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5th February 2013

Mr Simon Bartlett
Chairperson
ES Cornwall Scholarship Advisory Committee
Australia

Dear Mr Bartlett,

**ES Cornwall Memorial Scholar – Donald McPhail
Fifth Quarterly Report**

Please find enclosed my fifth quarterly report for the ES Cornwall Memorial Industry Scholarship for the period of 5th November 2012 – 3rd February 2013 during my employment with ECOtality North America in the United States of America.

During the first three months of my placement with ECOtality, I have been working as a Ground Energy Storage Engineer as part of the Engineering team based in Phoenix, Arizona. ECOtality North America is a leader in clean electric transportation and storage technologies, and provides Electric Vehicle Supply Equipment and services for Residential, Commercial and Industrial applications. ECOtality has also designed and currently manages the world's largest EV infrastructure demonstration - The EV Project.

The key work I have carried out during this quarter has included researching the USA electricity ancillary services and demand response markets/programs, so as to work towards producing a report outlining the technical/economical requirements and opportunities for ECOtality to participate in these markets/programs. In addition I have been investigating the concept of energy storage system assisted electric vehicle DC fast charging units, so as to work towards writing an engineering white paper on how and where to deploy such a system.

Given the confidential nature of much of the work I have undertaken, I have had to omit certain details of some developments that are of commercial significance to ECOtality.

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, which will be my final quarter on the ES Cornwall Memorial Industry Scholarship.

Kind regards,

Donald McPhail

**E.S. CORNWALL MEMORIAL INDUSTRY SCHOLARSHIP
FIFTH QUARTERLY REPORT**

By

Donald McPhail

Reporting period: 5th November 2012 – 3rd February 2013

5th February 2013

***Approved by Garrett Beauregard
(ECOtality North America)***

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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, 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)
- DNV KEMA (April 2012 to September 2012)
- ECOTality North America (November 2012 to April 2013)

This report is the fourth of six quarterly reports required under the scholarship guidelines, and covers 5th November 2012 – 3rd February 2013. This three month period is the first half of my six month placement with ECOTality North America (ECOTality) in Phoenix, Arizona in the USA, as a Ground Energy Storage Engineer.

Background of Current Placement

ECOTality North America

ECOTality North America is the leading installer and provider of charging infrastructure for Electric Vehicles (EVs) in North America. ECOTality has been involved in every major EV initiative to date in North America and is currently working with major automotive manufacturers, utilities, the USA Department of Energy (DOE), state and municipal governments, and international research institutes to implement and expand the presence of this technology.

ECOTality designed and currently manages the world's largest EV infrastructure demonstration - The EV Project¹. With a budget of over \$230 million (on a 50% cost-share basis with the US DOE) and due for completion in early 2013, The EV Project is deploying and studying Level 2 Alternating Current (AC) Electric Vehicle Supply Equipment (EVSE) stations for residential, commercial and public usage, and Direct Current (DC) Fast Charge (DCFC) stations. This represents thousands of field assets, coordinated for utilisation with the deployment of thousands of Nissan LEAF and Chevrolet Volt vehicles.

Upon completion The EV Project will deliver to ECOTality, the Government and the general public a wealth of technical and professional experience for jumpstarting regional EV adoption and replicating business models that lead to sustainable, market-based charge infrastructures.

¹ Further information about The EV Project can be found at: <http://www.theevproject.com/>



Figure 1 - High Level Map View of ECOtality's Blink Charging Network in the USA²

Summary of Work Experience

In my role as a *Ground Energy Storage Engineer* my work to date has allowed me to gain a greater understanding of the USA electricity markets and Ancillary Service (AS) and Demand Response (DR) markets/programs, as well as the challenges and opportunities for the deployment of a network of EVSE infrastructure. Specifically my work has included:

- Research the USA electricity markets, including their key attributes and the rate/tariff structures on offer.
- Research the USA AS and DR markets/programs in order to identify opportunities for involvement with aggregation of EVSE infrastructure
- Investigate the ability to combine an Energy Storage System (ESS) with a DCFC so as to coordinate the charging/discharging relationship for demand charge reduction, participation in AS/DR markets, and reduce the effect of DCFCs on the local electricity grid.

