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3rd August 2012

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

Dear Mr Bartlett,

ES Cornwall Memorial Scholar – Donald McPhail
Third Quarterly Report

Please find enclosed my third quarterly report for the ES Cornwall Memorial Industry Scholarship for the period 2nd April 2012 – 1st July 2012 during my employment with DNV KEMA in the Netherlands.

During the first three months of my placement with DNV KEMA, I have been working as an Electrical Engineer as part of the New Energy Technologies team in the Clean Energy Services business unit based in Arnhem, the Netherlands. The New Energy Technologies team is made up of a number of professionals from various technical and business backgrounds and has a focus on projects related to energy storage, carbon capture, transition to sustainable energies, and industrial use of polymers, for governments, utilities and businesses.

The key work I have carried out during this quarter has included working on the development of a tool to optimise the use of energy storage devices in power systems for the purpose of managing network loading and voltage with respect to loads, including electric vehicle charging, and distributed generation. This work has been part of a European Commission supported consortium project with partners from Germany and Denmark.

Given the confidential nature of much of my work I have undertaken, I have had to omit certain details of some developments that are of commercial significance to DNV KEMA and their clients.

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
THIRD QUARTERLY REPORT

By

Donald McPhail

Reporting period: 2nd April 2012 – 1st July 2012

3rd August 2012

Approved by Dr. Jos van der Burgt
(DNV KEMA)

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

This report is the third of six quarterly reports required under the scholarship guidelines, and covers 2nd April 2012 – 1st July 2012. This three month period is the first half of my six month placement with DNV KEMA in Arnhem in the Netherlands, as part of the New Energy Technologies team.

Background of Current Placement

DNV KEMA Energy and Sustainability

DNV KEMA Energy and Sustainability is an independent knowledge leader and a global provider of high-quality services to the energy value chain, specializing in business and technical consultancy, operational support, measurement and inspections, and test and certification. Established in 1927 with headquarters in Arnhem, The Netherlands, KEMA merged with the DNV group in February 2012 to strengthen its offering of business and technical solutions for the energy and utility industry around the world.

As part of the Clean Energy Services business unit of DNV KEMA, the New Energy Technologies group concentrates on innovation and new applications in the field of energy through the combination of consultants and laboratory facilities, feasibility studies, development projects as well as demonstration projects. Important areas of focus for the team are energy storage, carbon capture, transition to production of sustainable energy, and the industrial use of polymers. The group's project work can come from governments, energy companies, or industry related companies and organisations.

Summary of Work Experience

In my role as an *Electrical Engineer* within the New Energy Technologies group, my work to date has allowed me to gain a greater understanding of the application of technologies such as energy storage, and how they can be used to optimise electricity networks which include connections such as Electric Vehicles (EVs) and Photo-Voltaic generation systems (PV). Specifically the project I have

worked on has been the development of a grid modelling and optimisation tool for the European Commission supported NEMO project. In addition, I have also gained exposure to, and completed some work for the Sustainable Off grid Power for Rural Area's project (SOPRA), and the Easy and Safe Battery Switch in an EV project (EASYBAT). Both of which are European Commission supported projects.

Development of a Grid Modelling and Optimisation Tool

From 2007 to 2010 KEMA led a European Commission funded project with several industry partners known as the GROWDERS project (Grid Reliability and Operability with Distributed Generation using Flexible Storage). The aim of the project was to demonstrate the technical and economical maturity of transportable and flexible energy storage systems for meeting technical challenges faced by electricity networks from distributed energy sources[1]. One of the outcomes of this project was the development of a software planning tool known as PLATOS (Planning Tool for Optimised Storage), which utilised the load flow package called Digsilent PowerFactory. PLATOS was developed to optimise the location, type and size of storage systems for distribution grid applications, based on yearly power flow profiles. In order to efficiently solve this computationally challenging problem, the tool utilised a genetic algorithm to determine the most optimal storage solution, based on user defined performance criteria. Based on market available energy storage units, the tool was designed to then be capable of determining the following attributes of the storage systems for the purpose of over-load, over/under-voltage, and voltage dip alleviation, as well as for trading:

- The type of storage, taking into consideration charging and discharging rates for several models of each type. Storage types include Flywheel, Li Ion, Li Ion SL, Ni Cd, PB A, and Second Life battery systems.
- The size of the storage unit (kW) and the capacity of the storage unit (kWh)

While the tool was very useful in the carrying out the project, which included several real world case studies, as it was not user friendly, highly susceptible to bugs, and slow to run, it meant that the tool could not be readily used for future projects. Figure 1 shows a graphical representation of the concept of the PLATOS tool as part of the GROWDERS project.

