Look to use a new DC meter for PV whilst the customer inverter is not being used.
- Write to all customers' energy suppliers to let them know their customers have requested to be part of the trial and sort out a FIT arrangement.
- Allow customers to change energy supplier freely at any time,
- Obtain prior written consent from customers and the council before installing equipment in homes, schools and the office.
- Submit a customer engagement plan to OFGEM at least 2 calendar months before any contact is made with customers.
- Ensure that customers have clear information on the project, what will be installed, how long for and when it will be decommissioned.
- Continually engage with customers throughout the project.

8: Customer impacts contd.

- Rigorously enforce the data protection act. Including a customer data projection plan for dealing with personal data that will be submitted to Ofgem at least two calendar months before collecting any personal data.

Customer Safety
All aspects of the BRISTOL Project will be designed with safety as the first priority. Off the shelf technologies will be employed wherever possible. Siemens will Factory Acceptance Test their devices prior installation

- The LV connection manager will undergo testing during the one year development and procurement phase to ensure a fully functioning unit is rigorously tested before being installed in customers' properties.
- We are using a reliable, well tested battery technology, already used safely in off-grid, domestic PV installations.
- Our partners Bristol City Council will provide expert advice during the design stage and support customers, including training them then how to use any equipment.

Protecting customers from power cuts

As part of the trial WPD will ask selected domestic properties to test the energy security section of the project. To facilitate this we will ask selected customers to operate without AC power for a planned two hour period to gain better understating of the security of supply benefits the project provides. This technique will also be tested in the unlikely event of a network power failure.

Customers will be in full control of this section of the trial and will have the opportunity to opt out the planned domestic outage at any time. The knowledge captured by this section of the trial will indicate:

- How much value customers place on security of supply for short outages
- Seek to understand the hierarchy of needs for customers, including lighting, heating, communications, and entertainment.
- How much battery demand is required for short periods
- The operation of the PV panels during the loss of AC mains.

The focus of the power outage test is the DC network, batteries and customer behaviour during the outage. The operation of the PV panels may influence customers behaviours, however the test is not specifically focussed on the performance of the PV panels.

The LV Connection Manager will record the output from the PV, displaying the information to customers.

The trials will be scheduled at different times of the day with different weather conditions and battery capacities to maximise the learning. Selected customers will be asked to undergo this test once during the trial.

Equipment to be installed
It is envisaged that the equipment being installed in domestic homes will be located in the roof space next to the FIT inverter equipment. The equipment will be approximately 0.25 m^3 (e.g. 1m x 0.5m x 0.5m enclosure) and weigh about 250kg. Equipment being installed in schools and offices will be approximately 1 m^3 and weigh 1000kg located in the roof space next to the FIT inverter.

Bristol City Council will ensure customers fully understand the trial and educate them in how to gain the most from the equipment installed in their homes, schools and businesses.

8: Customer impacts contd.

Decommissioning phase

At the end of the trial equipment will be decommissioned and the homes, schools and office will be returned to their original state. Funds have been included for full decommissioning of the trial.

If the participants and the council wish to take ownership of the equipment and continue to operate a DC network, they will receive a briefing pack detailing ongoing maintenance and disposal arrangements they agree to comply with. The trial equipment will be legally signed over to the Council. Any decommissioning funds not spent will be reported and returned to customers.

8: Customer impacts contd.

8: Customer impacts images, charts and tables

Customer Impacts images

Section 9: Succesful Delivery Reward Criteria

Criterion (9.1)

Successful initial engagement with customers: This criterion corresponds to successfully holding a workshop with Bristol City Council, potential trial participants and interested parties before 30th April 2012. Holding the workshop on or before this date will demonstrate the project is on schedule to recruit trial participants' inline with the project plan. Prior to the workshop the customer communication plan will have been submitted and accepted by Ofgem. WPD will work with our partner, Bristol City Council and the trial participant recruitment specialist to engage with target domestic audiences and the selected schools from the Solar PV for schools scheme.
The workshop will be used to explain the purpose of the project, provide a guide to the installations, detail the project timeline and gather customer feedback. It will be an opportunity for customers to learn more about the project first hand and ask any questions they may have.

Evidence (9.1)

- The Customer Communication plan will be sent to Ofgem at least two months before any intended contact with customers, the final version will be shared with customers Energy Retailer when the trial participants have been selected, published on the Western Power Distribution website and on the project BRISTOL website.
- The recruitment plan, copies of material used to recruit trial participants and locations targeted will be recorded.
- Minutes and notes captured from the workshop will be stored for future use during knowledge dissemination outputs. Feedback from the event and recruitment process will be gathered through a post event questionnaire where any outstanding questions can be collated.
- An overview of the workshop and feedback will be posted on the BRISTOL website for interested parties within a month of the event.

Criterion (9.2)

Confirmation of the BRISTOL design: This criterion corresponds to signing off the design of the installations by 30th September 2012 for homes, schools and office after the trial participants and locations have been confirmed. The design will confirm the capability of the equipment being installed; details which equipment will be connected to the DC network, how the equipment will be connected together and the location of equipment in a typical home, school and the selected office.
The design will be developed with our partners, Siemens and the University of Bath. It will build upon the Technical Overview outlined in Appendix C and use the outputs from the detailed survey and planning, participants wiring and structural reviews. The final design will be published through the BRISTOL website. The designs will be reviewed and modelled to predict the performance of the solution, customer benefits and distribution network benefits of the final design.

Evidence (9.2)

- Regular meetings will be held between WPD, Siemens and the University of Bath to develop the BRISTOL design. Summaries of the meetings and design decisions will be captured and recorded.
- The results of the surveys, inspections and reviews will be recorded and stored by the University of Bath
- The predicted performance and benefits will be recorded and stored. The predicted performance will be compared against the actual performance.
- The final design will be signed of by WPD senior engineering managers and subsequently shared through the BRISTOL website.

9: Succesful delivery reward criteria contd.

Criterion (9.3)

Installation and commissioning of equipment: This criterion corresponds to installing and commissioning equipment in 30 domestic properties before 30th September 2014 ~~April 2013,~~ upto 5 ~~10~~ schools before 30th September 2014 ~~31st August 2013~~ and an office before 30th September 2014 ~~30th April 2013~~.
Prior to the installations WPD and our partners will Factory Acceptance Test the BRISTOL solution, provide training for the installation team, form method statements for installation, risk assessments for installation and operation, an appointment booking process, re-booking process, complaints procedure and operation guide.

Evidence (9.3)

- A test specification will be completed prior to the factory acceptant test and the commissioning of equipment; this will be signed off by the WPD project manager. The results from the factory acceptance tests will be analysed by Siemens and the University of Bath with final acceptance by WPD.
- Project documents will be peer reviewed by the WPD Project Manager before they are issued. Copies of the project documentation will be stored by the University of Bath.
- Regular installation progress reports will be posted on the BRISTOL website for interested parties to view.
- A review of the installation and commissioning activities will be carried out, capturing any lessons learnt. If required, the method statements and other related documentation will be updated and stored.

Criterion (9.4)

Early Operational Performance of BRISTOL: This criterion corresponds to successfully operating an integrated DC network with storage in homes, schools and an office. The operational performance from the data captured through the LV Connection Manager will be analysed to provide an early snapshot of the BRISTOL performance since commissioning.
We will capture and share the early learning from deploying and running DC networks and battery storage in customer premises. Data will be captured up to 30th November ~~2013;~~ 2014 the learning will be released by 31st December ~~2013~~ 2014. No customer sensitive data will be released, and any data relating to customers will be completely anonymous.
A review of the early learning will be undertaken to determine if any changes are required in the operation of the LV Connection Manager, including the battery use and charging algorithms to improve the future performance of the BRISTOL solution.

Evidence (9.4)

- An operations report will be produced and shared through the BRISTOL website, Stakeholder Dissemination symposia, and the project advisory board.
- The actual data will be collected and stored by the University of Bath. The performance data including system availability, battery usage and data rates will be analysed and compared to the pre installation predictions.
- If required, the method statements and other related documentation will be updated and stored.
- Notes from the project meetings discussing operational performance in homes, schools and the office will be recorded and stored.

9: Succesful delivery reward criteria contd.

Criterion (9.5)

Measured the impact on the LV network: This criterion corresponds to measuring the impact of the BRISTOL solution on the trial distribution substations operation, compared to the operation prior to the installation and commissioning of equipment in homes, schools and the office.
The long term operation of the distribution network will be captured through the LV Network Manager located in distribution substations, the data recorded will be analysed to monitor any changes in the voltage profile, load profile and power quality of the network as a result of the installation in homes, schools and the office. In substations with BRISTOL installed on one LV feeder, another similar LV feeder will also be monitored and used as a reference.

Through this criterion we will be capturing and sharing the early learning, measuring the network benefits of the BRISTOL solution, sharing the analysis before 31st May ~~2014~~ 2015.

Evidence (9.5)

Findings shall be shared through a summary report published through the BRISTOL website by 31st May ~~2014~~ 2015.
Notes from the project meetings discussing operational performance (changes to the LV voltage profiles, feeder demand profiles and power quality) will be recorded and stored.
The actual data will be collected and stored by the University of Bath. The performance data recorded by the LV Network Manager will be analysed and compared to the pre installation predictions.
If required, the method statements and other related documentation will be updated and stored.

Criterion (9.6)

Customer Opinion: This criterion relates to learning about customer acceptance of a BRISTOL solution. We will specifically report on how they feel about virtual asset sharing, taking up space in their home, the energy savings, how disruptive the equipment has been, how easy it is to operate and if there opinion of the BRISTOL solution has changed over time.
WPD will work with the trial participant recruitment specialist and the University of Bath to design a process and subsequently capture customers' feelings on the project in line with the customer communication plan. The first assessments will commence ~~be completed~~ before ~~30th June 2012~~ 30th March 2014 to capture customers' opinions before the trial starts, the second assessment will be completed before ~~30th June 2013~~ 30th November 2014 to capture customers' opinions during the trial and the third assessment will be completed before 31st November ~~2014~~ 2015 to capture customers' opinions after the trial.

Evidence (9.6)

- The Customer Communication Plan, detailing customer contact will be on the website
- Knowledge will be captured using a mixture of questionnaires and interviews with results published two months after each assessment is completed.
- Any customer complaints will be resolved within 14 days and the responses will be stored.
- Analysis will be shared with all trial participants, Bristol City Council and GB DNOs through the BRISTOL website. The learning from the customer opinion will be used to update the customer communication plan.

9: Succesful delivery reward criteria contd.

Criterion (9.7)

Keeping the lights on during power outages: This criterion corresponds to testing the domestic BRISTOL solution during an AC power outage. WPD will ask selected domestic customers to test the energy security section provided by the battery storage between ~~1st October 2013 and 1st October 2014.~~ 1st June 2014 and 1st June 2015.
The performance of the DC network and batteries will be monitored, through the LV Connection Manager. Customers' behaviour and use of energy during the short outage will also be captured through the LV Connection Manager and a survey. This test will inform us of the capability of the BRISTOL system during a power outage and the potential value to customers.
The trials will be scheduled at different times of the day with different weather conditions and battery capacities to maximise the learning. Selected customers will be invited to undergo this test only once during the trial.

Evidence (9.7)

The data from the LV Connection Manager and responses from the domestic questionnaire will be stored by the University of Bath.
The power outage test plan and communication methods used will be designed and stored by the University of Bath and will be signed off by the WPD Project Manager.
The learning generated by analysing the data will be shared with all stakeholders and interested parties through the end of project report on 15th January ~~2015~~.2016
Customers energy demands during the short power outage test will feed into the battery size review at the end of the project (SDRC 9.8 (5)).

Criterion (9.8)

Suitability of solution for mainstream adoption: This criterion corresponds to writing a comprehensive end of project report summarising the project findings. The report will contain sufficient information to advise other UK DNOs: **(1)**If the BRISTOL trial demonstrates solar PV can be integrated into the distribution network using battery storage and DC networks. **(2)**How the measured results compared to the predictions made in the set up and development period (SDRC 9.2). **(3)**How the solution could be used to incorporate other LCTs into the distribution network **(4)**What customer benefits where recorded throughout the trial. **(5)**The significant lessons learnt during the trial, how these would be reflected in a future roll out of the BRISTOL solution if used as an alternative to conventional network reinforcement. **(6)**Which policies and standards would need to be modified to allow a BRISTOL solution and **(7)**What impact the inclusion of BRISTOL will have on DNO business plans. The report will also contain an appendix with all the early learning reports from previous milestones and a feasibility study for installing a BRISTOL solution in an office using the learning generated from the trial.

Evidence (9.8)

The end of project report will review the detail knowledge generated from the design and operation of the BRISTOL project. The report will include the appendices from the key areas of learning highlighted in the other Successful Delivery Reward Criteria. The report containing the information above will be published by 15th January ~~2015~~ 2016.
The results from this milestone will determine if the solution can be adopted into mainstream. If limiting factors are present, preventing the inclusion into mainstream adoption at the end of the project, the report will recommend areas that need to be monitored (e.g. the future cost of energy storage, deployment of smart meters …) which may facilitate the future inclusion as a network reinforcement technique.

