LOW CARBON LONDON – A LEARNING JOURNEY

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ABSTRACT

UK Power Networks (UKPN) has been allocated funding of £24.3m by the UK Regulator – Ofgem – to trial new approaches to distribution network management to meet the challenges emerging for the growth in low carbon technologies such as electric vehicles, heat pumps and distributed generation. The Low Carbon London project [1] will focus on facilitating technologies to achieve carbon reduction targets, while exploring the role of the Distribution Network Operator to enable and share benefits throughout the low carbon supply chain. The project will trial new smart grid technologies and commercial arrangements with real London communities and businesses between 2011 and 2014. Through a series of coordinated trials, the project will demonstrate the impact on, and the role of, the distribution network in meeting low carbon objectives.

INTRODUCTION

As major cities and metropolitan areas embark on the transitional path towards a low carbon economy, a number of technical and commercial challenges emerge for electricity network operators. London has the highest concentrations of electricity demand and CO_2 emissions in Great Britain, and the most demanding carbon reduction targets (60% reduction on 1990 levels by 2025). Its central area electricity networks are already very highly utilised and its urban environment means that reinforcement costs to meet new demand are high. London also has enormous scope for distributed generation, micro-generation, and electric vehicles. All these factors make London the ideal test-bed for a low carbon network project.

Low Carbon London is a collaborative project between UK Power Networks and expert delivery partners including Siemens, Logica, National Grid, Smarter Grid Solutions, EnerNOC, Flexitricity and EDF Energy. The project will work closely with the Mayor of London's Office, Transport for London and the Institute for Sustainability to support their existing energy efficiency initiatives. Imperial College London will develop the 'Low Carbon London Learning Laboratory' to share the learning from the project and act as a portal to the project for industry and interested parties.

This paper will provide an overview of a series of activities to be undertaken in the Low Carbon London project, presented as a set of Use Cases. This paper provides an overview of each Use Case, as depicted in **Figure1.** Low Carbon London Use Case Structure.

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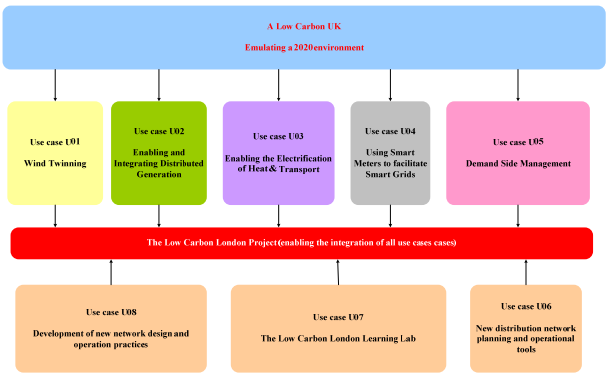

Figure1. Low Carbon London Use Case Structure.

WIND TWINNING

The UK Renewable Energy Strategy sets a goal of 34 GW of wind generation to be connected in the UK by 2020. Studies have shown that a 30% error in four-hour head forecasts even at an aggregated level of wind generator production is not uncommon [1]. The intermittent and variable nature of wind energy will therefore impact at a national system operation level where there is likely to be a requirement for either additional thermal peaking plant operating in spinning reserve mode or OCGT generation on cold standby.

In this Use Case, the ability of demand to follow local and national wind energy production and the corresponding impacts on distribution networks will be identified and explored. This form of "twinning" demand with wind generation will be trialled using day-ahead Time of Use (ToU) wind twinning tariffs, which will be designed and offered to a relatively small number of residential and Small and Medium Enterprise (SME) customers by electricity suppliers. The ToU tariff will provide an incentive for customers to plan their use of non time-of-day (or time-of-week) critical electrical appliances to coincide with times when wind energy output is expected to be high; for example by using washing machines on windy days.

Moreover, Aggregators will contract with and/or control the demand of Industrial and Commercial (I&C) customers to provide localised demand response to National Grid, essentially providing Short Term Operating Reserve (STOR) to cope with short-term variations in wind generation outside the forecast range. The potential conflicts of these wind twinning goals with the operation of the distribution network will also be explored in Use Case

05: Demand Side Management.