[1] Further information about the GROWDERS project can be found at: http://growders.eu/

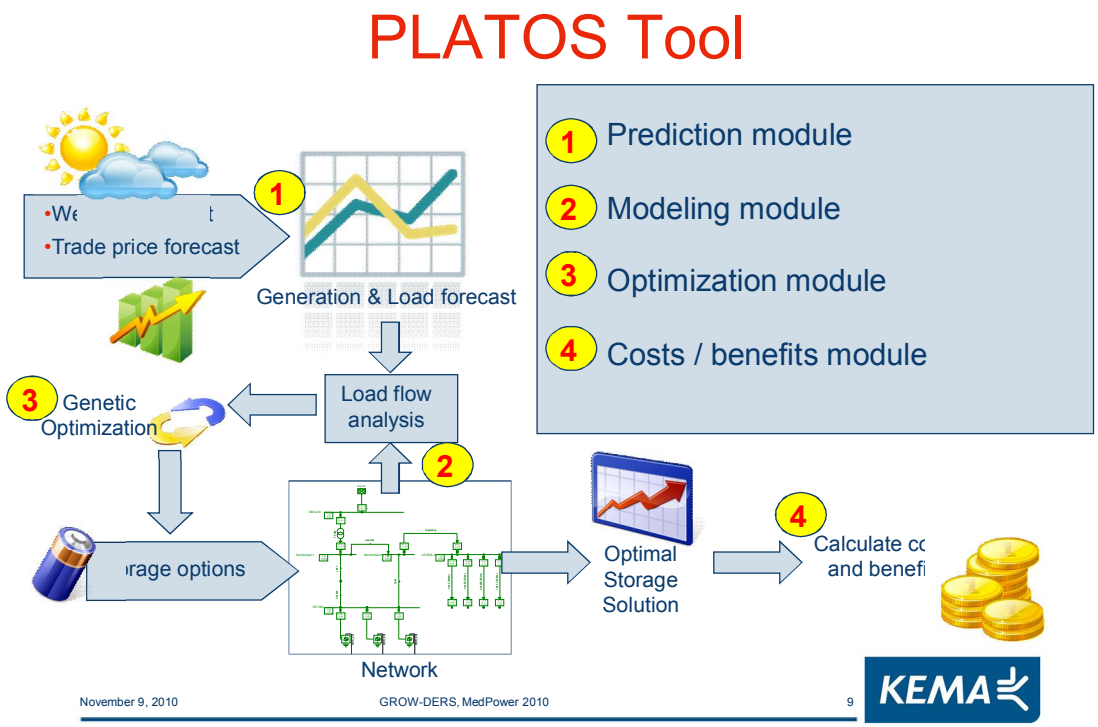

Figure 1 - Graphical Representation of the PLATOS Tool Concept

Following on from this project however, in mid-2012 DNV KEMA along with industry partners began a European Commission supported project to develop a simulation and optimisation tool suite capable of evaluating the impact of large scale deployment of EVs on the electricity grid. The project, known as NEMO, aims to build off the PLATOS platform to include EVs and match distributed generation and energy storage to support network power demands and capitalising on economics associated with energy trading[2]. The project is to run for 3 years and the deliverables will include a tool suite that will not be made commercially available but rather used by the partners to provide consulting services, as well as several real world study cases for optimisation of HV, MV and LV networks for EV penetration and trading of energy from DG and ES.