Section10: List of Appendices

BRISTOL Appendices

Appendix A Full Submission Spreadsheet
Appendix B Maps and network diagrams
Appendix C Technical Overview
Appendix D Project plan
RAID log
Organogram
Contingency Plan
Appendix E Partner Details
Appendix F Carbon Savings & Net Financial Benefits
Appendix G Letters of Support

WPD Low Carbon Networks Fund Project

Tier 2 Appendices

Appendix A	Full Submission Spreadsheet
Appendix B	Maps and network diagrams
Appendix C	Technical Overview
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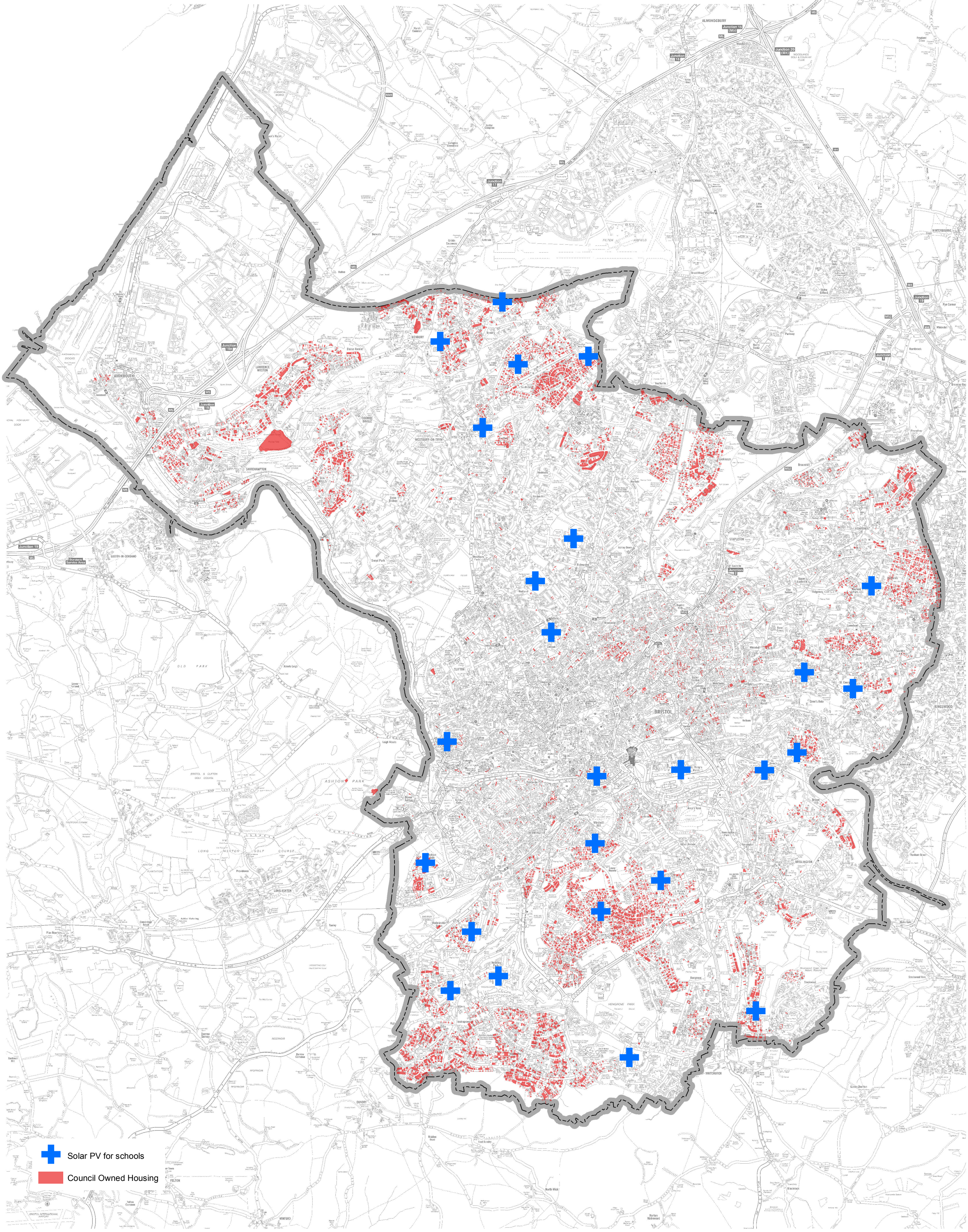
	RAID log
	Organogram
	Contingency Plan
Appendix E	Partner Details
Appendix F	Carbon Savings & Net Financial Benefits
Appendix G	Letters of Support

Appendix B - Bristol City Council owned housing with schools considered for PV installation



0 1 2 4 Kilometers

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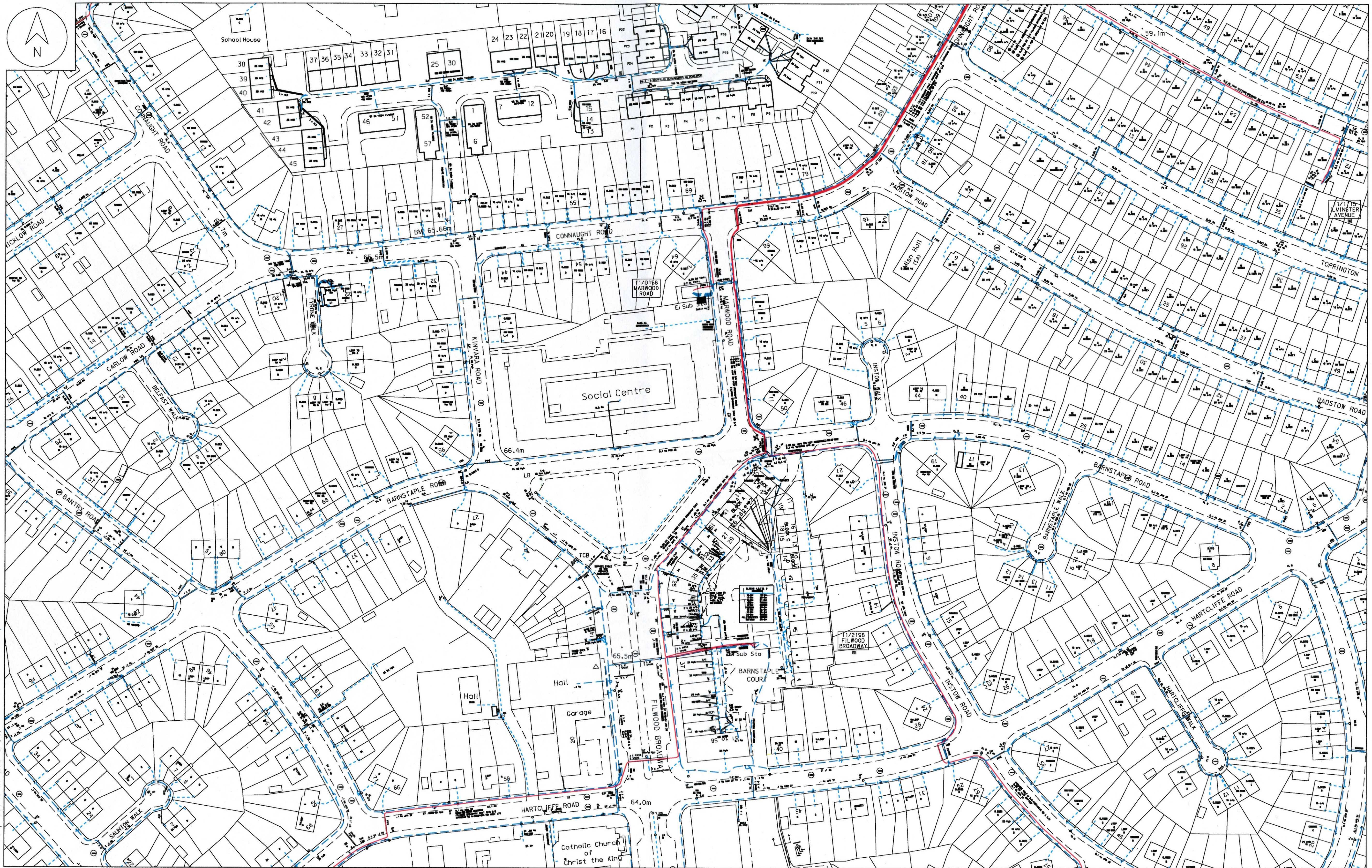
Produced by KS Corporate GIS Team Job No. 10 - 081

CARE SHOULD BE EXERCISED TO ENSURE THE PRECISE POSITION OF THE WPD APPARATUS IF WORK IS TO BE EXECUTED IN ITS VICINITY. If in doubt, contact your local WPD office.

Information is given as a guide only and it's accuracy cannot be guaranteed.



PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution.
Electricity assets owned by IDNO's (Independent Network Operators) MAY be present in this area.

	OVERHEAD LINE		UNDERGROUND CABLE
SURF TELECOMS APPARATUS		PL	
PILOT CABLES		SERVICE	
		LV	
		HV (11kV)	
		HV (33kV)	
		HV (66kV)	
	✳	HV (132kV)	✳

PME Earth — Underground Earth — Pole Mounted Transformer — Ground Mounted Transformer

✳ ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

DATE: 12-8-2011
SCALE 1: 1500
DRAWN BY:
TITLE:
PLOT CENTRE: 359392.384, 169763.689
A3

WESTERN POWER DISTRIBUTION
Serving the South West and Wales

Solution Outline

Product / Function:	**Overall Technical Solution**
Project:	Project BRISTOL (Buildings, Renewables and Integrated Storage, with Tariffs to Overcome network Limitations)
Document status:	Released

The document passes through the following states “Being Processed“, “In Review“ and “Released“

Document for external publication – internal references removed

Revisions

Chapter / Pages changed	Version	Object and Reason of Change/ Reference to Change Requirements	
	V1.00	Issued to client for review	
	V2.00	For publication	

Contents

Figures

Tables

1 Introduction

This document provides an overview of the proposed technical solution for Western Power Distribution's (WPD's) Tier 2 LCNF project: Buildings, Renewables and Integrated Storage, with Tariffs to Overcome network Limitations (BRISTOL). It has been compiled from information and input provided by all the project partners: Western Power Distribution, University of Bath and Siemens.

The information contained in this document is intended to demonstrate the technical feasibility of the project. The technical solution will be the subject of a detailed design phase within the Implementation phase of the project.

2 LV Distribution Network

Section 2 of the submission proforma describes the background to the project. This section seeks to identify the specific network issues that the project will resolve.

WPD's existing tier 2 project, Low Voltage (LV) Network Templates for a Low-carbon Future, seeks to characterise networks by features of customer (load and generation) and the network. Outputs from this project will be a valuable input into this project by forming the basis for network modelling activities.

For the purpose of highlighting the specific issues which the project seeks to solve, a simplistic piece of radial, tapered LV feeder is depicted with distributed loads, which are all assumed to be equal, Figure 1. It is further assumed that some of these properties have generation, which may be active for some of the time. This is shown in the top part of the figure. The second part of the figure represents the distributed load at each property along the network (in red), and the generation (green).

In the third part of the figure the resulting power flows along each section of network is shown – in blue when there is no generation output and in purple with generation. The cable thermal limits are also shown on the diagram. Finally the bottom part of figure shows the resulting voltage profile (in blue without generation output and purple with output) and again operational limits are shown.

As introduced in section 2 of the proforma, the introduction of low carbon technologies are expected to result in two specific cases with impacts on the LV network. These are listed below, along with the resulting effects that this project will address.

1. Excess generation over load on the local network, resulting in
    - 1a. Voltage upper limits exceeded, and/or
    - 1b. Thermal limits exceeded (power import); and
2. High peak load, resulting in
    - 2a. Voltage lower limits exceeded, and/or
    - 2b. Thermal limits exceeded (power export).

Three of these effects are highlighted in the power flow and voltage profile graphs of Figure 1.

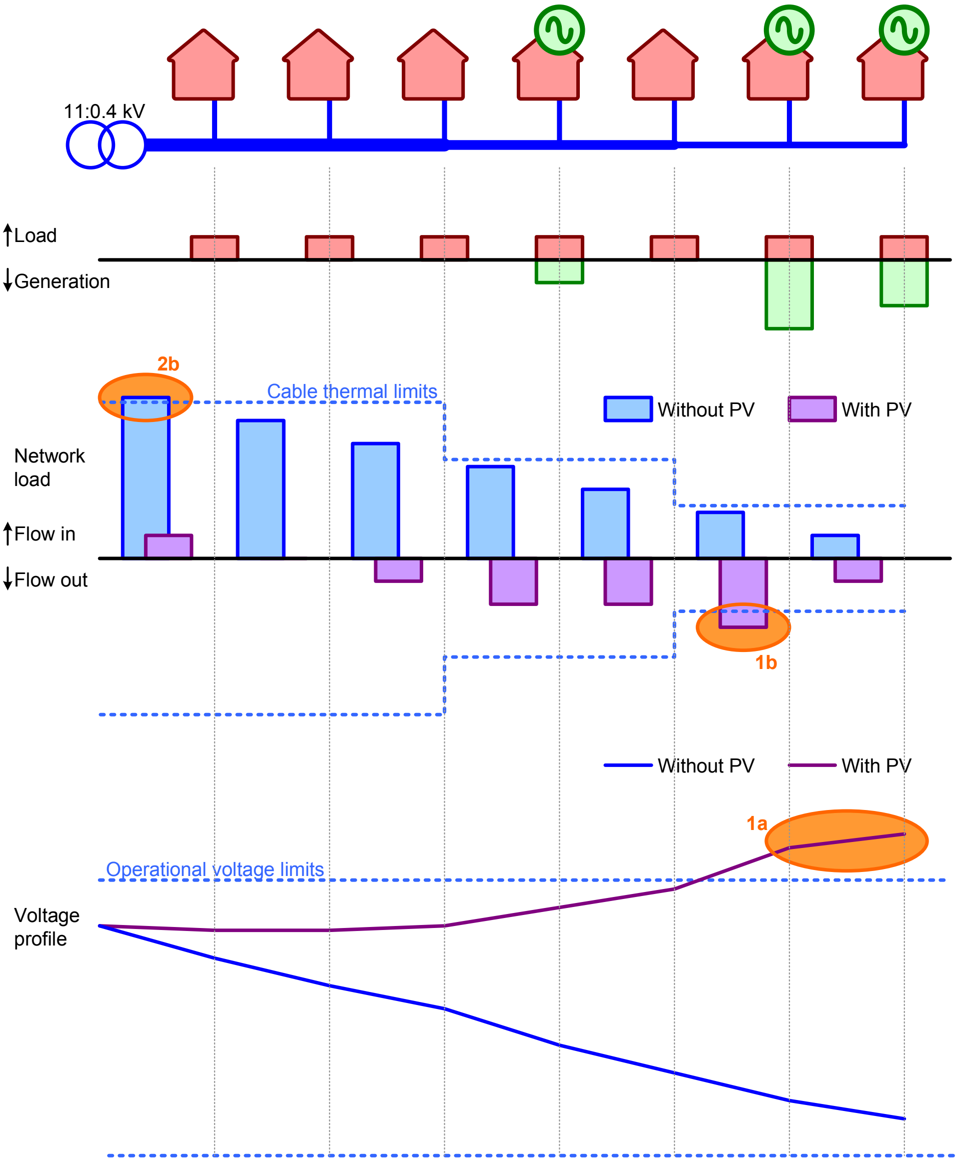


Figure 1 Problem Elaboration

3 Description of Subject Properties

3.1 Domestic Properties

The domestic properties will be selected from Bristol City Council housing stock, for social housing. It is assumed that these will be semi-detached or terraced properties with three bedrooms and two reception rooms, and fitted with double-glazing and loft insulation. While it would be advantageous for some of these properties to be fitted with PV, this is not a criterion for selection.

