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29 April 2012

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
Second Quarterly Report

Please find enclosed my second quarterly report for the ES Cornwall Memorial Industry Scholarship for the period 5th December 2011 to 4th March 2012 during my employment with UK Power Networks.

During the second three months of my placement with UK Power Networks, I have continued on being 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 hosting review workshops and finalising the high level design of the Residential Smart Metering, Industrial and Commercial Distributed Generation, Industrial and Commercial Demand Response, and Networks trials. I have also drafted the Hypothesis Test Approach documentation for the Electric Vehicle, Small Scale Embedded Generation, Heat Pump, Industrial and Commercial Distributed Generation, and Industrial and Commercial Demand Response trials.

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

15th March 2012

Reporting period: 5th December 2011 – 4th March 2012

Table of Contents

Introduction 2

Summary of Work Experience 2

Review and Finalisation of Trial Description Documents 2

Development of Hypothesis Test Approach Documents 4

Mapping of Trials Carbon Emissions Impact Analysis 5

Ongoing Programme Management Work 5

Additional Experiences and Opportunities 6

Future Direction 6

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 to September 2012)
- ECOtality North America (November 2012 to April 2013)

This report is the second of six quarterly reports required under the scholarship guidelines, and covers 5th of December 2011 to 4th of March 2012. This three month period is the second half of my six month placement with UK Power Networks in London UK, as part of the Low Carbon London programme. This period also concludes my six month full time tenure with UK Power Networks as part of the ES Cornwall Scholarship. I have thoroughly enjoyed my time working on the Low Carbon London programme and feel I have gained and developed a lot of useful knowledge related to my scholarship topic and the broader international power industry. I have also been fortunate to develop a number of great professional and personal relationships with my colleagues and co-workers.

Summary of Work Experience

In my role as a *Low Carbon London Trial Design Engineer*, my work this quarter has allowed me to further 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:

- Review and finalisation of high level design for programme trials;
- Development of hypothesis test approach for programme trials;
- Mapping of carbon emissions impact analysis for programme trials;
- Programme management work.

Review and Finalisation of Trial Description Documents

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.

Following on from the work I had completed last quarter in drafting the Trial Description documents for Electric Vehicle, Small Scale Embedded Generation, Networks, and Residential Smart Metering trials, this quarter I hosted workshops with the key stakeholders to review, finalise and issue the documents, and the subsequent design of the trials. So that I could get a better knowledge of all the Low Carbon London trials being carried out, my co-Trial Design Engineer and I reassigned the trial groups between us for chairing the workshops and subsequently finalising the trial designs. Subsequently I was responsible for the following trial groups:

- Residential Smart Metering (SM) – 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

- Industrial and Commercial Demand Response (I&C DR) – Determine the effectiveness of I&C DR aggregator contracts to allow for medium term and long term short notice demand response in post fault conditions, as well as long term advanced notice demand response for network outage and demand management to maintain stable network conditions. Determine the effectiveness of I&C DR aggregator contracts to provide fast response wind twinning demand response to meet rapid changes in network wind generation. Determine the appropriate commercial arrangements that make I&C DR aggregator contracts commercially attractive for customers and for DNOs as an alternative to network reinforcement.

- Industrial and Commercial Distributed Generation (I&C DG) – Determine the ability of Active Network Management (ANM) to manage the output of I&C DG to meet network voltage, power flow, fault limit constraints, and ensure that the network remains within statutory network reliability requirements in pre and/or post fault arrangements. Determine appropriate commercial arrangements that make ANM of I&C DG commercially attractive to I&C DG owner and the DNO, as well as enable maximum utilisation of DG and allow higher penetration of I&C DG on the network.

- 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.

Key stakeholders that took part in the trial design review workshops included the corresponding trial group work stream lead, the Solution Design Authority work stream lead, and work stream leads for the new network planning and operational practices and tools. I was also present at the other trial group workshops so that I could provide design support, and ensure I had up to date knowledge across all of the trials. The purpose of the workshops was for myself or my co- Trial Design Engineer to walk through the trial design document and address any open issues with stakeholders, and gain stakeholder acceptance of all trial design attributes. Following the workshops, the documents then gained programme approval and were issued out into the programme to guide the implementation and running of trails.