Since starting with DNV KEMA in April 2012, the main focus of my work has been taking the existing PLATOS tool and developing it into something that is working, user friendly, more efficient, and capable of meeting the additional requirements of the NEMO project. Initially my time was spent becoming familiar with the GROWDERS and NEMO projects, and more importantly, the PLATOS tool. Fortunately I had prior experience of working with PowerFactory, however the staff member involved in the detailed development of the PLATOS tool was no longer available, and the tool itself had no user guide nor instructions contained within the tool. Much of my time was then spent gaining an understanding of the inner workings of the PLATOS tool and the technical and computational design behind it. Eventually I was able to get a demo study case working in the tool, and had compiled a guide on how to use the tool, working around its many bugs. Having gained this

[2] Further information about the NEMO project can be found at: http://www.nemo-project.eu/

deep understanding of the tool as it stood in its present form, allowed me to compile an overview of recommendations which outlined:

- How the PLATOS tool currently worked, what it was presently capable of, and which existing functionality it was unable to perform correctly.
- What was required of the PLATOS tool in order for it to be used in the NEMO project.
- What in the tool would need to be changed and how this would need to be carried out, in order to meet the requirements of the NEMO project.
- A high-level diagram of how the improved tool would look with respect systems operation.

The goal of these recommendations was to propose how to make the tool more user-friendly, more efficient, and capable of performing the necessary analysis tasks. From this work and discussions with the project partnership team and DNV KEMA specific project management team, I then moved on to implementing the majority of these recommendations, in order to create an improved version of the PLATOS modelling tool for use also in the NEMO project.

As of the end of my third quarter of the ES Cornwall Scholarship (i.e. halfway through my six month role at DNV KEMA), I am now a fair way through the development phase for this improved modelling tool. I anticipate by the start of August 2012 to have a working version of the tool completed which will meet the project requirements and incorporates the earlier recommendations made.

In addition, the New Energy Technologies group of DNV KEMA has also been asked by a client to complete modelling scenarios for the anticipated Dutch energy network in 2050, based on meeting the national emissions reduction targets. As the modelling tool I am developing will also be used for this work, I have identified additional attributes to include in the tool to complete this work, and have begun incorporating these into the tool as part of the development phase. The additional attributes include the capability to model and compare the effects on network optimisation, across yearly power flow profiles, for items such as Heat Pumps (HPs) with electric boosters, Demand Side Management (DSM) initiatives, and thermal storage.

Additional Project Works

As mentioned earlier in this report, I have had the opportunity to be exposed to and carry out work for the SOPRA and EASYBAT Projects. The following is a brief summary of these projects and the work that I completed for them.

- **SOPRA** – The SOPRA project is European Commission funded, DNV KEMA led multi-partner project to develop a modular, sustainable, off-grid power station for rural applications. The SOPRA system consists of renewable energy sources (wind, solar, hydropower), electricity storage and back-up diesel power. Together they will provide power to the consumers (e.g. remote village) connected to this power system. The core of the SOPRA system is the multi-source hybrid inverter that connects all of the sources together, enables them all to run in their optimum operation state and defines the micro-grid of the system. In order to support the design of this system, a SOPRA tool has been developed which utilises the load flow simulation package Digsilent PowerFactory. The tool gives the user the ability to design,

calculate and optimise the SOPRA system for specific loads, taking into consideration geography, load profiles and growth, existing grids, and potential for generation sources. The greatest part of the SOPRA tool is its optimisation process which uses a genetic algorithm to determine the most optimal system design, based on the proposed scenario conditions.

The SOPRA tool itself was developed in house by DNV KEMA staff, and an Engineering intern was employed to evaluate the performance of the tool and conduct study cases for three SOPRA system locations, including one for a system to be deployed in the Indonesian island of Sumba. For my own personal benefit, as well as for the sake of the improved PLATOS tool I have been working on, at the start of this quarter I spent some time researching the SOPRA tool and evaluating how it worked with respect to system design and optimisation. In addition, the engineering student working on the SOPRA tool case studies was able to provide me a run through of each of the case studies and the process used to validate the design and results for each. It is possible that if time permits, I may also perform a case study using the SOPRA tool prior to the end of my time with DNV KEMA.

From my exposure to the SOPRA tool, it seems that a system such as this could be of significant benefit in Australia for improving many of the remote electricity networks found in central Australia and the island territories. The ability of the tool to evaluate local technical details such as solar radiation and diesel costs, as well as incorporate performance indicators for optimisation, means that more cost effective and sustainable off-grid system could be developed across remote Australia.