It is hoped that all the properties in the trial can be on a single distribution transformer, preferably on a single feeder.

These properties will normally be connected single-phase, with a 63 A fuse.

Assumptions

The following assumptions are made about a “standard” property for modelling and budgeting purposes.

- Two DC lighting circuits, with 8 light switches and 14 lamps
- One DC power circuit, with 5 power points
- Properties fitted with PV have 2 kWp installed

3.2 Schools

The schools will be selected from those which have pre-qualified for Bristol City Council’s Solar PV for Bristol Schools scheme. Criteria for selection are that they should have an LV connection and that there should be other properties connected on the same feeder. The connection can be 3-phase or single-phase.

Assumptions

The following assumptions are made about a “standard” property for modelling and budgeting purposes.

- One DC lighting control circuit, with a single control point, and 10 luminaires
- Three DC power circuits, each with 8 power points
- PV typically in the range 3 kWp to 10 kWp, with potential for one school with 50 kWp

3.3 Commercial Office Space

The commercial office space will be one floor of one of Bristol City Council’s office buildings. It will be fitted out with battery storage and IT equipment powered with DC power supplies. Criteria for selection are that they should have an LV connection and that there should be other properties connected on the same feeder. The connection can be 3-phase or single-phase.

Assumptions

The following assumptions are made for modelling and budgeting purposes.

- One DC lighting control circuit, with a single control point or zonal occupancy detection sensor, and 16 luminaires
- Four DC power circuits, each with 8 power points
- A 10 kWp PV panel

4 Solution Overview

This section identifies the components which are to be used, and describes their combined operation, to deliver the Learning Objectives.

4.1 Components

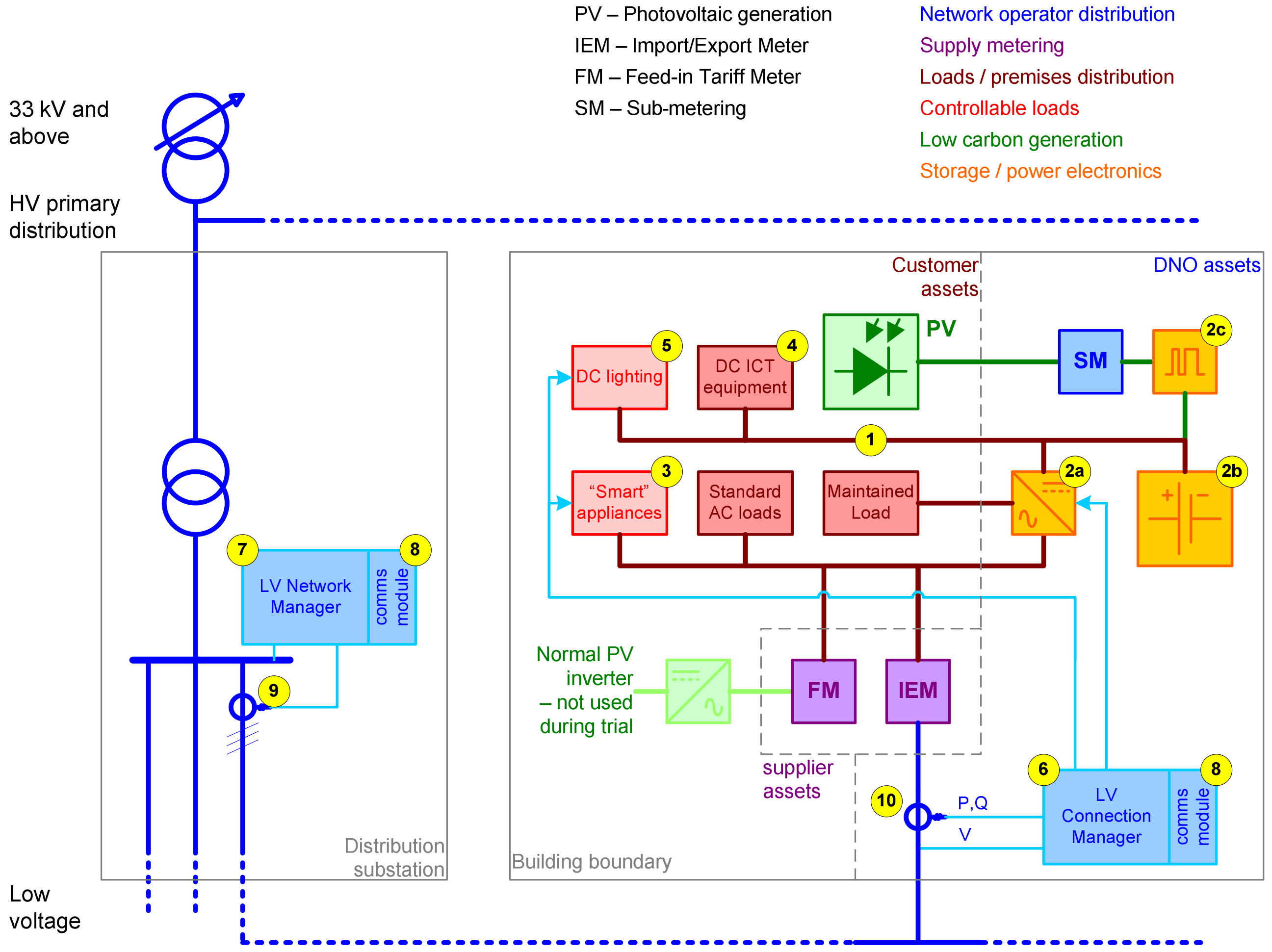


Figure 2 Technical Solution

Within Premises Equipment

Normal electrical distribution arrangements for premises connected at low voltage (LV) are as follows:

- The electrical supply is delivered by the network operator to the point of connection where it is metered. For feed-in tariff purposes this is an import/export meter (IEM in Figure 2).
- Photovoltaic (PV) generation is normally connected to the premises AC distribution through an inverter and feed-in tariff meter (FM).
- Appliances within the premises are supplied by AC distribution.

For the BRISTOL project it is proposed to modify this arrangement as follows:

- On the network side of the import/export meter (IEM) sensing equipment (10) is connected which provides measurements of voltage and power to the LV Connection Manager (6).
- An inverter (2a) connects a battery (2b) to the premises AC distribution.
- The battery also feeds a DC distribution system (1) which supplies DC loads such as IT equipment (4) and lighting (5).
- The PV generation, rather than feeding the AC distribution through its inverter, delivers its power to the battery and DC distribution system through a charge controller (2c).
- The LV Connection Manager is connected to control/influence the operating mode (charge/discharge) of the battery inverter (2a) and any loads which it can, including smart appliances (3), controllable AC loads such as intelligent appliances, and any controllable DC lighting.
- The LV Connection Manager communicates with the LV Network Manager (7) in the distribution substation using attached communication modules (8).

Substation Equipment

For the BRISTOL project equipment will be fitted at the distribution transformer/substation as follows:

- Sensing equipment (9) at the distribution transformer/substation is connected which provides measurements of voltage and power to the LV Network Manager (7).
- The LV Network Manager monitors the local measurements it receives, and those received from LV Connection Managers at premises on the LV network, to identify when the LV network reaches constraint points. These may be voltage and/or thermal constraints, and may be caused by an excess of load or an excess of generation. It then makes requests of the LV Connection Managers to adjust their load position to correct any constraint situations.

4.2 System Operation

The LV Connection Manager and the LV Network Manager provide the intelligence which allows the network to operate flexibly, to overcome the problems under investigation. The remaining components, while key to delivering the solution, respond to the instructions of these elements.

The LV Network Manager determines when a constraint is reached and determines where response is needed and requests that response.

The LV Connection Manager takes requests for response and turns those into actions by the equipment which is controllable in the premises.

4.3 Demand Response

While distributed electrical energy storage is the principle resource for responding to network needs, part of the solution being tested is demand response (DR), which is the ability of electrical equipment to modulate its load on the system in response to system needs and requests. The phrase is often used interchangeably with demand reduction, but DR may also include increasing load in response to system need.

There have been, and are ongoing, other studies[1,2] on the social aspects of DR and the depth of capability which they may offer. This project is not concerned with this, but rather to demonstrate and test the technical feasibility of integrating them within a system for management of the distribution network. This extends to whether the speed and duration demanded for network purposes is compatible with supply quality expectations of load customers.

Network planning activities for low carbon technologies frequently produce planning output with the constraint conditions described in section 1; reinforcements are required for these developments to proceed. Allowing the developments without reinforcement requires alternative methods of ensuring that the constraints do not occur, which is the basis for the technology trials of this project.

When there is low incidence of low carbon technologies, constraints at the planning stage may not necessarily result in actual constraint conditions in practice. However, as the quantity of these premises increases actual constraint conditions will become more prevalent. The frequency, duration and nature of constraint conditions under these scenarios is not yet known and this project will also allow this to be quantified, and hence establish which loads can provide the most appropriate demand response for the constraint.

Table 1 and Table 2 show the types of loads available in domestic properties in the UK, from the perspectives of demand reduction and demand increase respectively. It is not expected that immersion heaters or storage heating will be available within the domestic properties under consideration for this project, therefore these loads are not considered for the project.

[1] Energy Demand Research Project, http://www.ofgem.gov.uk/sustainability/edrp/Pages/EDRP.aspx

[2] Sustainability First project on GB Electricity Demand

Table 1 Loads Appropriate for Demand Reduction

Load	Typical load (domestic) (kW)	DR method	Typical availability *	Potential demand reduction (kW)	
				Peak †	Average †
Immersion heater	3	Interruption	Early morning, early evening	3	1
Storage heating	2	Interruption	Nighttime	2	2
Tumble drier	2.5	Smart appliance (requiring user interaction)	Occasional	2.5	2.5
Dishwasher	1		Occasional	1	1
Washing machine	0.63		Occasional	0.63	0.63
Lighting	0.01 – 0.2	Reduced output	Daytime, early evening and evening (esp. winter)	upto 0.1	upto 0.1

Table 2 Loads Appropriate for Demand Increase

Load	Typical load (domestic) (kW)	DR method	Typical availability *	Potential demand increase (kW)	
				Peak †	Average †
Immersion heater	3	Automatic control	Daytime, nighttime	3	3
Storage heating	2	Automatic control	Daytime, evening (cooler seasons only)	2	2
Tumble drier	2.5	Smart appliance (requiring user interaction)	Occasional	2.5	2.5
Dishwasher	1		Occasional	1	1
Washing machine	0.63		Occasional	0.63	0.63

<u>Notes for Table 1 and Table 2</u>

* Days are split into the following periods: early morning (0500-0700), morning (0700-0900), daytime (0900-1700), early evening (1700-1900), evening (1900-2300), nighttime (2300-0500)

† Peak DR potential is defined as 10 min. Average DR potential is defined as 30 min

5 Solution Technical Details

Each subsection below refers to a numbered element within Figure 2, e.g. section 5.3 refers to the item with a yellow numbered 3 in Figure 2.

5.1 DC Network

Description

While the use of DC networks within domestic and commercial premises is not common, there is wide experience of the use of DC appliances within the truck and leisure vehicle sector. Where possible it is proposed to make use of this learning for the BRISTOL project.

It is expected that 24 VDC will be used as the nominal voltage level for the DC network. This is a compromise between:

- Minimising current flow, and hence losses and switch breaking requirements, and
- Maximising availability of equipment (appliances, lighting, IT equipment, inverters and batteries).

The distribution voltage will be determined by the inverter and battery, but may float between 20 and 30 VDC, depending on battery charge state and mode of operation. Therefore all equipment and appliances will need to be suitable for operation over a wide voltage range.

A prototype DC distribution network has already been installed at University of Bath library, where it is supplying 50 PCs[3].

In the early stages of the project the choice of 24 VDC will be reviewed with regard to equipment cost, energy losses, technical feasibility and safety factors.

Requirements

The proposed requirements and features for the DC network are as follows:

- To be consistent with the requirements of Part P of the Building Regulations, drawing on BS 7671 IEE Wiring Regulations 17th edition as amended, to the extent that it is relevant to this installation;
- A nominal distribution voltage of 24 VDC, with a permissible voltage range of 20 to 30 VDC;
- Use of existing cabling, where safe and practicable (factors will include condition of existing cables and any connection points, cable sizes and required current ratings, ability to segregate DC requirements and proximity to other LVAC cables);
- Use of DC rated switches, contactors and circuit breakers; and
- Rating of the system as Functional Extra Low Voltage (FELV) and application of appropriate protective measures.

3 http://www.bath.ac.uk/news/2011/03/21/first-dc-network/

Technology Source

To confirm the project feasibility, enable budget costing and reduce technical risk the following sources have been identified for any special or non-standard equipment used for the DC network. (In this context 'non-standard' means not normally used for in-premises electrical distribution.) However, final decisions on the distribution arrangements, socket and switching arrangements and a full procurement exercise will be undertaken during the project.

