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16th December 2011

Mr Simon Bartlett
Chairperson
ES Cornwall Scholarship Advisory Committee
P.O. Box 1193
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Dear Mr Bartlett,

ES Cornwall Memorial Scholar – Donald McPhail
First Quarterly Report

Please find enclosed my first quarterly report for the ES Cornwall Memorial Industry Scholarship for the period 5th September 2011 to 5th December 2011 during my employment with UK Power Networks.

During the initial three months of my placement with UK Power Networks, I have been a part of the Low Carbon London Programme, working as a Trial Design Engineer in the Solution Design Authority team. The Low Carbon London programme is a UK Office of Gas and Electricity Markets' (OFGEM) Low Carbon Network Fund supported demonstration programme focussed on the effect the transition to a low carbon economy will have on distribution networks. The programme is made up of a partnership of 13 companies, with UK Power Networks being the lead partner.

The key work I have carried out during this quarter has included the design of Electric Vehicle, Small Scale Embedded Generation, Network, and Residential Smart Meter trials, and the development of programme scope mapping to trials for a dependency management tool.

I would welcome any feedback and advice from the committee and all interested parties, regarding this report or my proposed goals for the next quarter.

Kind regards,

Donald McPhail

E.S. CORNWALL MEMORIAL INDUSTRY SCHOLARSHIP
FIRST QUARTERLY REPORT

By

Donald McPhail

16th December 2011

Reporting period: 5th September 2011 – 5th December 2011

Approved by Liam O'Sullivan

Low Carbon London Programme Director

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Introduction

My proposed program under the E.S. Cornwall Memorial Industry Scholarship is to gain international experience in the best practices regarding the application of distributed generation and electric vehicle infrastructure on global electricity networks. In particular, I hope to gain experience and an understanding of the associated current and future engineering challenges through working with a distribution network operator (DNO), an energy consulting business, and an electric vehicle infrastructure business. It is anticipated that my scholarship period will run from September 2011 to May 2013, and will consist of the following placements:

- UK Power Networks (September 2011 to February 2012)
- KEMA (April 2012 – September 2012)
- ECOtality North America (November 2012 – April 2013)

This report is the first of six quarterly reports required under the scholarship guidelines, and covers 5th of September 2011 to 5th of December 2011. This three month period is the first half of my six month placement with UK Power Networks in London UK, as part of the Low Carbon London programme.

Background of Current Placement

UK Power Networks

UK Power Networks is a privately owned UK distribution network operator, who is the owner, manager and operator of the London, South East England and East of London distribution networks. Accumulatively, the network supplies almost 8 million customers, and has over 170,000km of underground and overhead lines, as well as more than 130,000 substations. Figure 1 below provides an overview of the UK distribution network regions, specifically those operated by UK Power Networks.