Ultimately though I am working towards developing a company white paper on the application of ESS assisted DCFCs (which will be published on the EV Project website) as well as a report on the state of AS/DR markets in the USA and the opportunities in the short term for ECOtality's involvement in these markets. This work is discussed in what follows.

Research of USA Electricity Markets

In order to familiarise myself with the current structure and state of the USA electricity markets, I carried out research into the key players that make up the market. In summary, I investigated the role and attributes of each of the eight reliability councils, seven Independent Service Operators

² <http://www.blinknetwork.com/blinkMap.html>

(ISOs) and Regional Transmission Organisations (RTOs), and over 120 distribution power utilities, power co-operatives and municipal power boards which lie in the regions of key interest to ECOTality³. As an outcome of this research I have produced two deliverables this quarter which consist of:

- **Catalogue of USA Electricity System and Markets** – The purpose of this catalogue is to provide an overview of the USA electricity market, in particular including details on:
 - ISOs/RTOs such as generation capacity and sources, annual peak demand, and average wholesale price (per/MWh); and
 - Electric utilities, co-operatives and municipal power boards such as supply territory location, corresponding ISO/RTO, utility type (generator, distributor, etc.), generation capacity and sources, annual peak demand, and network transmission/distribution size
- **Catalogue of USA Electricity Utilities' Rates/Tariffs** – The purpose of this catalogue is to provide complete structure and price details of the commercial electricity rates relevant to EVSE services (Level 2 AC and DCFC) as well as any EV specific residential tariffs. In total the catalogue has over 360 tariffs from over 120 distribution utilities, co-operatives and municipal power boards included in the electricity market overview catalogue (see above).

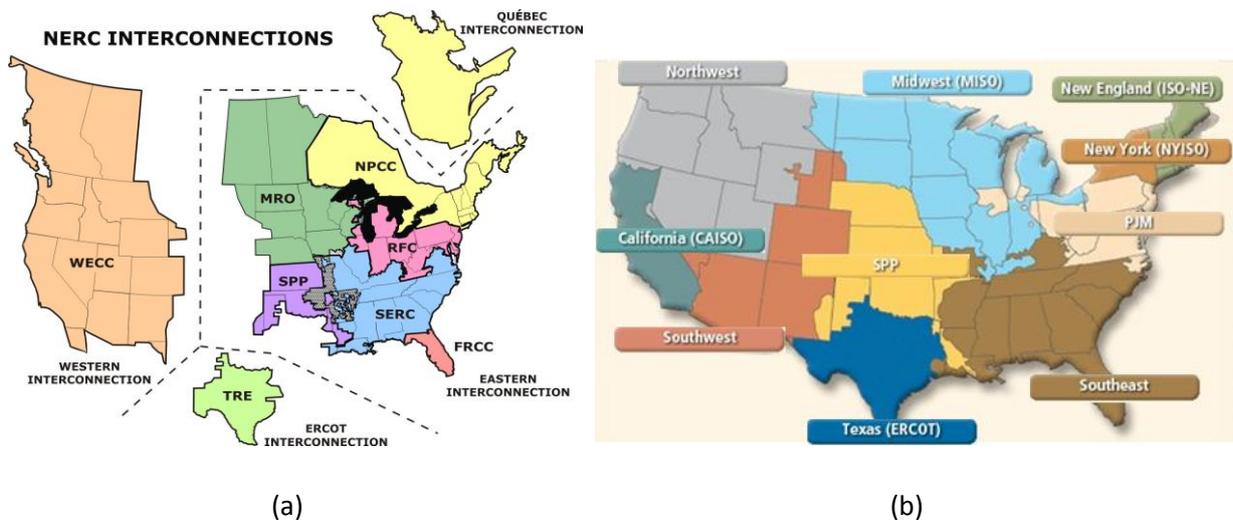


Figure 2 (a) North America Electricity Reliability Council Boundaries and Interconnections; (b) Map of North America Independent System Operators, Regional Transmission Organisations and Market Regions

³ There are over 3000 electric utilities, co-operatives, municipal power boards, and state and federal boards in the USA, however the just over 120 utilities and co-operatives I investigated supply over 70% of the country's population.