- Switches for DC lighting – Moixa

5.2 Power Electronics and Energy Storage

Description

The centre of the electrical energy storage solution is the inverter, which takes charge from the battery and delivers it to the AC network. To connect the PV to the battery, and hence the inverter and AC loads, a charge controller is required to prevent overcharging the battery.

If feasible the battery and power electronics will be accommodated close to the consumer unit (a distribution board in the schools or office environment), and the AC connection to the inverter will be via a dedicated way on the consumer unit or distribution board.

Requirements

The outline requirements for the solution are as follows:

For the **Inverter**:

Essential requirements:

- Controllable modes of operation (charging battery, exporting power)
- A nominal voltage of 24 VDC, with a float/boost/fast charge voltage no higher than 30 VDC
- Meets G83/G59 requirements for loss of grid

Desired requirements:

- Islanding capability on loss of grid (to dedicated AC output)
- Controllable reactive power capability

For the **Battery**:

Essential requirements:

- Sealed, maintenance free
- A nominal voltage of 24 VDC, with a safe operating voltage range of 20 to 30 VDC

Desired requirements:

- Appropriate lifetime with high depth of discharge
- Good capacity with fast discharge rate

For the **Charge Controller**:

Requirements:

- A nominal voltage of 24 VDC, with an upper voltage no higher than 30 VDC

Technology Source

To confirm the project feasibility, enable budget costing and reduce technical risk the following technology has been identified that is capable of meeting the essential requirements. However, a full procurement exercise will be undertaken during the project.

- Inverter – Outback GFX and VFX series, SMA Sunny Backup, Studer Xtender series
- Batteries – wide availability
- Charge controller – wide availability

Testing battery technology is not considered an element of this project and the technology chosen should be considered proven, low risk and low cost for the duration of the project.

5.3 Smart Appliances

Description

An important aspect of project BRISTOL is demand response. Smart appliances will provide a method of achieving additional demand response while minimising the effect on lifestyle.

The phrase ‘smart appliance’ hides a variety of methods for delivering demand response through appliances, which ranges from remotely switched plug adaptors interrupting the supply to the appliance through to full integration of an appliance with ability to receive signals through remote communication.

As discussed in section 4.3 different appliances will have different DR characteristics with regard to size of load, availability periods, utilisation lengths and effect on lifestyle and it is hoped to be able to apply a variety of appliances to explore how they can fit into network needs for DR.

Requirements

The outline requirements for the solution are as follows:

Essential requirements:

- Capable of remote initiation and/or interruption of appliance operation
- Ability for users to override locally

Desired requirements:

- Minimal user interaction needed

Technology Source

To confirm the project feasibility, enable budget costing and reduce technical risk the following technology has been identified that is capable of meeting the essential requirements. However, a full procurement exercise will be undertaken during the project.

- Switched plug adaptors – Green Energy Options, Moixa

5.4 ICT Equipment

Description

The DC powered ICT equipment for the project will generally be in the form of PCs fitted with DC-DC converters.

Requirements

The outline requirements for the solution are as follows:

Essential requirements:

- A nominal distribution voltage of 24 VDC, with a permissible voltage range of 20 to 30 VDC

Desired requirements:

- High efficiency, >95% at 50% load

Technology Source

The technical feasibility of this aspect of the project is proven from the prototype DC distribution network installed by University of Bath, which used the following technology.

- DC-DC converters – Mini-Box 24V DC ATX power supply

5.5 DC Lighting

Description

The voltage of the distributed DC power will be determined by the inverter and battery, and the lighting will need to cope with a variable voltage supply. The DC lighting solution must comprise the lamps or modules, with any required regulating equipment (control modules), and switches or contactors with DC capability for operational switching.

The principal role identified for DC lighting within the project is as a load suitable for supplying from DC, with benefits of reduced transformation losses and harmonic emissions. In some instances lighting could also form a resource for demand response.

Requirements

The outline requirements for the solution are as follows:

For the **lamps**, with any required control module:

Essential requirements:

- Nominal 24 VDC
- High luminous efficiency

Desired requirements:

- Ability to dim

If a **control module** is used, the following is additionally desired of it:

- Safety extra low voltage (SELV) Isolation
- High efficiency
- Remotely controllable dimming

For the **operational switches**:

Essential requirements:

- Capable of switching DC

Desired requirements:

- Fits standard UK pattresses

Technology Source

To confirm the project feasibility, enable budget costing and reduce technical risk the following technology has been identified that is capable of meeting the requirements. However, a full procurement exercise will be undertaken during the project.

LED or DC compact fluorescent lamp (CFL) technology will be sourced

- LED lamps and DC compact fluorescent lamp (CFL) – wide availability
- Dimmable control module – Osram
- Switches for DC lighting (including dimmable control) – Moixa

5.6 LV Connection Manager

Description

The function of the LV Connection Manager is to integrate the capabilities of the PV, battery storage and the electrical demand to:

- minimise the financial cost of energy used,
- minimise the carbon impact of energy used,
- actively manage the real power profile to support the distribution network (demand response), and
- provide reactive power support to the network

to an overall optimal position through the control of the following aspects of their function:

- advancing and deferring load use, and/or reducing load use,
- generation and absorption of reactive power (through the inverter),
- active management of battery charge and discharge.

The following network use cases are defined which the LV Connection Manager should support (see section 5.7 below for details).

Table 3 Network Use Cases for LV Connection Manager

Situation		Electrical demand	Storage	PV
1. Excess generation over load on local network	1a. voltage upper limits exceeded	Increase/ advance load	Charge battery Absorb reactive power	Absorb reactive power Last resort: reduce output
	1b. thermal limits exceeded	Increase/ advance load	Charge battery	Last resort: reduce output
2. High peak load	2a. voltage lower limits exceeded	Decrease/ defer load	Discharge battery Export reactive power	
	2b. thermal limits exceeded	Decrease/ defer load	Discharge battery	
3. Need to profile match availability of low carbon generation		Adjust load to availability of LC energy	Charge/discharge battery to availability of LC energy	

The LV Connection Manager will be housed in each premises in the trial, close to the electrical point of supply. It is anticipated that this will be internal to the premises, although for some supply arrangements an external enclosure may be required.

Requirements

The outline requirements for the solution are as follows:

Essential requirements:

- Able to optimise the factors listed in the above Description
- Able to manage the resources of the premises in support of the Network Use Cases
- Able to communicate with the LV Network Manager
- Able to communicate/integrate with the other components in the premises
- Appropriate for deploying in unmanaged domestic and non-domestic premises

Desired requirements:

- Of a size and form to facilitate deployment at point of connection

Technology Source

The LV Connection Manager will be based on Siemens automation hardware integrating other off the shelf components as necessary to achieve the required functionality.

5.7 LV Network Manager

Description

The function of the LV Network Manager is to identify constraint conditions within the LV network and attempt to resolve them by calling on the capabilities of customers connected to the LV network, managed by LV Connection Managers.

Section 1 describes the specific constraints that the LV Network Manager seeks to highlight and mitigate. These are repeated here:

1. Excess generation over load on local network, resulting in
   - 1a. Voltage upper limits exceeded, and/or
   - 1b. Thermal limits exceeded (power import); and
2. High peak load, resulting in
   - 2a. Voltage lower limits exceeded, and/or
   - 2b. Thermal limits exceeded (power export).

The LV Network Manager will receive measurements locally from the distribution substation/transformer, and from those premises with LV Connection Managers. Additional measurements may also be required from other premises at the ends of feeders. These measurements will be used to determine if any of the constraint conditions (1a, 1b, 2a or 2b) are reached and if so will attempt to redress the associated cause (1 or 2) by changing the power flow from/to premises under control of the scheme via their LV Connection Managers.

The LV Network Manager will be installed at a distribution substation or transformer. It will need to employ components suitable for such deployment and housed in an appropriate enclosure. It is expected that all the substations will be ground-mounted. The project will ideally seek test networks involving indoor substations with space to accommodate the equipment, however, space requirements may dictate that outdoor enclosures are required.

Requirements

The outline requirements for the solution are as follows:

Essential requirements:

- Able to receive measurements from LV Connection Managers and local sensors
- Able to determine when voltage and/or thermal constraints are reached from available measurements
- Able to determine which actions are most beneficial to mitigating the constraint
- Able to communicate requests for those actions to LV Connection Managers
- Able to operate autonomously
- Appropriate for deploying alongside ground-mounted distribution substations

Desired requirements:

- Able to be remotely accessed for supervisory and data collection purposes
- Appropriate for deploying externally

Technology Source

The LV Network Manager will be based on Siemens automation hardware integrating other off the shelf components as necessary to achieve the required functionality.

5.8 LV Communications

Description

The LV Communications (indicated by A in Figure 3) are required to communicate from the LV Network Manager to LV Connection Managers, and vice versa. The communication channel will allow the LV Network Manager to issue requests for action to alleviate constraints to the LV Connection Managers, and allow the LV Connection Managers to provide the LV Network Manager with measurements from within the network, and report on actions taken in response to requests from the LV Network Manager.

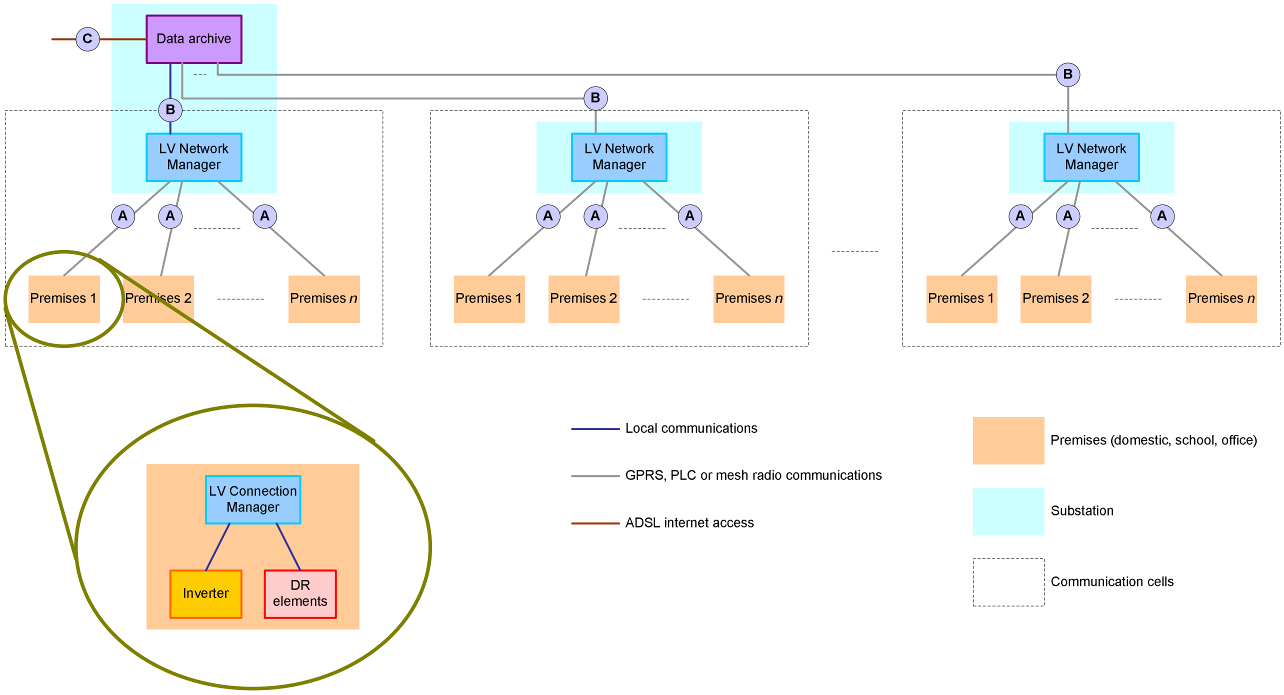


Figure 3 Communications Architecture

Requirements

The outline requirements for the solution are as follows:

Essential requirements:

- Allow an LV Network Manager to communicate with up to 32 LV Connection Managers;
- Support event driven communications (in either direction) with a latency not exceeding 1 second;
- Support periodic communication of measurements from the LV Connection Managers to the LV Network Manager (could be polled), with periods of no less than 1 minute
- Support a total peak payload data rate (total of all stations) of 4 kB per second on the uplinks (to the LV Network Manager) and 0.5 kB per second on the downlinks, with a sustained rate of 3 MB per day on the uplinks and 1 MB per day on the downlinks
- Privacy and security of customer's data is of paramount importance, and appropriate authentication mechanisms to access the communications payloads are required

Desired requirements:

- Communications channel behaves as a bridge, with TCP/IP interfaces at each end (transparent operation)

Technology Source

Testing communications methods is not considered an element of this project and the method chosen should be considered proven and low risk. WPD have existing LCNF projects which are trialling communications for LV networks using power line carrier (PLC). If the PLC communications of these existing projects meet the requirements for Project BRISTOL, and the existing projects indicate sufficient confidence can be placed on these communications, they will be considered for Project BRISTOL.

Other methods under consideration include General Packet Radio Service (GPRS) and, if geography allows, meshed radio such as Zigbee.

5.9 LV Distribution Network Sensors and Instrumentation

Description

The purpose of the LV distribution network sensors and instrumentation is two-fold: firstly, to collect measurements which are used by the LV Network Manager as part of its management of the distribution network; and secondly, as part of the collection of trial data to measure the effectiveness of the intervention methods.

For the LV network management the required data will be voltage of the busbars and real and reactive power flow into each phase of each feeder under management. These measurements will be concerned with RMS values only.

For the collection of trial data the requirements will include measurement of harmonics since one of the hypotheses is that the use of DC networks can improve power quality.