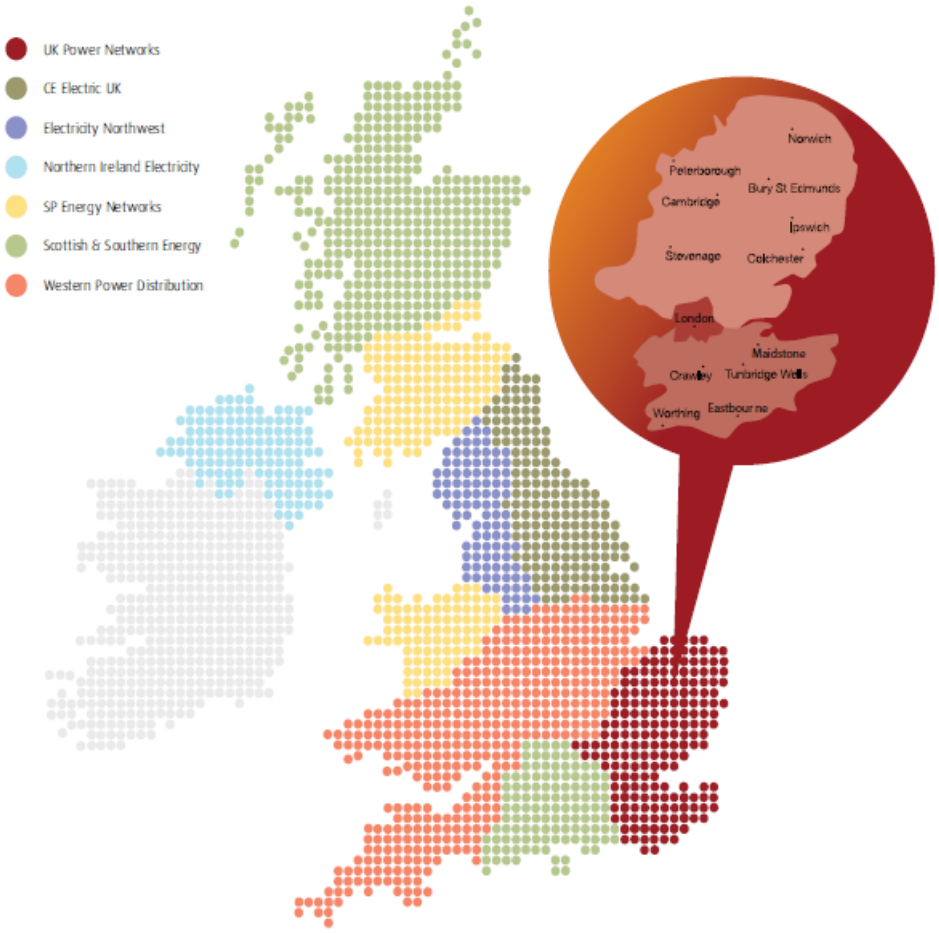

Figure 1 - UK Power Networks Distribution Networks

The Low Carbon London Programme

The Low Carbon London (LCL) programme is a low carbon economy transition demonstration programme, and is a collaboration between UK Power Networks (UKPN) and industry partners including Siemens, Logica, National Grid, Smarter Grid Solutions, EDF Energy, EnerNOC and Flexitricity. Additional national and local government body partners include TfL, London Mayor's Office, Department of Energy an Climate Change, OFGEM, and the UK government. The project began at the start of 2011, following being awarded £25 million as part of the OFGEM, the UK gas and electricity market regulator, Low Carbon Network Fund initiative. The goal of the programme is to develop a new approach to distribution network management to meet growing demand from emerging low carbon technologies such as electric vehicles, heat pumps, and distributed generation. The programme incorporates a suite of trials across the London power network to explore the role of innovative commercial contracts, innovative technical solutions, time of use tariffs supported by Smart Meters (SM), and active network management practices to optimise low carbon generation, maximise both the utilisation of the distribution network and overall efficiency of the end-to-end electricity system and energy supply chain, and reduce and/or shift consumption patterns.