ENABLING AND INTEGRATING DISTRIBUTED GENERATION

Incentives for renewable and low carbon generation in the form of the Renewables Obligation and Feed-in Tariffs (FIT) are expected to encourage an increase in both large scale renewable generation and low carbon generation up to 5 MW. Moreover, the Mayor of London Renewables strategy positions London as a leader in the uptake of low carbon technologies such as combined heat and power, photovoltaics, solar water heating, wind, and ground-coupled heating and cooling, which will need to be deployed across UKPN's LV and HV networks.

In order to support the connection of existing and new DG units on London's distribution network, UKPN will require increased visibility and controllability of network components and parameters, connected devices and DG units. New connection solutions that provide better economy for low carbon users of the network and facilitate increased access to the existing infrastructure, while maintaining or improving network security and reliability, are required. The deployment of technologies such as Active Network Management (ANM) to manage network constraints in real-time will allow UKPN to maximise the use of the existing network, avoiding or delaying the requirement to invest in new network infrastructure.

New commercial arrangements with DG developers will be required to permit their output to be regulated by an ANM scheme. By making the network more 'active' UKPN anticipate enabling increased DG connections to the existing network infrastructure. UKPN will also require the network planning process to consider new connection solutions for DG units, considering the best economic and carbon solution.

ENABLING THE ELECTRIFICATION OF HEAT AND TRANSPORT

Electrification of Transport

Road based transport currently accounts for approximately 22% of UK CO_2 emissions and therefore decarbonising road transport is an essential part of building a low carbon future for the UK. Moreover, the long term objective of the Carbon Reduction Strategy for Transport is to substantially decarbonise the UK's transport system by 2050. Electricity is likely to become a major transport fuel, resulting in electric road vehicles replacing internal combustion engine vehicles.

London leads the way in the UK with regard to electric vehicles; almost 25% of the electric vehicles registered in the UK are in London. Moreover, the Mayor of London has ambitious plans to make London the electric vehicle capital of Europe. As part of the Low Carbon London project, UKPN will implement monitoring of planned EV charging deployments, to learn more about the nature, behaviour and network impacts of this new technology. Uncontrolled charging of EVs has the potential to add significant loading to the network, resulting in thermal and voltage constraints, and possibly impacting on the quality and security of supply. This is particularly true during times of peak demand for electricity. Therefore, it is anticipated that some form of EV charging management through ANM would provide significant economic and carbon benefit. The learning gained regarding the performance, network impacts and controllability of EV charging will be significant and play a crucial role in informing the debate regarding the increased electrification of transport.

Electrification of Heat

Over three quarters of domestic energy consumption is used to heat space and water. This energy consumption equates to approximately 13% of all UK greenhouse gas emissions [2]. The majority of this energy is used for space heating and is largely consumed by gas fired boilers. The policies set out in the UK aim to reduce gas consumption for domestic heating to zero by 2050 through the electrification of the heat sector. One of the technologies anticipated to enable this is heat pumps.

The Renewable Heat Incentive is planned for implementation in June 2011. In London, initiatives such as the Low Carbon Zones and Green Enterprise Districts are also encouraging the deployment of heat pump technologies in combination with energy efficiency measures.

The introduction of heat pumps in volume to properties connected to the UKPN electricity distribution network in London is likely to increase network loading, resulting in direct impacts on power flow magnitude and voltage profiles. These network impacts could be exacerbated by a coincident uptake of electric vehicles.

The use of heat pumps may also coincide with existing peak network demand, providing a significant additional burden to the distribution network. This Use Case will implement monitoring of heat pump deployments within the Low Carbon Zones and Green Enterprise Districts to learn more about this technology, its behaviour and how it impacts on the operation of the distribution system. This Use Case will identify future strategies that may be required to plan or operate the network to accommodate heat pumps. The learning gained regarding the performance and network impacts of electrically powered heat pumps is expected to be significant, playing a crucial role in informing the debate regarding the grid integration of increased electrification of heat.

USING SMART METERS TO FACILITATE SMART GRIDS

By 2020 (or possibly earlier) the roll-out of smart meters to all residential and most SME customers will have been completed in the UK, as mandated by the UK Government.