It is possible that the differing requirements, programme timing and cost implications result in separate sets of sensors and instrumentation for each purpose

Requirements

For network management:

Essential requirements:

- Measurement of voltage, real and reactive power, true RMS
- Averaging period maximum 1 second
- Instantaneous values only required
- Capable of fitting without customer interruption

For collection of trial data:

Essential requirements:

- Measurement of voltage, including harmonic content
- Measurement of real and reactive power, true RMS
- Averaging period minimum 1 minute
- All data to be logged continuously and time stamped
- Time stamps within each cell to be synchronised with 20 millisecond accuracy

Desired requirements:

- Measurement of real and reactive power, including harmonic content

Technology Source

To confirm the project feasibility, enable budget costing and reduce technical risk the following technology has been identified that is capable of meeting the essential requirements. However, a full procurement exercise will be undertaken during the project.

- CT – split core, Rogowski coil or optical fibre based current sensors
- Instrument – Siemens Simeas P50

Testing measurement sensors is not considered an element of this project and the method chosen should be considered proven and low risk. WPD have existing LCNF projects which are trialling different measurement sensors. The BRISTOL project will draw on the results of these trials in the selection of appropriate sensors.

5.10 Customer Premises Sensors

Description

The customer premises sensors are required to collect measurements for transmission to the LV Network Manager as part of its management of the distribution network.

The required data will be voltage at the point of supply and real and reactive power flow to/from each premises. These measurements will be concerned with RMS values only. Measurements will be restricted to those premises which are part of the trial, although a further voltage measurement from a point towards the end of the feeder may be required.

Requirements

The outline requirements for the solution are as follows:

Essential requirements:

- Measurement of voltage, real and reactive power, true RMS
- Averaging period maximum 1 second
- Instantaneous values only required

Technology Source

To confirm the project feasibility, enable budget costing and reduce technical risk the following technology has been identified that is capable of meeting the essential requirements. However, a full procurement exercise will be undertaken during the project.

- CT – solid core, split core, Rogowski coil or optical fibre based current sensors
- Instrument – Siemens Simeas P55

Testing measurement sensors is not considered an element of this project and the method chosen should be considered proven and low risk. WPD have existing LCNF projects which are trialling different measurement sensors. The BRISTOL project will draw on the results of these trials in the selection of appropriate sensors.

5.11 Data Collection and Archiving

Description

The LV Communications (indicated by A in Figure 3) are required to communicate from the LV Network Manager to LV Connection Managers, and vice versa. The communication channel will allow the LV Network Manager to issue requests for action to alleviate constraints to the LV Connection Managers, and allow the LV Connection Managers to provide the LV Network Manager with measurements from within the network, and report on actions taken in response to requests from the LV Network Manager.

A system for logging metering and operational data and allowing access to this data for trial evaluation purposes is required. Figure 3 shows the expected location for the data archive and the communication links with the various devices being monitored are shown.

Requirements

The outline requirements for the solution are as follows:

Essential requirements:

- Able to receive data from all the LV network managers, LV connection managers, LV network instruments and customer premises instruments
- Able to be accessed by the relevant project partners as part of the evaluation of the trial results

- Data should be stored securely recognising that privacy of customer's data is of paramount importance, and appropriate authentication mechanisms to access the data are required

Technology Source

The LV Network Manager will be based on a Siemens data logging system.

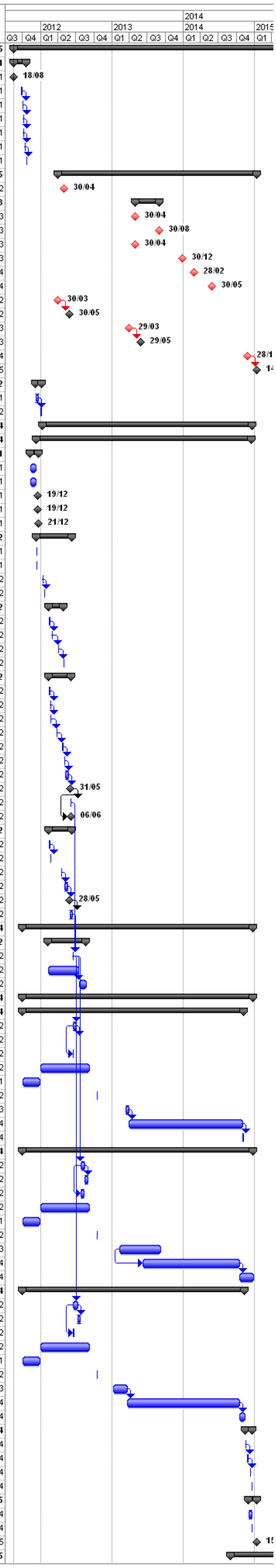
5.12 Energy Supplier Tariffs

Description

A number of Variable Tariffs will be will be trialled on the domestic installations to incentivise customers to alter their demand profile, flattening their demand, reducing their peaks using the automated LV connection manager, battery storage, micro generation or lifestyle changes or a mixture of the four. The variable tariff will be coordinated through the LV connection manager.

Appendix D: Project Plan

ID	Task Name	Duration	Start	Finish
1	**BRISTOL PROJECT**	**988.02 days**	**Thu 18/08/11**	**Wed 01/07/15**
2	**Post Submission**	**44.77 days**	**Thu 18/08/11**	**Fri 21/10/11**
3	Submit Proforma to Ofgem	0 days	Thu 18/08/11	Thu 18/08/11
4	Review partner MOU comments	5 days	Fri 23/09/11	Fri 30/09/11
5	Send Revised MOU to partners - Scope	1 day	Fri 30/09/11	Mon 03/10/11
6	All Partner meeting	1 day	Mon 03/10/11	Tue 04/10/11
7	Send T&C - Partners	1 day	Tue 04/10/11	Wed 05/10/11
8	Agree T&C's	1 day	Wed 12/10/11	Thu 13/10/11
9	Sign Final MOU	1 day	Thu 20/10/11	Fri 21/10/11
10	**OFGEM Milestones**	**713.81 days**	**Fri 30/03/12**	**Wed 14/01/15**
11	Hold a customer workshop with Bristol City Council and potential trial participants	0 days	Mon 30/04/12	Mon 30/04/12
12	**Successfully install equipment in all of the selected trial properties**	**87.21 days**	**Tue 30/04/13**	**Fri 30/08/13**
13	Homes	0 days	Tue 30/04/13	Tue 30/04/13
14	Schools	0 days	Fri 30/08/13	Fri 30/08/13
15	Business	0 days	Tue 30/04/13	Tue 30/04/13
16	Capture and share early learning (DC networks and battery storage)	0 days	Mon 30/12/13	Mon 30/12/13
17	Capture and share early learning (economics of demand side management)	0 days	Fri 28/02/14	Fri 28/02/14
18	Capture and share early learning (impact on the distribution network)	0 days	Fri 30/05/14	Fri 30/05/14
19	Knowledge Capture - Customer opinion Pre trial	0 days	Fri 30/03/12	Fri 30/03/12
20	Share customer opinion Pre trial	0 days	Wed 30/05/12	Wed 30/05/12
21	Knowledge Capture - Customer opinion during trial	0 days	Fri 29/03/13	Fri 29/03/13
22	Share customer opinion during trial	0 days	Wed 29/05/13	Wed 29/05/13
23	Knowledge Capture - Customer opinion Post trial	0 days	Fri 28/11/14	Fri 28/11/14
24	Share customer opinion Post trial	0 days	Wed 14/01/15	Wed 14/01/15
25	**Project Governance and Control**	**20 days**	**Mon 05/12/11**	**Thu 05/01/12**
26	Project Team Mobilisation	10 days	Mon 05/12/11	Mon 19/12/11
27	Project Governance processes in place	5 days	Wed 28/12/11	Thu 05/01/12
28	**Senior Management Meetings**	**754.15 days**	**Mon 09/01/12**	**Fri 19/12/14**
42	**Lessons Learned**	**768.03 days**	**Mon 12/12/11**	**Tue 16/12/14**
50	**Stakeholder engagement and communications**	**31.71 days**	**Mon 07/11/11**	**Wed 21/12/11**
51	Develop a Stakeholder Engament Plan	20 days	Mon 07/11/11	Mon 05/12/11
52	Develop a Data Protection Plan	20 days	Mon 07/11/11	Mon 05/12/11
53	Stakeholder engagement strategy reviewed and approved internally	0 days	Mon 19/12/11	Mon 19/12/11
54	Stakeholder engagement strategy reviewed and approved internally	0 days	Mon 19/12/11	Mon 19/12/11
55	Sent to Ofgem	0 days	Wed 21/12/11	Wed 21/12/11
56	**Setup and Development**	**120.23 days**	**Mon 12/12/11**	**Fri 08/06/12**
57	Send Press release to all partners	1 day	Mon 12/12/11	Tue 13/12/11
58	Update WPD website	1 day	Mon 12/12/11	Tue 13/12/11
59	Project Kick off meeting - All Partners	1 day	Mon 09/01/12	Tue 10/01/12
60	Write detailed specification for each section	5 days	Tue 17/01/12	Tue 24/01/12
61	**Office**	**51 days**	**Mon 13/02/12**	**Thu 26/04/12**
62	Create Information pack for the office	5 days	Mon 13/02/12	Mon 20/02/12
63	Send Information pack out	1 day	Mon 27/02/12	Tue 28/02/12
64	Arrange for meeting with relevant parties	2 days	Thu 29/03/12	Mon 02/04/12
65	Hold Meeting with BCC	1 day	Wed 25/04/12	Thu 26/04/12
66	**Schools**	**78 days**	**Mon 13/02/12**	**Thu 07/06/12**
67	Create information pack for schools recruitment	5 days	Mon 13/02/12	Mon 20/02/12
68	Get contact details for schools	1 day	Mon 20/02/12	Tue 21/02/12
69	Send Information pack Head teachers and the board of governors	1 day	Tue 21/02/12	Wed 22/02/12
70	Arrange for meeting with relevant parties	2 days	Fri 23/03/12	Tue 27/03/12
71	Speak to schools	5 days	Thu 19/04/12	Thu 26/04/12
72	Review process	2 days	Wed 02/05/12	Fri 04/05/12
73	Site visits - Completed	10 days	Fri 04/05/12	Mon 21/05/12
74	Site visit report - Received	0 days	Thu 31/05/12	Thu 31/05/12
75	Select Schools	3 days	Thu 31/05/12	Thu 07/06/12
76	DECISION - Is their a requirement for a change in scope	0 days	Wed 06/06/12	Wed 06/06/12
77	**Homes**	**78.61 days**	**Mon 13/02/12**	**Fri 08/06/12**
78	Create information pack for homes recruitment	5 days	Mon 13/02/12	Mon 20/02/12
79	Send to (Bath / kwm)	1 day	Mon 20/02/12	Tue 21/02/12
80	Hold workshop	1 day	Mon 16/04/12	Tue 17/04/12
81	Site visits - Completed	10 days	Tue 01/05/12	Wed 16/05/12
82	Site visit report - Received	0 days	Mon 28/05/12	Mon 28/05/12
83	Select properties	5 days	Wed 30/05/12	Fri 08/06/12
84	**Trial**	**823.51 days**	**Fri 30/09/11**	**Tue 23/12/14**
85	**Substations**	**131.55 days**	**Thu 09/02/12**	**Mon 20/08/12**
86	Substation Site visits	3 days	Tue 12/06/12	Fri 15/06/12
87	Detailed Design and procurement	105 days	Thu 09/02/12	Thu 12/07/12
88	Substation Installations	26 days	Fri 13/07/12	Mon 20/08/12
89	**Customer Installations**	**823.51 days**	**Fri 30/09/11**	**Tue 23/12/14**
90	**Office**	**792.26 days**	**Fri 30/09/11**	**Fri 07/11/14**
91	Detailed survey and planning	10 days	Fri 15/06/12	Fri 29/06/12
92	Review of wiring	3 days	Fri 29/06/12	Wed 04/07/12
93	Civil / structural review	2 days	Fri 15/06/12	Tue 19/06/12
94	Detailed Design and procurement	168 days	Fri 30/12/11	Mon 03/09/12
95	Factory Testing	60 days	Fri 30/09/11	Fri 23/12/11
96	Training	2 days	Mon 15/10/12	Wed 17/10/12
97	Install office equipment	10 days	Mon 11/03/13	Mon 25/03/13
98	Operation	416 days	Mon 25/03/13	Fri 31/10/14
99	Decommissioning	5 days	Fri 31/10/14	Fri 07/11/14
100	**Schools**	**823.51 days**	**Fri 30/09/11**	**Tue 23/12/14**
101	Detailed survey and planning	15 days	Mon 23/07/12	Mon 13/08/12
102	Review of wiring	10 days	Mon 13/08/12	Tue 28/08/12
103	Civil / structural review	10 days	Mon 23/07/12	Mon 06/08/12
104	Detailed Design and procurement	168 days	Fri 30/12/11	Mon 03/09/12
105	Factory Testing	60 days	Fri 30/09/11	Fri 23/12/11
106	Training	2 days	Mon 15/10/12	Wed 17/10/12
107	Install Schools equipment	147 days	Fri 08/02/13	Wed 04/09/13
108	Operation	351 days	Tue 04/06/13	Mon 13/10/14
109	Decommissioning	50 days	Tue 14/10/14	Tue 23/12/14
110	**Homes**	**792.67 days**	**Fri 30/09/11**	**Mon 10/11/14**
111	Detailed survey and planning	15 days	Fri 15/06/12	Fri 06/07/12
112	Review of wiring	10 days	Fri 06/07/12	Fri 20/07/12
113	Civil / structural review	5 days	Fri 15/06/12	Fri 22/06/12
114	Detailed Design and procurement	168 days	Fri 30/12/11	Mon 03/09/12
115	Factory Testing	60 days	Fri 30/09/11	Fri 23/12/11
116	Training	2 days	Mon 15/10/12	Wed 17/10/12
117	Install Homes Equipment	50 days	Mon 07/01/13	Mon 18/03/13
118	Operation	406 days	Mon 18/03/13	Mon 13/10/14
119	Decommissioning	20 days	Mon 13/10/14	Mon 10/11/14
120	**Benefits Realisation**	**23.79 days**	**Mon 17/11/14**	**Fri 19/12/14**
121	Benefits Review sessions	3 days	Mon 17/11/14	Thu 20/11/14
122	Interim Benefits report produced and approved	5 days	Mon 24/11/14	Mon 01/12/14
123	Final Benefits report completed	1 day	Mon 08/12/14	Tue 09/12/14
124	Final Benefits report approved	1 day	Thu 18/12/14	Fri 19/12/14
125	**Project Completion**	**30.72 days**	**Wed 03/12/14**	**Thu 15/01/15**
126	Project Closure Report	10 days	Wed 03/12/14	Wed 17/12/14
127	Project Closure Report signed off	1 day	Thu 18/12/14	Fri 19/12/14
128	End of project	0 days	Thu 15/01/15	Thu 15/01/15
129	**Other**	**215.05 days**	**Mon 01/09/14**	**Wed 01/07/15**