Development of Hypothesis Test Approach Documents

Following on from the high-level trial design that was outlined in the Trial Description documents, the next step in managing the trials, was to developed Hypothesis Test Approach documents for each of the trial groups. The purpose of these documents was to provide a detailed overview and completeness check of the three key stages of each trial group, so as to allow for analysis of data to be easily carried out at the end of trials for the purpose of answering the trial hypotheses. These stages and subsequent sections of the document were:

- Trial Design Development – This section describes the design work required, the high-level requirements of the design, and the approach to be taken for the development of the trial design. References are also included to the programme/ work stream product/s that develops and delivers the design work.

- Trial Intervention Development – This section describes the design work required, the high-level requirements of the design, and the approach to be taken for the development of the trial intervention (e.g. initiating and managing Time of Use trials, conducting short term power quality data capture, and conducting demand response events). Again, references are also included to the programme/ work stream product that develops and delivers the design work.

- Trial Analysis Approach - This section provides a detailed analysis methodology for each hypothesis, including input requirements, and analysis process roles and responsibilities.

Similar to the Trial Description documents, my co- Trial Design Engineer and I decided to split the trial groups between ourselves, and I carried out the design work for the Electric Vehicles, Heat Pumps, Small Scale Embedded Generation, Industrial and Commercial Distributed Generation, and Industrial and Commercial Demand Response trial groups. For each trial group there was one Hypothesis Test Approach document which encompassed all of the objectives for that trial group. A description of these trial groups is included earlier in this report, as well as in my First Quarterly ES Cornwall Scholarship Report.

In writing the documents, through utilising previous trial design documentation and knowledge, I drafted specific details regarding the design and initiation of trials, such as:

- Design of each individual participant grouping, which included the required personal attributes, numbers, and any further subgrouping.

- The process and associated responsibilities regarding design of trial participant behaviour influence activities, such as ANM, EV Time of Use (ToU) tariffs, charge point control, and DR interventions

- In the case of I&C DG, the process for selecting the best participants so as to effectively manage trial opportunities.

In addition I drafted specific details regarding the design of trial interventions, such as the process, frequency, quantity and responsibilities for:

- The collection of short term power quality data using temporary power analysers for each trial participant grouping
- Implementation, ongoing running and ending of trial participant behaviour influence activities, such as ANM, EV ToU tariffs, charge point control, and DR interventions

With respect to the trial analysis approach section of the documents, following discussion with key stakeholders, the decision was made that only high-level detail would be added to this section of the document at this stage, and the detailed analysis approach information would be added once trials where underway. Delaying writing this stage of the document allowed for initial trial data to be gathered and for a better understanding of the data being captured to be gained, so that analysis approaches could be more effectively designed.

Following this drafting stage, I then ran through these draft documents with corresponding work stream leads in order to address any open items and where required, highlight the need for an additional work stream product and its associated attributes. At this point, I then handed over all of the Hypothesis Test Approach documents I had been responsible for to my co- Trial Design Engineer, so that he could be responsible for completing the documents at the appropriate time, which would occur after my leaving date from UKPN.

Mapping of Trials Carbon Emissions Impact Analysis

As part of Low Carbon London's successful Low Carbon Network Fund bid to OFGEM in 2010, a Carbon Tools suite was proposed to be developed and implemented that would be responsible for evaluating the programme's performance with regards to the impact on CO_2 emissions, specifically reductions through trials. As such, the tool is designed to calculating and reporting the impact on CO_2 emissions on a per monthly basis, based on programme activities. As part of the trial hypotheses, there was a need to also determine the impact, if any, there would be on CO_2 emissions, as this information is likely to be used to impact future industry policies and decisions. While many of the hypotheses could have their CO_2 impact calculated using the Carbon Tools suite, there were a number that fell outside of the scope of the tools or involved forward projections. Therefore, in order to have a high-level interpretation of the trial CO_2 calculation process based on the work completed as part of the Trial Description documents, I developed an analysis process map for the hypotheses CO_2 impact calculations. While the mapping was deliberately high-level, I designed the process map so that it showed the calculation inputs and where they were to come from (e.g. specific trial data, analysis from UKPN or Imperial College, UKPN standards), as well as who would be responsible for completing the analysis (i.e. UKPN, Carbon Tools, or Imperial College) and whether this calculation fell into actual CO_2 emissions impact analysis or predicted impact analysis. I then shared this process map with my co-Trial Design Engineer, and the team member responsible for managing the programme benefits, so that it could be utilised after my tenure with the programme.