Research of USA Ancillary Services and Demand Response Markets / Programs

Following on from my research of the USA electricity markets, I carried out research into the state of the USA AS and DR markets/programs in order to gain an understanding of the requirements, barriers, costs, and rewards for entering and operating in these markets/programs. This work included looking at, for each of the ISOs/RTOs, utilities, co-operatives, and municipal power boards their market status and offerings, attributes/guidelines and the level of AS/DR as a percentage of the relative network peak demand. In addition, I also investigated attributes and offerings of the third party aggregators that are operating in these markets. In many cases utilities require their customers to go through aggregators in order to participate in the AS/DR markets/programs.

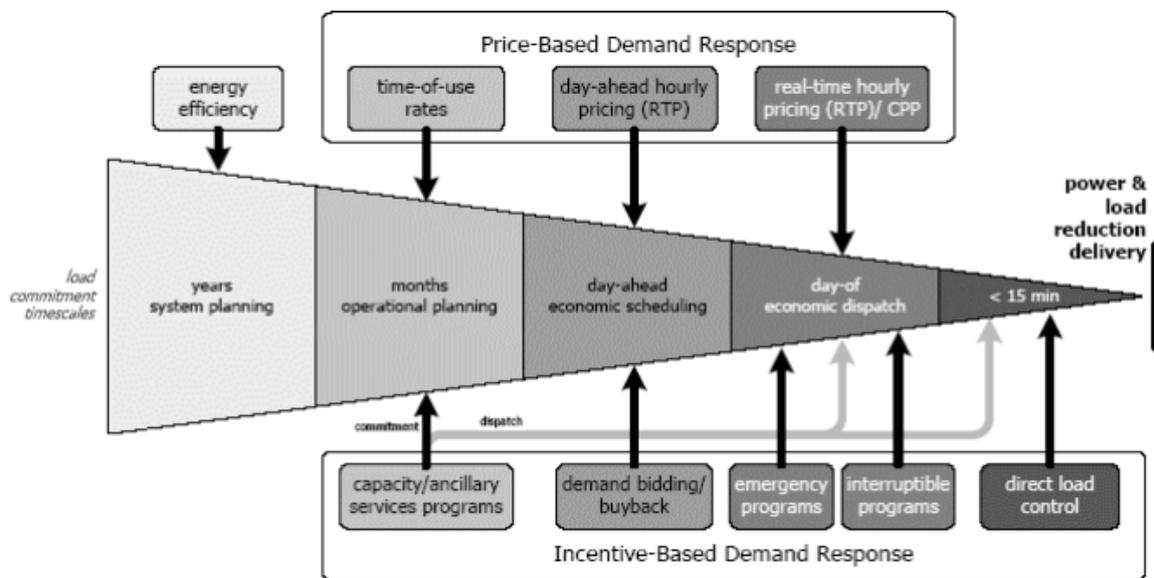


Figure 3 – Diagram of the Different Types of DR Programs and their Load Curtailment Timescales⁴

In order to assess ECOTality’s current and forecasted opportunities in AS and DR markets, I carried out an analysis of ECOTality’s EVSE demand in each electric utility’s and ISO/RTO’s supply territory so as to understand the average weekday and weekend demand curves (including each quartile’s curve in order to understand the statistical distribution). From this present-day data I extrapolated the expected short- to medium-term growth in ECOTality’s EVSE electricity demand using research/analysis released by a USA research body so as to understand also ECOTality’s future potential opportunities in AS and DR space.

In addition to my research of the USA markets, I also carried out high-level research into the Australian and United Kingdom AS and DR markets. The purpose of this research was to compare with the USA markets for the purpose of making some prediction of how the USA markets may change and apply learning to ECOTality’s potential involvement. I selected these markets for comparison with the USA given these markets have significant experience with load participation in

⁴ Leo, Mark, et al, “Ancillary Service Revenue Opportunities from Electric Vehicles via Demand Response”, University of Michigan School of Natural Resources and Environment, Ann Arbor MI USA, April 2011.

providing AS, there is substantial information on them in English, and I have previous knowledge of these markets.