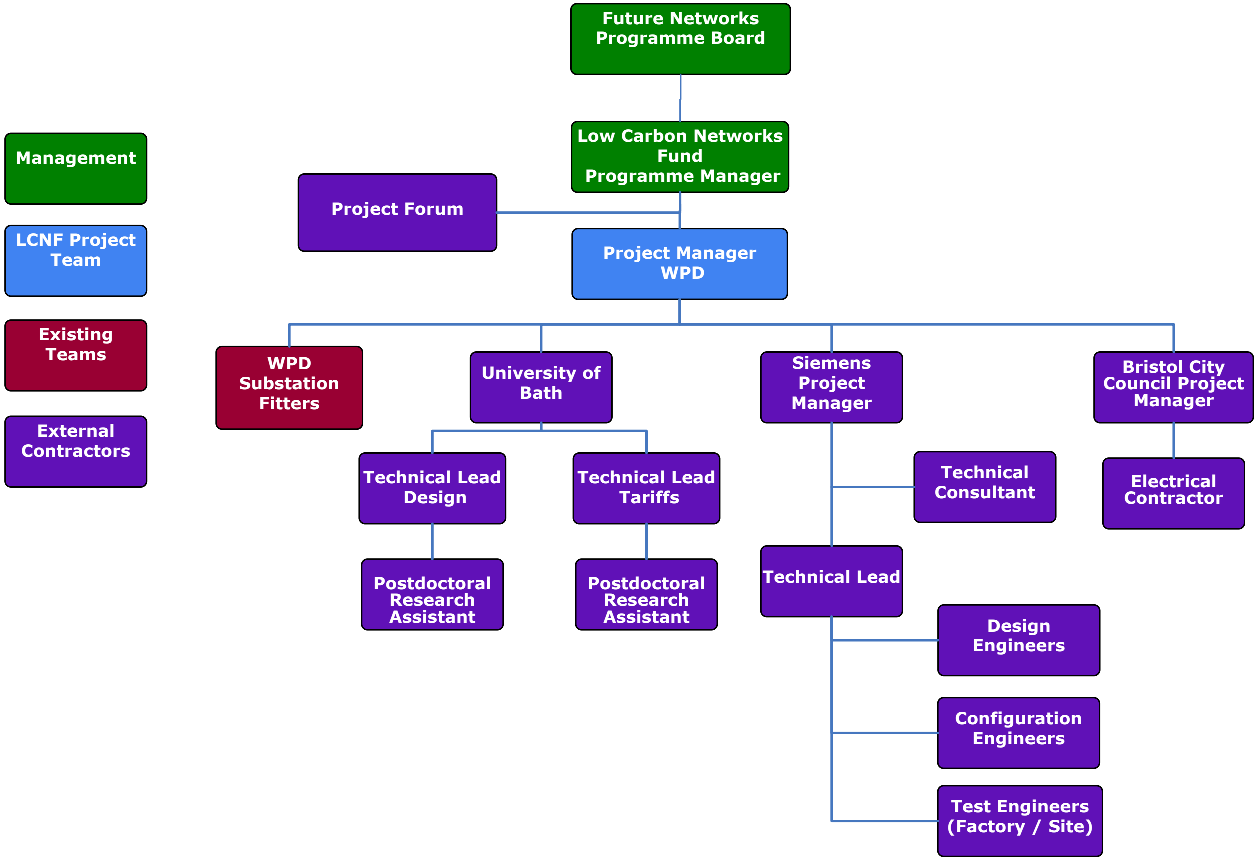
Appendix D - Risk Register

Project Name: Bristol | **Project Manager:** Roger Hey

Risk Ref. No.	Risk Status	Owner	High Level Definition: "There is a risk that..."	Impact	Probability	Proximity	Rating	Movement	Raised by	Raised on	Target Date	Last Updated	Cause: "...because of..."	Effect: "...leading to..."	Mitigation Action Plan	Signs that the risk is about to occur or become an Issue	Issue ID
Next No.	Dropdown list	Responsible for mgt	Details of the Risk	See Table below Score 1-5	See Table below Score 1-5	See Table below Score 1-5	Auto Calculated	If risk has changed to a higher / lower priority	Who raised the Risk?	when was it raised?	Target Date for Resolution	Last date the risk was updated	What will Trigger the Risk?	What will happen if it occurs?	How will this Risk be avoided?	How do you know if Risk has Occurred?	ID of Issue Risk has transferred to
R001	Raised	Roger Hey	RWE npower are unable to support the development of the smart tariffs, feeding information into the University of Bath.	2	2	4	16	⇩	PB	20-May-11	3-Jun-11	12-Aug-11	RWE npower not being able to provide advice for this section of the project.	No energy retailer support from RWE npower, a risk of produce a variable tariff that is unrepresentative of future tariffs.	Engage with RWE npower early in the project, maintain the relationship. If risk materialises, arrange a meeting with all energy retailers to discuss future tariffs.	RWE npower unable provide information to the University of Bath	
R002	Raised	Roger Hey	Energy efficient smart appliances used for demand response are not available in the UK when required or appliances can not be retrofitted (making them smarter)	2	3	2	12	⬄	PB	20-May-11	15-Jun-11	31-May-11	Demand for appliances exceeds capacity or retro fit kits are not available	A limited number of appliances available with long lead times or very high costs / No retrofit kits available	Regularly monitor the availability of key components, updating the project plan if required.	No development in the smart appliance market	
R003	Raised	Roger Hey	There will be insufficient WPD resource to deliver BRISTOL	3	2	4	24	⇩	PB	13-Jun-11	24-Jun-11	13-Jun-11	Insufficient resource in the innovation and low carbon team	Insufficient project engineers to manage BRISTOL and other T2, T1 and IFI projects	The business is aware of the additional resources required for BRISTOL.	A lack of resource	
R004	Raised	Roger Hey	When surveying properties, the BRISTOL scope of works must change, resulting in unanticipated cost variations.	3	3	4	36	⬄	PB	5-Aug-11	13-Sep-11	12-Aug-11	The properties are significantly different than the assumptions.	Use contingency allowed for in the submission spreadsheet or refer to the project board for guidance.	The scope has been agreed with all project partners using the experience from all parties. A contingency allowance has been built into the project scope and the default cost overrun of 5% has been requested.	The installations will have to significantly change after the initial surveys.	
R005	Raised	Roger Hey	Our partners and supporters perceptions on the project may change	4	2	4	32	⬄	PB	5-Aug-11	13-Sep-11	12-Aug-11	Unclear communications and a belief the project will not achieve the original objectives.	Project partners being unhappy with the project delivery, potentially no longer wishing to support the project	Work with all project partners and supporters through out the design and development of the project. Ensure communications are clear and the objectives are known. Send final submission to project partners before submission.	Feedback from our partners	
R006	Raised	Roger Hey	Thirty homes do not volunteer to participate in BRISTOL in one area, connected to one distribution substation.	4	3	4	48	⬄	PB	5-Aug-11	13-Sep-11	12-Aug-11	A limited or poor response when engaging with customers.	A limited number of customers attending the workshop and volunteering for the trial.	An participant recruitment company with prior experience will work with Bristol City Council and WPD to communicate the project. Homes could be spread across several locations close to schools participating in the trial.	Poor response from customers, limited interest, and a poor turnout at the customer workshop	
R007	Raised	Roger Hey	Ten schools do not volunteer to take part in the project.	4	3	4	48	⬄	PB	5-Aug-11	13-Sep-11	12-Aug-11	A limited or poor response when engaging with schools.	A limited number of schools attending the workshop and volunteering for the trial	An participant recruitment company with prior experience will work with Bristol City Council and WPD to communicate the project. A significant number of schools will be approached.	Poor response from customers, limited interest, a low turnout at the customer workshop	
R008	Raised	Roger Hey	A suitable office can not be found to take part in the project	3	2	4	24	⇩	PB	5-Aug-11	13-Sep-11	12-Aug-11	No suitable office location can be found.	No office environment to test the trial	Work with Bristol City Council early in the project to identify a suitable office, offer the trial to other participants with LCT and / or high DC loads.	No office is put forward for the trial after the project has received funding	
R009	Raised	Roger Hey	Bristol City Councils M&E teams or normal qualified electrical contractors are unable to install and maintain the premises BRISTOL equipment	4	3	4	48	⬄	PB	5-Aug-11	13-Sep-11	12-Aug-11	The M&E team or the contractors do not have sufficient resource to commit to the installations	Tender with Bristol City Council for an alternative contractor to install and maintain the LV connection manager and associated equipment	Discuss the project with other qualified electrical contractors from other areas including PV installation as the skills set is similar. Potentially using two contractors with different skill sets.	Feedback that the M&E team or contractors can not complete the installations when the funding has been awarded.	
R010	Raised	Roger Hey	The LV connection & network manager are not be ready for installation inline with the project plan	4	2	3	24	⬄	PB	5-Aug-11	13-Sep-11	12-Aug-11	The design and factory testing falls behind the project plan	A delay in the project plan	Regular monthly meetings will be held with the Siemens project manager to ensure delivery is inline with the project plan.	Slips in the project plan that can not be recovered discussed during the monthly meetings	
R011	Raised	Roger Hey	Siemens are unable to integrate Moixa's smart hub into the LV home controller	1	3	4	12	⬄	PB	5-Aug-11	13-Sep-11	12-Aug-11	The technologies are unable to be integrated, or the costs of integrating the technologies are to high	Siemens developing the LV Connection Manager without Moixa	Allow sufficient time for the development of the LV Connection Manager by Siemens without Moixa.	Discussions with Siemens and Moixa after the awarding of funding	
R012	Raised	Roger Hey	The cost of some higher cost items are significantly higher then estimated	3	2	4	24	⬄	PB	5-Aug-11	13-Sep-11	12-Aug-11	During procurement stage of the project results in higher costs then in the project submission spreadsheet	The project contingency built into the submission spreadsheet being used or if exceeding the contingency refer to the project board	Costs will be re forecasted after the award of funding in greater detail.	The results from the costing exercise after funding award.	
R013	Raised	Roger Hey	The equipment is too heavy to be stored in the roof space.	3	3	4	36	⬄	PB	5-Aug-11	13-Sep-11	12-Aug-11	The structural review of the integrity of homes, schools and an office roof space.	A review of the project, potential change of scope.	The roof space will undergo a structural survey to advise if it is sufficient to store equipment.	The output from the initial survey.	
R014	Raised	Roger Hey	There is no suitable location to store the equipment in homes, schools and an office.	4	3	4	48	⬄	PB	5-Aug-11	13-Sep-11	12-Aug-11	The survey of properties	A review of the project and a potential change of scope.	The properties will be reviewed to find alternative locations to site equipment. The potential issue of space constraints has already been	The output from the initial survey.	
R015	Raised	Roger Hey	The AC wiring in homes, schools and the office are can not be converted to DC operation	4	3	4	48	⬄	PB	5-Aug-11	13-Sep-11	12-Aug-11	The existing wiring is not suitable for operation with DC due to its age or condition	A review of the project, potential change of scope.	The wiring will undergo an survey to advise if it is possible to retrofit to DC operation.	The output from the initial survey.	
R016	Raised	Roger Hey	A suppliers regulatory restrictions are not lifted, preventing the use of DC metering for micro generation	3	3	3	27	⬄	PB	5-Aug-11	13-Sep-11	12-Aug-11	Suppliers can not meter for FIT payments	BRISTOL not being able to feed PV into the batteries without converting to AC first	The energy supplier signed up for the FIT will be contacted to request a derogation from an AC meter. This has been discussed with Ofgem and DECC	The output from initial conversations with the chosen energy supplier	
R017	Raised	Roger Hey	Customers do not use the equipment installed effectively	3	2	3	18	⬄	PB	5-Aug-11	13-Sep-11	12-Aug-11	Customers do not engage with the equipment.	Little changes in behaviour and customers not feeling engaged with the trial	A participant recruitment company with prior experience will work with Bristol City Council and WPD to maintain a relationship with customers, providing help where needed.	Customer feedback shows they are unhappy with the installations	
R018	Raised	Roger Hey	Customer wish to terminate the trial before 18 months	4	2	3	24	⬄	PB	5-Aug-11	13-Sep-11	12-Aug-11	A customer inform either the recruitment company or Bristol City Council they wish to terminate the trial	The recruitment company will work with the customer to rectify any issues, if not successful, early decommissioning of the project in the property.	The project will ensure customers feel engaged with the trial and solve problems quickly.	Customer feedback or complaint	
R019	Raised	Roger Hey	The BRISTOL project does not successfully integration LCT into the distribution network	3	2	2	12	⬄	PB	5-Aug-11	13-Sep-11	12-Aug-11	The LV connection manager or network manager records the network performing outside of the permissible levels	Network monitoring equipment will installed to check the results, if outside of the permissible levels reinforce using the most appropriate method	A network study will be carried out before any LCTs are installed.	Alerts from the LV Network Manager or a complaint from a connected customer	
R020	Raised	Roger Hey	The customers do not want to use a variable tariff.	3	3	2	18	⬄	PB	5-Aug-11	13-Sep-11	12-Aug-11	Customer feedback suggests the variable tariff is too complicated	A review of the variable tariff, potentially removing if from the trial for selected customers	The variable tariff will be presented to customers before being implemented. The complexity will be considered through out the development.	Customer feedback or complaint	
R021	Raised	Roger Hey	The communications for BRISTOL is used by a third party in a method other then designed	3	2	2	12	⬄	PB	5-Aug-11	13-Sep-11	12-Aug-11	The communications in BRISTOL may be used for purposes other then designed	Shutting down the communications, running the properties without network communications until a secure solution can be found	Secure communications protocols will be used when developing the trials. All equipment in properties will be in a secure container. The connection to WPD will not integrate with any other networked computers.	Alarm or failure of communications.	
R022	Raised	Roger Hey	Communications between the LV connection manager and LV network manager drops out	2	2	2	8	⬄	PB	5-Aug-11	13-Sep-11	12-Aug-11	Failed or compromised communications between the LV Connection Manager and LV Network Manager	The LV Connection Manager will operate in a islanded mode without communications, customers will not notice any difference	A robust communications network will be installed and tested before installation.	Alarm or failure of communications.	
R023	Raised	Roger Hey	Bristol City Council are unable to support the customer engagement and installations	4	2	4	32	⇩	PB	5-Aug-11	13-Sep-11	12-Aug-11	Bristol City Council can not support the trial installations and maintenance	WPD will discuss with the Council a change in scope, with WPD supporting the installations and maintenance.	Continued involvement of all project partners and supporters, commitment at all levels of the council.	Feedback	
R024	Raised	Roger Hey	The LCT installation falls through or is delayed	3	1	4	12	⬄	PB	5-Aug-11	13-Sep-11	12-Aug-11	Bristol City Council informing WPD microgeneraiton will not be connected	Reduced learning	Funding has already been secured, the progress of other connecting projects will form part of monthly progress meetings.	Feedback	