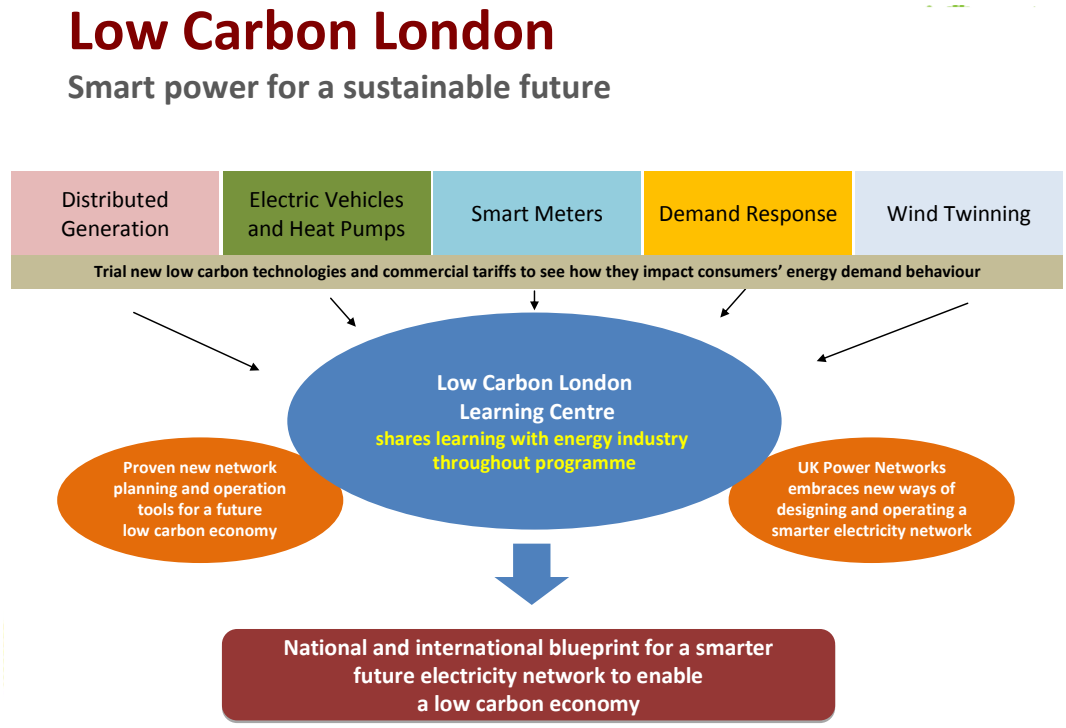

Figure 2 – Low Carbon London Overview

The operation of the programme consists of a work stream lead for each trial group who is responsible for running and overseeing of their corresponding trials throughout the programme. In addition there is a Solution Design Authority work stream which is responsible for the technical design of the trials, and the subsequent supporting business processes. Further to this, there are also additional supporting work streams which are responsible for programme management, development of the carbon impact analysis tool, running of the LCL learning lab, finance, specific technology development, and a design governance authority.

Summary of Work Experience

In my role as a *Low Carbon London Trial Design Engineer*, my work to date has allowed me to gain experience in the way in which a large smart grid trial programme is managed, as well as the design of complex network trials. Specifically my tasks have included:

- Development of a LCL programme dependency management tool;
- Design of smart grid enablement trials;
- Detailed review of programme task dependencies; and,
- Project management tasks for Electric Vehicle (EV), Small Scale Embedded Generation (SSEG), and Heat Pump (HP) trials.

LCL Programme Dependency Management Tool

Upon commencing with the LCL team, my first task was to develop a tool that mapped out the inter-dependencies of the trials and scope of the program, such that stakeholders could easily see what regulatory deliverables were dependent on which programme trials, and tasks the trials were

dependent on. This complex mapping was required as part of the programmes Q3 2011 submission to OFGEM, and provided me an early opportunity to gain a detailed understanding of the programme, its trials and goals, and planned means of achieving them. The programme is represented by key element groupings, which are:

- *Use Cases* – The use cases were part of LCLs successful bid to OFGEM for funding, and provided the high-level activities and outcomes of each trial group to be undertaken in the LCL project. In total, there are eight groups (use cases) with corresponding expected learning outcomes and challenges/opportunities.

- *Learning Points* – For each trial group, a number of learning points were identified in the use case document as anticipated knowledge to be gained from the LCL trials.

- *Trial Description Documents* – The purpose of the trial description documents is to provide a high level overview of trials, their requirements, and the hypotheses they are expected to answer.

- *Trials/Hypotheses* – Based on the high-level trial group overviews in the use case document, hypotheses were proposed to deliver each of the program learning points.

- *Products* – The LCL products provide a means to divide the programme up into individual tasks to be completed. Essentially they are a project management tool that allows for identification of the work that needs to be completed, the process flow of the tasks, and the corresponding deliverables.

- *Successful Delivery Reward Criteria (SDRC)* – As part of the LCL bid a number of SDRCs were identified and incorporated as milestones and deliverables for the programme to meet by proposed dates throughout the programme timeline. Upon achieving all of these targets, UKPN would be given additional funding from OFGEM as a reward for successful execution of the programme.

- *Learning Lab Reports (LLRs)* – As part of LCL's deliverables to OFGEM, 19 LLRs are to be written for the purpose of sharing the programme findings with the public, specifically, the other UK Distribution Network Operators. The reports investigate the results of the trials, model simulations and case studies, as well as extrapolate the findings out for future and/or whole of UK scenarios.