My deliverables from this work has included:

- Building off the *catalogue of USA electricity systems and markets* I created to add details on the AS and DR markets/programs offered by each of the ISOs/RTOs and electric utilities. In addition, I added information of the products and attributes of over 50 active AS/DR aggregators that are approved to offer services to clients for participation in one or more of the ISO/RTO or utility AS/DR markets/programs.
- Due for release during the second half of my secondment at ECOtality, I am also currently working on a report and accompanying roadmap that outlines my findings of the state of the AS and DR markets in the USA, and identifies opportunities for ECOtality's involvement in the short- to medium-term, and the process required for doing so.

Investigation of an Energy Storage System Assisted DC Fast Charger System

The other main piece of work I have been carrying out has been to investigate the concept of an ESS assisted DCFC system. Typical Level 2 DCFC units draw approximately 50-60kW from the LV AC grid in order to charge an EV to approximately 80% capacity within about 15 minutes. This in turn has the potential to put sudden strain on the local electricity network, and to incur significant demand charges. Presently an average DCFC unit in North America can expect to be providing a charge to a vehicle only ~5% of the time in a typical month. As such this results in a very low load factor and a high demand charge to kWh price ratio. As demand charges can be seasonal, time-based and/or incurred for up to one year following the peak demand event (depending on the utility's rate structure), a DCFC unit can expect to experience demand charges of several thousand, or even tens of thousands, of US dollars every year.

With this in mind, I have been investigating how an ESS-assisted DCFC system would operate, what are the costs associated with the battery system and associated power electronics, and what are the necessary communication/control requirements/capabilities with the EV and a third party (e.g. grid operator, aggregator, etc.). Building off my work in collating electricity utility tariff prices and structures, I have also calculated what the potential annual savings are between a 50kW (i.e. no ESS) and a 20kW (i.e. an ESS with a 30kW discharge size) AC grid connection at each utility by selecting the best rate in each case. Subsequently this is allowing me to identify the areas where an ESS assisted DCFC unit is financially viable.

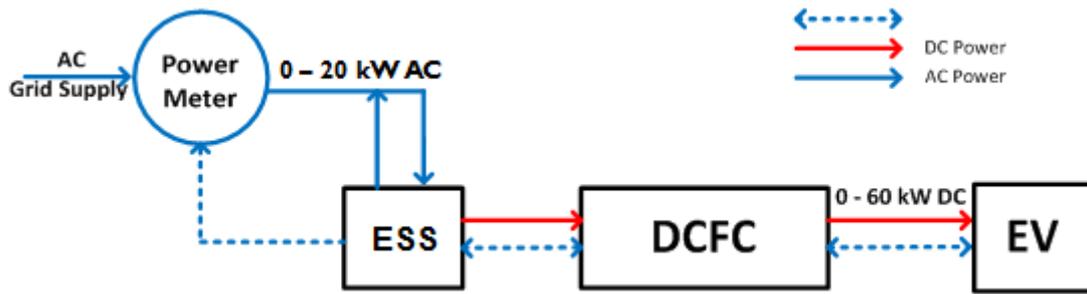


Figure 4 - Configuration of Energy Storage System Assisted Electric Vehicle DC Fast Charger Unit

In order to allow for quick analysis of the suitability of an ESS size (kW) and capacity (kWh) for a user-selected DCFC demand profile, I developed a simulator that - based on desired ESS parameters - calculates the time-based state of charge of the ESS and subsequent AC grid demand. The simulator also highlights what the ESS's lowest state of charge was and whether at some point it ran out of stored energy, which in turn affected the DCFC's ability to provide charge to the connected EV. For convenience, the simulator is also able to calculate what the monthly and annual demand charge would be for the system, based on the user selected utility.