IMPACT	PROBABILITY	PROXIMITY	Movement
5 – Inability to deliver, business case/objective not viable	**5** – Certain	**5 –** Imminent	⇧
4 – Substantial Delay, key deliverables not met, significant increase in time/cost	**4** – More likely to occur than not	**4 –** Likely to be near future	⇩
3 – Delay, increased cost in excess of tolerance	**3** – 50/50 chance of occurring	**3 –** Mid to short term	⬄
2 – Small Delay, small increased cost but absorbable	**2** – Less likely to occur	**2 –** Mid to long term	
1 – Insignificant changes, re-planning may be required	**1** – Very unlikely to occur	**1 –** Far in the future	

Appendix D: Organogram - The schematic below shows the structure of BRISTOL



Overall Solution Design and Integration - Siemens

Project activity	Customer installations & maintenance	LV Network Controller	LV Connection manager	Smart Appliances	DC Lighting	Power Electronics & Storage	ICT	Comms, Sensors & Substation installation	Knowledge Dissemination	Feasibility study	Variable Tariff	Network Modelling
Lead Delivery Partner	BCC	Siemens						WPD	University of Bath			
Supporting Partner	University of Bath									Siemens	RWE npower	WPD

Appendix D: Contingency Plan

A contingency plan has been written for the significant risks on the Risk Register (Appendix D). All risks will be continually monitored and risks with a rating greater than 40 will be referred to the project board. Below are details of how we will mitigate against significant risks becoming an issue and the contingency plans.

R006. 30 homes do not volunteer to participate in BRISTOL in one area, connected to one distribution substation.
Mitigation • Develop a detailed customer communications plan between the project submission and bid award. The customer communications plan will be checked by all project partners and Bristol City Council to gain a seal of approval. • Work with a trial participants recruitment company and Bristol City Council who have a proven track record for recruiting trial participants. • Hold a workshop before April 2012 to highlight any issues early. **Contingency** • Offer the trial to a increased number of homes, Recruiting homes in multiple locations connected to the same distribution substations as the 10 schools participating in the trial.
R007. 10 schools do not volunteer to take part in the project
Mitigation • Develop a detailed customer communications plan between bid submission and bid award. • Work with a trial participants recruitment company and Bristol City Council • Hold a workshop before April 2012 to highlight any issues early. **Contingency** • Offer the BRISTOL solution to schools not included on the solar for PV scheme
R009. Bristol City Councils M&E teams are unable to install and maintain the equipment or Bristol city councils normal qualified electrical contractors do not wish to install the equipment.
Mitigation • Include a training allowance so any contractor will be trained on installing the equipment • Include a high level of contingency on the cost for the installation and the amount of time needed. • Start conversations with delivery teams early in the project to identify if this could become an issue. • Install equipment with a high technology readiness levels and no maintenance requirements • Hold a Factory acceptance test for the equipment before the equipment is installed in homes, schools and the office. **Contingency** • Engage with other electrical contractors who have not previously worked on Bristol City councils homes. • Potentially split the work into smaller areas, engaging specialists from other areas for some aspects of the installation.

R014. There is no suitable location to store the equipment in homes, schools and an office.

Mitigation

- Visit properties signed up for the project early in the product development cycle so any restrictions can be taken into account before the design is completed

Contingency

- Re evaluate the project aims, looking for alternative ways to generate the new learning detailed in the bid submission
- If weight or equipment size is a limiting factor, consider separating equipment into smaller boxes or reducing the scale of the storage.
- Look to reduce the size of the equipment or find alternative locations to store equipment including outside premises.

R015. The AC wiring in homes, schools and the office are can not be converted to DC operation

Mitigation

- Existing AC wiring has been converted to operate on DC before.

Contingency

- Change the trial locations, to avoid locations where the wiring is not suitable
- Present options to the project board and discuss alternatives when the survey results have been reviewed.

R023. Bristol City Council are unable to support the customer engagement and installations of the project.

Mitigation

- Sign the memorandum of understanding before the project ahead of an Ofgem go-no go decision.
- Ongoing communications at all levels of Bristol City Council.

Contingency

- Western Power Distribution takes the lead in the customer engagement and installations supported by Bristol City Council.

Appendix E: Partner Details

The University of Bath (with RWE npower)

The University of Bath is ranked in the Top 10 universities within the UK and has an extensive track record of knowledge capture, dissemination and engagement with stakeholders within the power industry. The University of Bath is involved in flagship projects across the energy sector which will help shape the UK's future energy system. The University recently installed a DC network within its Library and Learning Centre which has received significant press coverage in the engineering and academic press. The University is also a current partner in the LCNF Tier 2 funded LV Customer Templates project. The key researchers involved from the University, Dr Furong Li, Dr Ian Walker, Dr Miles Redfern and Prof Raj Aggarwal all have significant publishing track record. Dr Li's research has been endorsed by Ofgem and consequently adopted by 3 UK DNOs and Dr Ian Walker has recently been appointed project mentor for a Department of Transport knowledge capture and dissemination project.

Bath has organised and hosted a range of engagement events within the energy sector targeting a wide variety of stakeholders, from specialised workshops with the power industry, academic dissemination conferences to broader public engagement through events such as the annual Bath Taps into Science festival (http://www.bath.ac.uk/math-sci/bath-taps/). Bath's research and teaching is supported by extensive resources such as its Moodle Virtual Learning Environment which is a key part of Bath's internationally renowned distance learning MSc in Electrical Power Systems which is strongly supported by the power industry. The University is also the chosen delivery partner by The Goldsmiths for a Sustainable Energy course delivered to secondary school teachers on an annual basis (http://www.bath.ac.uk/news/2011/07/26/summer-school/)

Bath would expect to use the outputs from BRISTOL to develop learning and teaching materials for undergraduate, postgraduate and CPD courses for both the UK and International audiences. Academic staff at Bath have an excellent track record in academic journal and conference publication with a number of staff sitting on the editorial and management boards of organisations such as the IEEE.

RWE npower

RWE npower is a leading integrated UK energy company and is part of the RWE Group. In the UK RWE npower serve around 6.5 million customer accounts and produce around 10% of the electricity used in Great Britain. In the UK, RWE is at the forefront of producing energy through renewable sources. RWE npower have participated in numerous large scale projects in conjunction with industry and with Universities funded through research council and Government programmes. Knowledge within RWE npower is captured and shared through its "knowhow" system that allows secure internal and external data access. RWE npower will support the dissemination of the Project BRISTOL through co-authoring academic papers with the University of Bath, through facilitating articles in their monthly "TEAM" publication, and through links to the project from its RWE npower public website.

Siemens
Siemens is a global partner for cities in relation to sustainable development of urban infrastructures with green, efficient products, solutions and financing models. Siemens Energy Transmission and Distribution Ltd is a world leading supplier of a wide range of products, solutions and services for power generation, transmission and distribution. Siemens have been involved in a wealth of multi-partner projects within the area of networks. Key examples include, BritNed interconnector project, ETI Joined Cities plan and the LCNF Tier 2 funded Low Carbon London project. Siemens will support the knowledge capture and dissemination of BRISTOL through joint authoring of journal and conference papers, case studies and links to the project from its website. There may also be opportunities for an article in its quarterly global customer facing and key influencer publication, Living Energy.

Bristol City Council
Bristol CC have been involved in numerous high profile low carbon projects across the city. Examples of these include:

- DEHEMS – Digital Environment Home Energy Management System project which is investigating how technology can improve domestic energy efficiency.
- 3e Houses – The 3e Houses project is investigating the integration of established ICT technologies in social housing to provide an innovative service for energy efficiency. This includes real-time monitoring of energy consumption and integration of microgeneration.
- Local Carbon Cities Programme –a 3 city pilot with Leeds and Manchester to develop citywide climate change action plans
- Local Carbon Framework – a DECC-led pilot programme to co-design a series of local carbon frameworks to identify what works at what spatial level and to develop templates for action on carbon for all local authorities.

Bristol CC will support the knowledge capture of the project through its Portfolio, Programme and Project Management Centre of Excellence. Dissemination of the project findings to stakeholders will be facilitated through its “Our City” publication which is distributed to every household in Bristol. Other routes of dissemination will include links to the Bristol CC website, through its Bristol Futures / Connect Bristol Twitter accounts and Connect Bristol YouTube channel, articles in other Bristol CC publications which go to schools and to EU partners via the European Commission Smart Cities Portal.

Appendix F: Carbon savings through Solar PV installation & Net Benefits

The carbon saving can be calculated by determining the kWh production of the installed Solar PV and multiplying this by the carbon emissions attributable to traditional electricity provision (Electricity production, transmission and distribution losses).

Solar PV kWh per year

Using the Energy Saving Trust's cashback calculator[1], in the Bristol region the kWh production for a 1kW Solar PV installation is ***901kWh***.

Electricity production kg of CO2 per year

The Department for Environment Food and Rural Affairs (DEFRA) has produced figures from 1990 to 2008 detailing the average CO2 emissions from the UK national grid per kWh of electricity used at the point of final consumption[2].

The calculated values for the latest data are:

0.54160kg CO2 per kWh (Purely CO2 emissions)
0.54522kg CO2 equivalent per kWh (Total direct Greenhouse Gas emissions)

CO_2	CH_4	N_2O	Total Direct GHG
kg CO_2 per kWh	kg CO_2e per kWh	kg CO_2e per kWh	kg CO_2e per kWh
0.54160	0.00024	0.00337	0.54522

Table 1 – Carbon content of grid connected generation

Savings Calculations

Assuming BRISTOL is used to connect both large and small PV installations with an average aggregated size of 60kW.

Solar PV Installation (kW)	Annual kWh equivalent (kWh)	(kg) CO_2	(kg) CH_4	(kg) N_2O	(kg) Total Direct GHG
60	54060	29280	0	180	29460

Table 2 – Carbon Saved through displacement of conventional generation

Carbon Saved
Assuming BRISTOL is increasing used between 2014 and 2030 with the number of locations outlined below; incorporating an average of 60 kWe of microgeneration that over wise would not have been incorporated.

[1] http://www.energysavingtrust.org.uk/Generate-your-own-energy/Cashback-Calculator

[2] http://archive.defra.gov.uk/environment/business/reporting/conversion-factors.htm

Connected micro generation					
Year	Estimated number of locations	Average micro generation (kWe)	CO_2 (kg) per site	Yearly CO_2 (kg) per year	Total CO_2 (kg) per year
2015	40	60	29280	1,171,200	23,424,000
2016	60	60	29280	1,756,800	35,136,000
2017	80	60	29280	2,342,400	46,848,000
2018	100	60	29280	2,928,000	58,560,000
2019	120	60	29280	3,513,600	70,272,000
2020	140	60	29280	4,099,200	81,984,000
2021	160	60	29280	4,684,800	93,696,000
2022	180	60	29280	5,270,400	105,408,000
2023	200	60	29280	5,856,000	117,120,000
2024	200	60	29280	5,856,000	117,120,000
2025	200	60	29280	5,856,000	117,120,000
2026	200	60	29280	5,856,000	117,120,000
2027	200	60	29280	5,856,000	117,120,000
2028	200	60	29280	5,856,000	117,120,000
2029	200	60	29280	5,856,000	117,120,000
2030	200	60	29280	5,856,000	117,120,000
				Thousand tonnes $C0_2$	1,452.3

Table 3 – Carbon saved through BRISTOL

The total carbon savings associated with BRISTOL is expected to be **1,452.3 thousand tonnes** of CO_2.

Net Financial Benefits

Using the same assumptions as detailed in the carbon savings, if BRISTOL was used across GB.

BRISTOL costs per substation - £48,900
One LV Network Manager (£2,400) and thirty properties per substation (£1,550) assuming the properties are on average located over three LV feeders.

Conventional network reinforcement costs per substation - £63,720
Based on 120m LV overlay and Harmonic Filtering on three LV feeders.