Given the trial/hypotheses had been created to deliver the requirements of the use cases, learning points, SDRCs, and LLRs, reviewing them allowed me to gain a more detailed understanding of what the programme aimed to achieve. I was then able to review the products for each work stream, and then work with each work stream lead to identify the expectation of the trials, which products were key to delivering the trials, and what additional products needed to be created to address missing tasks for successful execution of the trials. Having identified the inter-programme dependencies, I developed an interactive workbook that provided the most effective means of allowing stakeholders to search and explore the inter-relationships of programme elements for the purpose of programme planning, trial design, trial outcome reporting, and managing SDRCs for regulatory submissions.

This tool has proven to be quite valuable for the programme, and formed part of the programme's successful regulatory submission to OFGEM at the end of September 2011, to meet the first significant programme SDRC. In addition given the effectiveness of the tool, I was asked by the programme director to present the tool several times at programme meetings to project staff, senior project managers, programme director, programme sponsors, and the UKPN Director of Strategy and Regulation. Figure 3 below shows the overview poster for the tool which made part of the Q3 2011 programme submission presentation to OFGEM.

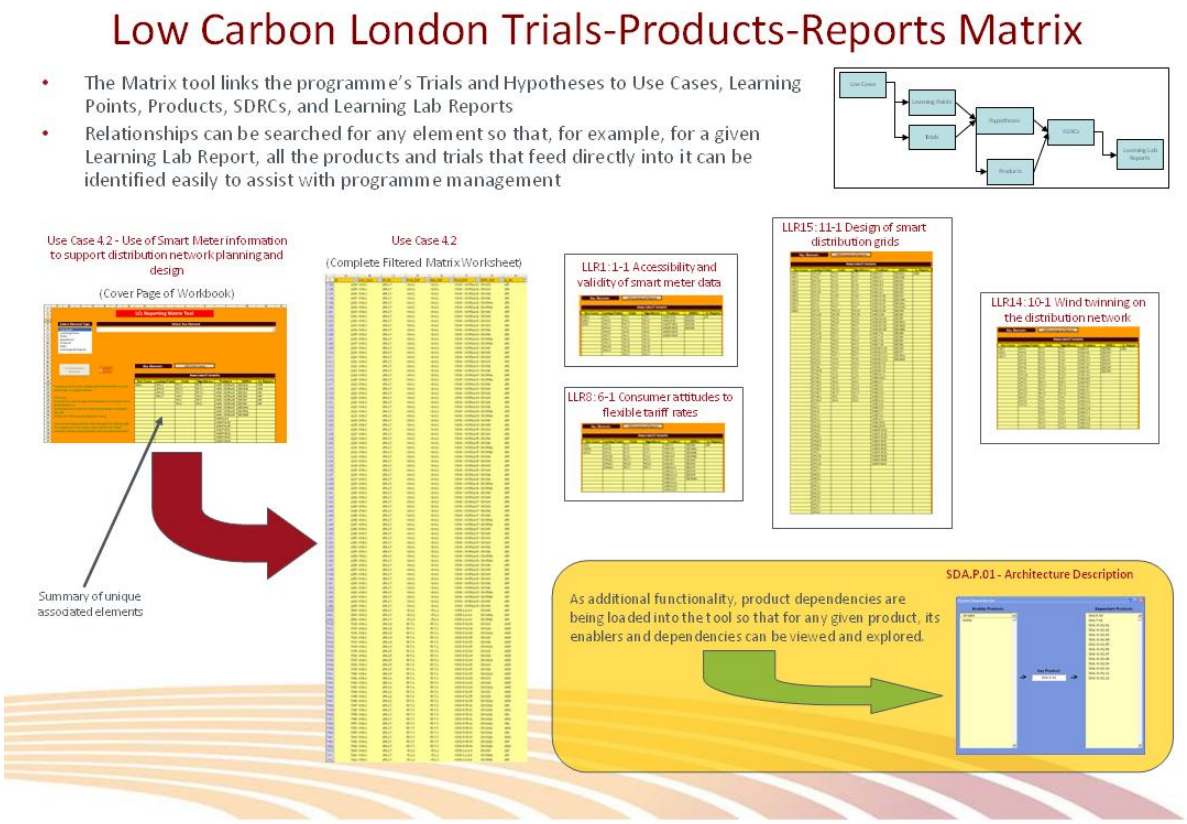

Figure 3 - Programme Dependency Management tool overview poster used as part of submission to OFGEM