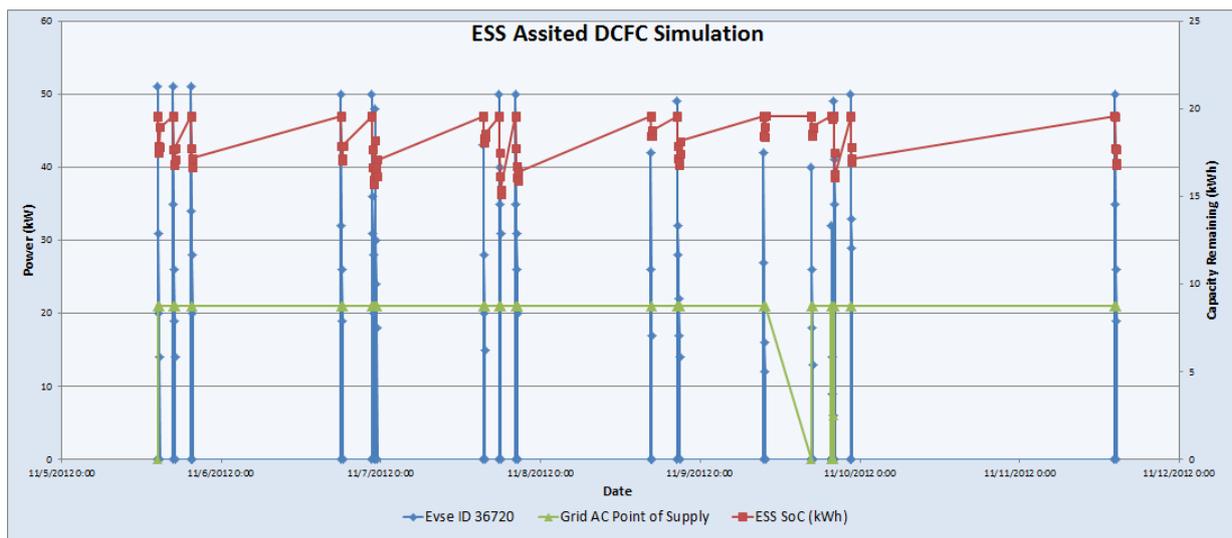


Figure 5 - Example Plot from Energy Storage System Assisted DCFC Effects Simulator/Calculator

In addition to this work I am doing for the subsequent white paper, I have also been involved in the early design stages of some complementing vehicle-to-grid project trials.

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 the Barrett-Jackson Collector Car Auction, the largest of its kind in the world
- Chair the organising committee for the 2013 Global Humanitarian Technology Conference Young Professional Project contest.

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. Being a part of the engineering team and working alongside automobile professionals, mechanical engineers, electronics and control system engineers, chemical engineers, and project managers, has allowed me to gain a greater understanding of the challenges faced with EVs and EVSEs from the user and vehicle perspective. This in turn has improved my thinking of how best to manage the effects of EVs from the electricity supply side.

Outside of my work, I have also taken advantage of the opportunity the scholarship has provided me in being able to travel internationally. Between my time with DNV KEMA in the Netherlands and ECOTality in the USA, I managed to spend some time travelling through Spain and Portugal. Over the past three months while living in the USA I have been able to attend a number of events and see a great deal of Arizona, including enjoying a white Christmas near Flagstaff, as well as visiting several west coast cities. Over the coming months I plan to continue doing some travel on my weekends, and making the most of the opportunity this scholarship has given me.

Future Direction

I am currently just over halfway through my six month secondment with ECOTality North America, and I envisage that the majority of my remaining time will be spent working on:

- Continuing to pull together my research and work to date on analysing the USA electricity AS and DR markets/programs and delivering a report which evaluates the potential for ECOTality to participate in these markets/programs, as well as a roadmap for doing so.
- Continuing to pull together my investigation and analysis to date on the concept of combining an ESS with a DCFC so as to produce an engineering white paper which discusses the opportunities, barriers and requirements for the system applications I identified earlier.
- On completion on the above two deliverables which are my main focus, I envisage that I will then be spending any remaining time working with the engineering projects team on their vehicle and EVSE testings and user studies.

Upon completing my placement with ECOTality on the 3rd of May, my plan is to travel in the USA for a few weeks before returning to Australia in the first week of June to re-enter the Australian electricity supply industry. Upon my return I am more than happy to make myself available for any industry or ES Cornwall scholarship events as required.