Smart meter functional requirements will have been defined by the summer of 2011 and will support a wide range of smart grid functionalities. In order to leverage the benefits of smart meters, DNOs will require the ability to access, process and make use of large amounts of data from smart meters. Moreover, DNOs will need to evaluate the potential for demand response, improving network visibility, improving quality of service, informing future network planning and enabling the penetration of low carbon technologies. As part of the Low Carbon London project, UKPN will explore the opportunities to deploy and assess the different means (both technical and commercial) of accessing and using smart meter data. These include the challenges and opportunities associated with distribution network operation and design. In order to do this, it will be necessary to access and compile smart meter data on the consumption of electricity by various types and numbers of consumers in the residential and SME categories. The data captured will be used to understand how existing network planning and design will need to change to allow cost effective design of smart grids. This Use Case will also identify and test the benefits of options for making use of real-time or near real-time data from smart meters in automatic or manual network operation decision making. This will include the presentation of data to control engineers to assist in decisions regarding planned and unplanned outages.

DEMAND SIDE MANAGEMENT

In order for the UK electricity industry to maximise the use of low carbon intermittent generation and enable a high penetration of new types of electrical loads such as heat pumps and electric vehicles in a cost-effective and affordable way, it will be necessary to engage with the end customer to gain their participation in the management of the electricity system.

Energy efficiency programmes are expected to bring benefits to the customer in terms of a reduction in energy bills and benefit to the wider UK due to a reduction in CO_2 emissions. It is also expected that energy efficiency will impact on electricity network power flows; however, these impacts are yet to be identified and quantified. The Low Carbon London project will evaluate the impact of several residential and SME energy efficiency and demand response programmes on the distribution network.

This Use Case will investigate the ability of Aggregators to provide demand response services tailored to the requirements of distribution network. The services to be trialled in this Use Case will provide varying magnitudes of demand response over different time periods. This Use Case will also demonstrate the effectiveness of DSM I&C customers as a tool available to DNOs to defer/avoid network reinforcement.

NEW DISTRIBUTION NETWORK PLANNING AND OPERATIONAL TOOLS

Operational Data Store

The Operational Data Store (ODS) is a key component of the London Carbon London project. It providers a network centric view of all trial actors, by storing all smart meter and half hourly metering data, network data, network events and control actions within a time series database that is then relationally linked to the active network hierarchy within the ODS. Data captured in the ODS will form the foundation for the learning analysis that will be undertaken within the Learning Lab. This will provide insight into the operation, performance and potential of the LCL project trials. This platform's aim is to provide a common point of visualisation of pilot actors within each Use Case and to simplify access to learning through a centrally managed and expandable set of tools to the Learning Lab.

Active Network Management

Active Network Management (ANM) involves the deployment of hardware and software to facilitate the connection of increased load or generation and manage network constraints when they arise on the network in real-time. When a breach of network constraints occurs, ANM automatically regulates the consumption or production of power, or adjusts the operating position of network components, to ensure the network remains within safe operating limits. In doing so, ANM can provide a means of connecting more to the existing network while avoiding expensive and time consuming network reinforcement. ANM also provides a means of removing existing network constraints in pre-fault and post-fault network conditions. ANM is therefore a powerful tool for UKPN to implement and trial that could enable new connections for low carbon technologies, maximise the use of existing low carbon technologies and defer/avoid network reinforcement.

Smart Metering Head-end System

A Smart Metering Head End manages access to the smart meter communications infrastructure and translates commands from the market participants' (energy suppliers, network operators, metering agents, etc) systems into the languages used by the meters and devices connected to the Home Area Networks (HAN). The primary users of the smart meter communications infrastructure and the smart meters (and therefore the Head End) are the electricity suppliers. As well as having to obtain measurements and readings for billing and settlement purposes, the suppliers also set the tariffs used by the meters and oversee the prepayment infrastructure for customers of that type. The head end to be trialled in the LCL project is Logica's Instant Energy solution. This system is already well established in the UK smart metering market, supporting over 80% of deployed residential smart meters. Data from smart meters, half hourly metered customers and EV charging points will

be accessed through Logica's head end system and then stored in the ODS for subsequent analysis.