Ongoing Programme Management Work

In addition to the main trial design work I have completed, I have also carried out a number of pieces of programme management work which has allowed me to gain and maintain broader programme knowledge, as well as develop and improve my project management skills. The main pieces of programme management work I have completed this quarter have included:

- **Hypothesis Breakdown Document** – This excel workbook was originally developed as part of the early very high-level programme trial design. As the Trial Description documents had now been completed, I identified the need to bring this workbook document up-to-date and provide additional useful information, as the workbook had become a handy quick point of reference for details regarding the programme trials. As an earlier version of the workbook had been previously included in a programme update submission to OFGEM, I had to ensure I kept a detailed log of all changes to the workbook. In addition, I had to ensure that the details in the workbook were in agreeance with that in the Trial Description documents. On completion of the update, a formal change request was logged to the programme to have the new version accepted for use by the programme.

- **Programme Dependency Management Tool** – Following on from the work I completed last quarter in developing a LCL programme dependency management tool, as there had been a number of changes in work stream and programme products, and trial hypotheses and the associated trial design documents had undergone a lot development work, I identified the need to review the tool and bring it up-to-date. As such, I completed a complete review of all the inter-programme dependency relationships updated where appropriate. In addition I took this opportunity to add alterations to the tool that had been suggested by users of the original release.

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. In addition, I have also been able to attend a number of presentations by suppliers, industry bodies and community groups regarding industry related developments and issues. My highlight events of this quarter that I had the opportunity to attend included:

- Institute of Engineering and Technology UK event: *An obsession with speed – The Challenges of Formula One.*
- Tour of the four UK Power Networks 132/11kV Olympic park substations (4 x 240MVA (N-2), 6 x 240MVA (N-2), 161MVA (firm), and a 35MVA Switching Station).
- Redr UK course: *So you think you want to be a relief worker?*

This quarter I have also once again taken advantage of the opportunity the scholarship has provided me in being able to travel internationally. I was fortunate enough to spend Christmas in Paris and New Years in Prague, and I have also had a number of day and weekend trips throughout Great Britain.

Future Direction

As I have now finished my six month tenure with UK Power Networks, I am taking part of the month of March 2012 off to spend some time travelling Eastern Europe. In this time I will also relocate to the Netherlands where I will be commencing a six month engineering role with KEMA in Arnhem on the 2nd of 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. My time will be spent working as an Electrical Engineer in KEMA's Energy Storage team within their Clean Energy Solutions business unit, which will allow me to get a variety of project experience, and a global understanding of the Electric Vehicle and distributed generation market developments. With respect to immigration, the team at KEMA has begun assisting me, ensuring that Visa and Work Permits are organised. I am very much looking forward to this placement and the opportunities it presents to build off of my E.S. Cornwall scholarship.

I have also established with Liam O'Sullivan, the Low Carbon London Programme Director, that I will I continue a professional relationship with the programme by becoming the first Low Carbon London Global Ambassador. The specifics of this role include:

- Attending and presenting on behalf of the Low Carbon London programme at relevant conferences where I am more ideally located to do so.
- Develop connections with organisations and projects around the world where a mutually beneficial relationship can be established, whereby allowing knowledge and learning to be exchanged.

The benefit to me will be that I will be kept well informed of the programme's progress, above the general level of public exposure, including access to reports outlining learning from the programme. In the case where I am asked to present at a conference on behalf of the programme, I will have my registration and conference costs covered for by the programme.