Design of Smart Grid Trials

As part of the original LCL bid to OFGEM, a use case document was included which provided a high-level overview of the anticipated activities, outcomes and learning points for each trial group. Upon commencement of the programme, trial hypotheses were created out of the learning points so that trials could subsequently be designed that would answer these hypotheses. Trial design documents were therefore required to be written that grouped like hypotheses under each of the eight trial groups, and provided a scope of the trial, role responsibilities, high-level test approach, timings, locations, participant and data requirements, required equipment, and trial outputs. This work was divided between myself and another Trial Design Engineer, and the trial groups I was responsible for designing consisted of:

- Electric Vehicles – Characterisation of home, business and public EV charging profiles, and identifying their current and forecast impact on network loading, voltage and harmonics. The potential uptake and effectiveness of EV Time of Use (ToU) tariffs. Whether remote

control of EV charging is possible and its effectiveness of managing the network impact of EV charging, and potential for vehicle to grid strategies.

- Small Scale Embedded Generation (SSEG) – Development of typical SSEG profiles and identifying their current and forecast impact on network power flows, voltage and harmonics.

- Networks – Determine the ability for SMs and LV monitoring to identify faults and provide network state estimation. Evaluate the cost versus benefit of 24hr delayed and real time SM and LV monitoring data. Evaluate the impact on network visibility through lack of real time data or customers withholding consent to allow DNO to use SM data.

- Residential Smart Metering – Characterisation of household load profiles for different customer groupings and compare to the profiles currently used for network planning. Impacts of SMs with In Home Displays on household electricity consumption. Level of network visibility of load, voltage and faults from installation of SMs

These groups amounted to 16 trial design documents which encompassed 35 trial hypotheses. The design process and writing of the subsequent documents involved:

- Reviewing the corresponding use case, learning points and hypothesis to develop a corresponding scope of the trial and high level test approach. This included the controls, constraints, means of quantification, assumptions, dependents, and caveats.

- Identifying the metadata and measuring data required for trial analysis, then working with corresponding work stream leads to determine what equipment would be required and whether it could be sourced and delivered.

- Through literature reviews and discussion with academic experts from Imperial College London, determine participant attributes and sample size required for trials. In addition, identify which locations would be targeted for administering the trials.

- Based on trial test approach, determine the duration that data capture would need to run for, and including whether complete annual/seasonal data was required.

- Working with the Carbon Tools work stream and the corresponding trial work stream lead, to determine the method for calculating the trial impact on CO_2 emissions.

- Identify the role requirements of the trial to successfully administer the trial and carry out the corresponding analysis.

- Identify the direct benefits to UKPN and determine the potentially affected business documents/policies and business units, as well as staff within the organisation who would be the benefits owners/sponsors.

At the end of November 2011, I had completed this process, having designed the trials for 35 hypotheses and written the corresponding 16 draft trial description documents. These documents have now been sent out to the key stakeholders for review, and following their feedback, workshops have been scheduled for me to step through the trial description documents with them, and address

any final issues so that documents can be signed off and issued out to the programme. Given the number of trials being run, it is envisaged that this process will be completed by the middle of January 2012.

Review of Programme Task Dependencies

Following on from my work in developing the inter-programme dependency tool, I carried out a complete programme product review. The purpose of this review was to ensure that inter-work stream dependencies on products were correctly aligned, that work stream leads correctly understood the expectations of other work streams on their products, and that all foreseeable products had been scoped to meet these dependencies. This work involved first understanding each work stream's products, working with work stream leads to understand their expectations of other work streams, and then following up with work stream leads to discuss the expectations of the remainder of the programme on their products.

Upon completion of this work I had validated the mapping of the programme's inter-work stream product dependencies, identified all product gaps and dependency issues, developed an action plan, and worked through the action plan with work stream leads and Solution Design Authority manager to address all issues. While this work was particularly important for the programme, it also allowed me to get an even more detailed understanding of how the programme will be executed beyond my time with the programme, up until its completion in 2014.

Project Management for EV, SSEG and HP trials

Given the whole of programme experience I had gained from developing the programme dependency management tool, I have been involved in a number of project management tasks for the EV, SSEG and HP trials. This work has included:

- Product management – As part of my work in reviewing the programme's inter-product dependencies, I identified that no products had been outlined for the SSEG trial. As the responsible work stream lead was new to the role, I went through and developed a list of products required, a structure of their dependencies, and brief overview of the role of each. I presented these to the work stream lead so that they could be included in the work stream portfolio and managed appropriately.