Carbon Tools

The Low Carbon London project will use ENXSuite carbon tools to evaluate performance with regards to the level of CO_2 reduction achieved. This will ensure that there is a full audit trail for carbon reductions and will provide detailed information on CO_2 emissions reductions over the life of the project. The power of the ENXSuite carbon tools to support a large scale project such as LCL is demonstrated by its role as a strategic technology partner in the Chicago Climate Action Plan (CCAP).

THE LOW CARBON LONDON LEARNING LAB

The Low Carbon London Learning Lab will exhibit an integrated approach to collecting learning, knowledge and experiences gained from the Low Carbon London project. This will be achieved through the design of trials, analysis of results from all Use Cases and through the dissemination of the resulting knowledge. The Learning Lab will provide a means of disseminating information and learning from the LCL project to a wide audience through the 'Low Carbon London web portal' and other dissemination activities such as workshops and seminars. The Learning Lab will provide an environment to run simulations of future network scenarios, extrapolating the results of real-world LCL trials considering synergistic benefits of technology deployment and the wider, short and long-term implications for the UK. The Learning Lab user community will be made up of industry participants (expected to include representatives of other network operators), academia, media and Government. Users of the Learning Lab will have the ability to interact with real data and witness the simulation of a 2020 electricity distribution network scenario to investigate and understand the issues and opportunities that the electricity industry will face in a low carbon future. The Learning Lab will be accessible to the user community to witness and replay firsthand the various scenarios which will target the planning, development and operation of an efficient distribution system, and to identify and discuss the implications and challenges for accelerating progress toward low carbon electricity networks.

DEVELOPMENT OF NEW NETWORK DESIGN AND OPERATIONAL PRACTICES

The activities being undertaken as part of the LCL trials present a number of challenges and opportunities to DNOs. These demonstrate the changing nature of the electricity industry and presenting new requirements for the planning and operation of distribution networks. These new requirements are concerned with facilitating low carbon electricity supply in a cost effective way and to permit the DNO to play a facilitating and enabling role, ensuring that benefits of new technologies are shared throughout the low carbon supply chain. These challenges augment the existing and continuing goal of increasing the efficiency, reliability and security of supply for all users of the distribution network. The LCL project will explore the short and near-term impacts on the planning and operation of distribution networks, identifying the new requirements being placed upon the DNO business and the development of new standards and methods used to plan and operate distribution networks.

CONCLUSIONS

The next few years will be the most exciting (and challenging) facing the electricity distribution industry for 30 years. The UK Low Carbon Transition Plan plots how the UK will meet the 34% cut in emissions on 1990 levels by 2020, while the Electricity Market Reform consultation proposes far-reaching reforms to enable our industry to provide the reliable, 'decarbonised' and affordable electricity that will help deliver a low carbon future. Today's electricity networks must become smarter in order to manage the demands of this low carbon future.

The London Carbon London project, which started in January 2011, aims to find the most efficient and cost-effective way to make this transition. It will create a full scenario of the challenges and opportunities facing low carbon electricity networks in 2020, including electric vehicles, distributed generation, solar PV panels and heat pumps. It will also investigate the largely unexplored territory of how real customers respond to commercial and technological innovation. New distribution operational and planning management tools will be used within the UKPN's London network, such as Active Network Management and Operational Data Store, which will facilitate the integration of low carbon technologies.

A dedicated and real learning Lab will provide a platform for learning to be captured and disseminated across all interested stakeholders.

Low Carbon London is a flagship project which will prepare and enable the UK electricity industry to achieve a low carbon future.

REFERENCES

[1] http://www.ofgem.gov.uk/Pages/MoreInformation.aspx?file=EDFET2001%20Addendum%20and%20Pro%20Forma.pdf&refer=Networks/ElecDist/lcnf/stlcnp

[2] IEA Wind Task 25, Design and operation of power systems with large amounts of wind power, Final report Phase one 2006-2008, VTT Research notes 2493, 2009 (http://www.vtt.fi/inf/pdf/workingpapers/2007/W82.pdf)

[3] "Low Carbon Transition Plan" - http://www.decc.gov.uk/