Connected microgeneration				
Year	Estimated number of locations	Average micro generation (kWe)	Cost savings per substation	Cost savings per year
2015	40	60	£14,820	£592,800
2016	60	60	£14,820	£889,200
2017	80	60	£14,820	£1,185,600
2018	100	60	£14,820	£1,482,000
2019	120	60	£14,820	£1,778,400
2020	140	60	£14,820	£2,074,800
2021	160	60	£14,820	£2,371,200
2022	180	60	£14,820	£2,667,600
2023	200	60	£14,820	£2,964,000
2024	200	60	£14,820	£2,964,000
2025	200	60	£14,820	£2,964,000
2026	200	60	£14,820	£2,964,000
2027	200	60	£14,820	£2,964,000
2028	200	60	£14,820	£2,964,000
2029	200	60	£14,820	£2,964,000
2030	200	60	£14,820	£2,964,000
				£36,753,600

Table 4 – Financial savings through BRISTOL

Name	Paul Maher
Department	NWE RC-GB E D NWE RC-GB E T
Telephone	+44 (0) 161 446 5400
Fax	+44 (0) 161 446 5989
Mobile	
E-mail	Paul.maher@siemens.com
Your letter of	
Our reference	
Date	12 August, 2011

Western Power Distribution 2011 LCNF Tier 2 Proposal
Siemens' Support for Project

To whom it may concern,

Siemens has been working intensively with Western Power Distribution (WPD), University of Bath and Bristol City Council in the preparation of WPD's bid for its B.R.I.S.T.O.L. project within tier 2 of the Low Carbon Network Fund.

Siemens is delighted to be involved in this project, which is innovative and forward-thinking and provides some unique and distinctive opportunities to enhance the decarbonisation of electricity supply. Siemens looks forward to the bid achieving success and subsequently to contributing fully to the project as detailed in this submission.

With kind regards,

P. Maher

Paul Maher
Divisional Managing Director, Energy UK T&D Divisions

UNIVERSITY OF BATH

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Dr Robin Bidwell
Chairman
Ofgem
9 Millbank
London
SW1P 3GE

12th August 2011

RE: WPD Low Carbon Networks Fund Tier 2 Project – Buildings, Renewables and Integrated Storage with Tariffs to Overcome network Limitations (B.R.I.S.T.O.L).

Dear Dr Bidwell

I am writing to express the University of Bath's support for the WPD BRISTOL project submission. The energy network faces a number of challenges within the next two decades to support the drive towards a lower carbon economy. The innovative approach proposed by Project BRISTOL, that of using DC networks within homes, offices and schools to allow better integration of renewable sources, energy storage, reductions in network "pollution" and greater consumer choice centrally addresses a number of energy related issues faced by society as a whole. The University of Bath takes a strongly interdisciplinary approach to its energy research, epitomised by its Institute for Sustainable Energy and the Environment which brings together engineers, social scientists, technologists and economists to address energy problems. Project BRISTOL provides a very strong blend of technological innovation and engineering challenge with consumer behaviour and financial choice.

Project BRISTOL offers the University an opportunity to use knowledge related to DC networks developed in a small scale research and development project within its own Library which has shown significant benefits for the University in terms of economic, energy and carbon savings but also for its users and the network operator and deploy this on much larger scale. Demonstrating "impact" from its research portfolio is a principal requirement for the University and involvement in projects such as BRISTOL is critical in addressing this. Bath will work within all areas of the project from the technical design aspects through the expertise of Prof Raj Aggarwal and Dr Miles Redfern, through the application of Dr Furong Li's development of flexible tariffs to Dr Ian Walker's research in understanding consumer behaviour.

Equally, the value of the wealth of knowledge developed within BRISTOL will only be realised through effective dissemination of the outputs of the project to a variety audiences within industry, Government, academia and the general public. To this end, Bath will, through

Dr Ian Walker, lead on the knowledge capture and dissemination of the project to ensure that all insights, knowledge and outputs are effectively captured and transferred to the stakeholders who require them.

In conclusion, I would again like to express my great interest in Project BRISTOL and my thorough support for this proposal. The University of Bath very much looks forward to working with all of the BRISTOL project partners in delivering this challenging and innovative project.

Yours sincerely

J M Millar

Professor Jane Millar
Pro-Vice-Chancellor Research

BRISTOL CITY COUNCIL

To Whom It May Concern

Reply to	Stephen Hilton
Telephone	0117 92 23293
Minicom	
Fax	
E-mail	stephen.hilton@bristol.gov.uk
Our ref	17 Aug Philip Bale
Your ref	
Date	17 August 2011

Project B.R.I.S.T.O.L

Bristol City Council is very pleased to be working in partnership with Weston Power distribution and Bath University on the Project B.R.I.S.T.O.L bid.

Bristol City Council has a proven track record of reducing the Council and the City's energy use and associated carbon emissions. We are fully committed to working with the consortium to ensure that the project brings maximum benefits in terms of efficiency for the grid, as well as improving information and understanding of tenants.

We feel that this is a very strong consortium and look forward to receiving Ofgem's assessment of the bid. Please do not hesitate to contact me should you require any further information about Bristol City Council's work in this area.

Yours sincerely

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17th August 2011

Dear Mr. Bale

RE: WPD Low Carbon Networks Fund Tier 2 Project – Buildings, Renewables and Integrated Storage with Tariffs to Overcome network Limitations (B.R.I.S.T.O.L).

I would like to thank you for the invitation to participate in this LCNF project. In the project RWE npower will work with the University of Bath in relation to the development of the DC network and in the design of flexible tariffs to be used in conjunction with this.

The BRISTOL project provides RWEnpower and Bath with an opportunity to use knowledge related to DC networks developed in collaborative small scale research project within the University of Bath Library which has shown significant benefits in terms of economic, energy and carbon savings. As an output from the project RWE npower would seek to develop further knowledge in relation to……..

- Energy trading using storage.
- Cheaper renewable technology connection specifically PV and small wind.
- DC network installation and related equipment, products and services
- Overall energy savings.
- Higher utilization of renewable energy from both domestic sources and with the right tariffs, centrally connected sources.
- The process if introducing innovative Tariffs that would encourage customer choice, efficiency and better utilization of networks and renewable resources.
- The requirements of smart meters and related technologies.

On behalf of RWE npower, I would like to wish you every success with your proposal and we look forward to working with you and the University of Bath in the future.

Yours sincerely

Chris Harris
Head of Retail Regulation

RWE npower

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1. Page 21- 22 & 49 – 52, Section 9: Change of Successful Delivery Reward Criteria as requested in Question 21
2. Appendix D, Organogram: Updated to show how the steering committee, project forum aligns to the Organogram as requested in Question 12 and correcting the Siemens technical consultant alignment.
3. Financial Spreadsheet WPDT2003_A7: Updated to include information requested in Question 7.
4. Appendix E, Partner Details: Correction, Siemens are a partnered with UKPN with Low Carbon London.
5. Page 19, Section 4 a and Appendix F: as requested in Question 1, clarification that the carbon emissions calculations are due to solar PV, the carbon emission calculations do not include carbon savings through heat pumps, EV's or reduced road works.
6. Page 19, Section 4 a and Appendix F: as requested in Question 2, clarification that the carbon savings have been based on the DEFFRA's Guidelines –GHG conversion factors document. As with the uptake of EVs and heat pumps, there is a level of uncertainty around the future carbon intensity of the grid.
   The view was taken to use the latest accurate figures to give, what is predicted to be, conservative carbon savings as it is recognised that the carbon content of grid may well reduce.
7. Page 19, Section 4 a and Appendix F: Question 3, clarification that the average aggregated size of 60kW has been derived from the estimation of 30 properties per network connected substation connecting a level of 2kW micro-generation each, totalling 60kW.
8. Page 19, Section 4 a: Question 5, clarification that new build properties were considered in the development of the project, but discounted for a number of factors. Integrating Low Carbon Technologies into new houses as they are built is relatively easy; however two thirds of the 2050 housing stock has already been built today. It was therefore considered that the level of learning associated with retro-fit activity would be greater and applicable to a larger number of properties.
9. Page 19, Section 4 a and Appendix F: Question 6, clarification that the source used, DEFRA's Guidelines – GHG conversion factors document, details that in 2008 the kg CO_2 per kWh, which is for the final consumer including transmission and distribution losses was 0.54160. This value is the latest and most accurate available.
10. Page 5, Project Description: Question 8, clarification on the variable tariff. During the trial all customers will still retain their existing energy tariff which will be levied by their existing retailer throughout the trial. A number of variable tariffs will be developed as part of the project that will be aligned to the wholesale costs of energy; domestic customers could reduce their energy bill through reducing their energy consumptions during peak energy periods by transferring demand to other periods of the day. Domestic customers who reduce their energy consumption during peak energy price periods will receive a payment, reducing their energy bills. Any changes in behaviour will be recorded through the LV connection manager and a payment to users will be made to compensate the

difference between their actual energy bill paid by the domestic user to energy retailers and their bill had the variable tariff been implemented.

Variable DUoS rates have been considered during the development of BRISTOL however we are not proposing to alter the DUoS revenue from customers.

It is our aiming to replicate a tariff that may be implemented when smart meters are installed; variable tariffs may increase the business case for domestic storage and alter customers ADMD, altering the impact of customers and Low Carbon Technologies on the distribution network.

11. Page 5, Project Description: Question 9, clarification on battery scenarios. There is a scenario where if the battery storage is fully-charged, the PV output may have to be reduced; however this is very unlikely with the BRISTOL solution. Batteries will allow excess generation to be stored in batteries instead of exporting power into the network. Forecasting and appropriate sizing will reduce the risk of the batteries being fully charged at times when PV couldn't be exported to the network.

    If this scenario did occur, the equipment would behave in the same way as conventional PV installations, charge controllers to prevent PV from damaging the battery and the inverter will prevent power from being exported if the voltage is at statutory limits; this is an existing technology.

    Customers will not be disadvantages by having the BRISTOL solution installed.
12. Page 45, Customer Impact: Question 10, clarification that the focus of the power outage test is the DC network, batteries and customer behaviour during the outage. The operation of the PV panels may influence customers behaviours, however the test is not specifically focussed on the performance of the PV panels. The LV Connection Manager will record the output from the PV, displaying the information to customers.

    The trials will be scheduled at different times of the day with different weather conditions and battery capacities to maximise the learning. Selected customers will be asked to undergo this test once during the trial.
13. Page 34, Project Readiness and Appendix D: Question 11, clarification that the project will have a dedicated project manager. Sufficient resources and personal from the WPD future networks team will be made available as required.

    During the detailed project development and installation of equipment the project manager is likely to be working full time on project BRISTOL. During the operation phase we have estimated the dedicated project manager will spend two days per week working on BRISTOL.
14. Page 23, Relevance and timing: Question 13, clarification that the LCNF BRISTOL trial is fully independent of the smart metering rollout. Any customer taking part in the BRISTOL trial will be able to switch to a smart meter if so offered by an Energy Retailer.

    The LV Connection Manager has many features that could be simplified if integrated with smart meters.
15. Page 22, Involvement of other partners and external funding: Question 14, clarification on the potential contractual arrangement with Moixa. Siemens have committed to providing the LV Connection Manager and LV Network Manager and associated equipment. If Siemens feel there is an advantage to integrating Moixa's technology into the LV Connection Manager they will form a contractual arrangement with Moixa. Siemens are continuing their discussions with Moixa. Any subcontractor arrangement will be approved by WPD as outlined in the terms and conditions of the contractual arrangement with Siemens.
16. Page 22, Involvement of other partners and external funding: Question 15, clarification on contracts with RWE npower. The University of Bath and RWE npower have established working arrangements. The organisations collaborate

on a project by project basis, each with suitable commercial arrangements. There will not be a specific contract between the project and npower, a confidentially agreement will be formed regarding the project. RWE npower's contribution to the project will be time in kind in return for learning generated by the project.

The variable tariffs will be developed by the University of Bath with input from npower.

17. Page 34, Project Readiness and Appendix D, Risk Register: Question 16, clarification on the risk of failing to complete contracts. Both Western Power Distribution and our project partners view the risk of failing to complete contracts as a low risk.
18. Page 20, Evaluation Criteria: Question 17, clarification on the BRISTOL funding. There are no costs for customers' for the BRISTOL trial. For future uses of BRISTOL it is assumed £700 per customer for a 50% ownership of the 4.8kWh batteries.

    During the project the most appropriate mechanism for funding will be evaluated. This may include storage being funded through green deal, being treated as a registered asset and funded through customer DUoS payments or being purchased outright.

    All other project costs including the LV Connection Manager and communications have been included within the DNO finances.
19. Page 20, Evaluation Criteria: Question 18 and Expert Panel Meeting response to a Business case question. We believe the trends of battery storage will continue. There is significant evidence that these costs could fall to £100/kWh by 2020; reducing the customer and DNO costs considerably. The bid's financial business case assumes battery costs of nearly three times the 2020 estimate.
20. Page 20, Evaluation Criteria: Question 19, clarification that the BRISTOL solution does not require all customers to have battery storage installed. BRISTOL it is a modular solution that will allow increasing numbers of customers to connect microgeneration and other Low Carbon Technologies to the network when its headroom has been reached. In situations where customers requested further connections which would cause the distribution network to operate beyond its limits, who do not wish to have a BRISTOL solution the appropriate conventional network reinforcement would be used to complement the network controlled battery storage on the same substation.
21. Page 20, Evaluation Criteria and Appendix F: Question 20, clarification that the number of locations is per year. It is expected that 2480 locations will have the BRISTOL solution installed by 2030. These are a very conservative number and anticipated to be across the whole of the UK. This does not include the potential roll out of the solution to incorporate the connection of heat pumps or electric vehicles.
22. Page 19, Evaluation Criteria and Appendix F: Correct a mistake, the carbon saved through the UK rollout of BRISTOL upto 2030 is 1,452.3 thousand tonnes of CO_2.