- Work stream planning – Following on from my work in outlining the SSEG products and developing the inter-programme dependency matrix tool, I worked with the programme management team to develop the programme plan for the EV, HP and SSEG work stream.

- Participant recruitment – Given my existing knowledge of the operation of SSEG in distribution networks, I attended meetings with the work stream lead and UKPN connection team in order to identify opportunities for the LCL program and potential trial participants through installers and relevant industry bodies.

- Stakeholder engagement – Again given my previous experience in the connection of SSEG on distribution networks, I attended meetings on behalf of the LCL programme with the different groups within UKPN who were involved in either SSEG connections, or other trial projects involving SSEG. The purpose of these meetings was for me to capture an understanding of what the business was doing in this field so that I could report back to the

programme, as well as raise awareness throughout the business of the work being done as part of LCL.

Additional Experiences and Opportunities

In order to further continue my professional development, I have also taken advantage of the opportunity to attend a number of engineering events, as well as some site visits. So far I have had the opportunity to attend:

- Decentralised Energy Knowledge Base Conference
- Institute of Engineering and Technology events, including *Electric vehicles, fuel cells and bio fuels: competitors or partners?*; *Optimising Energy Utilisation - an End User Perspective*; and *CHARGE – The Electric Super Bike Racing movement.*
- Tour of the London Olympic Park site and King Yard Energy Centre
- GE Smart Grid Innovation Centre workshop

In addition to the industry events I have attended, I have also had the opportunity to meet and work with professionals from a variety of backgrounds. As the LCL programme is a multi-organisation partnership, working with staff from Siemens, Logica, and Imperial College London, as well as UK Power Networks staff, has allowed me to gain an understanding of the different ways to approach engineering problems, as well as project management, trial design, and customer/stakeholder management/engagement/communication, including the importance of the customer's experience and journey.

Outside of my work, I have also taken advantage of the opportunity the scholarship has provided me in being able to travel internationally. I have so far been focussing on exploring a great deal of the UK and Ireland, and have made plans to start seeing parts of Europe over the next couple of months.

Future Direction

I am currently just over halfway through my six month placement with UK Power Networks, and it is envisaged that the majority of my remaining time will be spent working on:

- Review and approval of trial design documents – This process includes running workshops with key stakeholders to step through the trial design documents, capture and address any issues, and subsequently receive approval for the trial design.

- Development of the hypotheses test approach documents - The purpose of these documents will be to outline process and requirements involved in the analysis of the data gathered during the trial phase of the programme, so as to answer the trial hypotheses. This analysis phase will be very important as it will be the basis of which the UKPN planning and operational practices recommendation documents are based upon. As I won't be involved in the LCL programme when the analysis phase commences, being involved in the development of the test approach guidelines will allow me to gain a better understanding of how it is envisaged that the results from the trials will be converted into meaningful recommendations for the distribution network operator.

Upon completing my placement with UK Power Networks on the 2nd of March 2012, I will be relocating to the Netherlands to begin a six month placement with KEMA in April 2012. KEMA is a global energy consulting business with expertise throughout the entire energy chain, including the integration of distributed generation and EVs into the electricity network. My goal for this placement is to gain experience developing engineering solutions for the connection of distributed generation, distributed energy storage, and electric vehicle infrastructure, through project work and learning from working alongside KEMA's expert staff. I have been informed that I will be spending my time working between the European and Australasian project teams, which will allow me to get a variety of project experience, and a global understanding of distributed generation market developments. With respect to immigration, the team at KEMA has been really helpful and begun assisting me, ensuring that Visa and Work Permits are organised sufficiently in advance. I am very much looking forward to this placement and the opportunities it presents to build off of my E.S. Cornwall scholarship.

In addition, as part of my role at UKPN and the Low Carbon London programme, the Programme Director, Liam O'Sullivan, has me to become the programme's first global ambassador. The idea of the ambassador role will be to allow me continued engagement in the programme so as to allow for global awareness of the programme and improve global knowledge sharing.