- **EASYBAT** – The EASYBAT project is a Seventh European Union Framework Programme (FP7) project which runs for two and a half years and is made up of several industry partners from Europe, with Better Place the project lead. The objective of the project is to standardise automobile components and interface to help automobile and battery manufacturers integrate battery switch technology into their EV platform.

  In order to complete part of their portion of the project, DNV KEMA had employed a Masters of Engineering student to develop an algorithm for the battery operation cycle management system which aims to enable the optimal life time and state of health of the entire battery switching pool. Given my experience in modelling and simulation of engineering systems in *The Mathworks Matlab*, I worked with the Masters Engineering intern to design the simulation of the battery swap algorithm in Matlab, and help to improve the efficiency of the model so as to allow for scenarios of greater complexity to be modelled. This meant that I was able to get a greater understanding of the project and also allowed me to benefit the project and intern's Master's thesis by being able to further validate the battery swap algorithm under more complex scenarios that reflected closer to real world scenarios.

  From the work I have been apart of and the knowledge I have gained from this project, my belief now is that through the deployment of an effective battery swapping methodology that compliments conventional slow and fast charging, it could completely change the uptake and utilisation of EVs within the Australian market. The effectiveness of such a solution will really come down to the business models that are put in place and the willingness of vehicle and battery manufacturers to utilise standardised connectors to

enable battery swapping across different vehicles types. Further information about the EASYBAT project can be found on the EASYBAT project website at: http://www.easybat.eu/

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:

- Concentrated Solar Power Young Energy Professionals in Europe kick-off event. This was a half day mini conference and provided a great insights into CSP developments around the world, the present industry opportunities, and a chance to network with professionals working in this space.
- DNV KEMA in house presentation on industry and market developments in geothermal power and the opportunities in the Netherlands and Northern Europe.
- DNV KEMA sponsored presentation by the Delft University of Technology, and the Norwegian University of Science and Technology on their developments in Sustainable Racing with electric vehicles.

Both in my day to day work, and through attending these industry events, I have also had the opportunity to meet and work with a large group of professionals from various technical or management backgrounds from across Europe. Outside of my work, I have also taken advantage of the opportunity the scholarship has provided me to be living in the Netherlands, to attend an ongoing Dutch language course, and to travel throughout Europe. Over the past three months I have been able to see much of the Dutch, German, Danish, and Belgium cities and countryside, and I have plans over my next quarter to see even more.

Future Direction

I am currently just over halfway through my six month placement with DNV KEMA, and it is envisaged that the majority of my remaining time will be spent working on continuing with the development of the improved network modelling tool for the NEMO project. Upon completion, I hope that the tool will be able to accurately determine the type, size and capacity of energy storage system for optimisation of energy networks with loads (including EVs and electric booster HPs), generators (such as household PV), and DSM initiatives. In addition, as part of the work DNV KEMA has been contracted to do to evaluate a number of Dutch energy network scenarios for 2050, I will complete case studies using the developed tool. This will involve simulating the potential scenarios in order to determine the impact the different technologies and solutions will have on the energy network.

Upon completing my placement with DNV KEMA on the 30th September 2012, I will be relocating to the United States of America to begin a six month placement with ECOtality North America in November 2012. ECOtality North America is the research, development and operations unit of the ECOtality Inc. and is a leader in services related to electric transportation and storage technologies. My goal for this placement is to gain greater experience in the deployment of electric vehicle

charging infrastructure, the impact it has the energy network, and the best practices for managing these systems. It is anticipated my time will be spent working as a Ground Energy Storage Research Engineer and focussing on evaluating local grid conditions to determine the requirements for ground energy storage and estimating the optimum size of DC Fast Charge energy storage; conducting research with utility companies to understand and resolve issues regarding the use of ground energy storage systems; exploring the US energy markets, comparing them to the Australian market and evaluating the revenue opportunity potentials in the EV infrastructure market. With respect to immigration, the team at ECOtality North America has begun the process of assisting me to get the necessary work permits so that I can get a working visa for this placement. I am very much looking forward to this placement and the opportunities it presents to build off of my E.S. Cornwall scholarship.