Mr Aidan Roberts
United Kingdom

5th January 2010

Mr Simon Bartlett
Chairperson
E S Cornwall Scholarship Advisory Committee
P O Box 1193
Virginia QLD 4014

Dear Mr Bartlett

**E S Cornwall Memorial Scholar – Aidan Roberts**
**Fourth Quarterly Report**

Please find enclosed the third quarterly report for the E S Cornwall Memorial Scholarship for 2008-2010 which is a requirement set out in the scholarship rules (6).

The points of interest for the quarter are the completion of my second placement with EA Technology Consulting Ltd., IEA DSM Task XIX Subtask 3, STP Module 5 “Smart Meters: Next Steps” and my attendance at the IEA Workshop on Demand Side Management.

I would welcome the committee’s feedback and advice on the report, particularly concerning my proposed goals for the next quarter and placement.

Yours faithfully,

Aidan Roberts

Enclosures: E S Cornwall 2009-10 Quarterly Report 4

## 1. Introduction

My tenure of the E. S. Cornwall Memorial Scholarship is currently from October 2008 through to October 2010. The purpose of the proposed program is to gain experience in the areas of Smart Networks and Distributed Generation. In particular, I hope to gain an understanding of how these areas will impact and/or enable network operation & planning, energy & demand management, metering and carbon emissions. The proposed program is designed to give me experience with a regulator, a consultancy/research facility, a technology provider and a distribution network operator.

This report is the fourth of 6 quarterly reports required under the rules of the scholarship. The period of employment reported on is July 21st to October 22nd 2009 which covers the first half of a planned 6 month placement.

My current placement is with EA Technology Consulting Limited. The main objective of this placement is to gain exposure to New Energy Technology projects relating to my areas of interest.

## 2. EA Technology Consulting Limited

### *Work Experience*

During the third quarter with EA Technology Consulting Limited (EATCL), the majority of my time was involved with two Implementing Agreements (IAs) under the International Energy Association (IEA).

- Energy Networks Analysis, Research and Development (ENARD) – Annex I
- Demand Side Management (DSM) Programme – Task XIX

The two major deliverables for ENARD were the Information Subtask I "Smartgrids" and the conference proceedings for the Workshop on "Communications & Control", which I attended. Both of these pieces were completed and were well received by the ENARD Executive Committee (ExCo) and the workshop participants.

Toward the end of the quarter, I began working on Subtask 3 for the DSM Task XIX. My involvement with this project continued on through the majority of the fourth quarter. During this quarter I was further tasked with completing a Strategic Technology Programme Module 5 (STP 5) Project on Smart Meters. My involvement with this project due to an overlap with my previous contributions to Task XIX and ENARD, along with my particular areas of interest under the ES Cornwall Memorial Scholarship, *IEA DSM IA Task XIX – Subtask 3 – Delivery Mechanisms for Micro Demand Response and Energy Saving*

During the Fourth quarter with EATCL the majority of my time was spent on the delivery of a report for DSM Task XIX Subtask 3. As outlined in my previous report, the major objectives for Subtask 3 were to:

- *Define mechanisms for motivating and delivering energy savings by residential and SME customers (disaggregated demand information, TOU pricing, remote switching, Demand Side Bidding and customer interviews etc.)*

- *Define "smart" metering, disaggregated data and control mechanisms for motivating and delivering demand shifting by residential and SME customers (metering, switching, pricing, EUMF)*

The first objective was achieved through an extensive review of existing DSM programmes around the world along with a detailed survey of participating member countries. The survey was aimed at collecting a wide range of information from demand and generation compositions to existing telecommunications infrastructure. From the information reviewed, it was clear that the delivery mechanisms should be separated into those that promoted energy savings and those that encouraged a demand response. Within each of these categories, further distinctions were made such that each delivery mechanism could be defined as a product with particular characteristics. The defined products are listed in Table 1 below.

| Programme Category | Product Group | Product |
|---|---|---|
| Energy Saving | End Use Monitoring & Feedback (EUMF) | Billing |
| | | Websites |
| | | Real Time Information Provision |
| | | Disaggregated Demand Information |
| | | Face-to-Face Energy Advice / Energy Audits |
| | | Community Energy Saving Schemes |
| | Block Tariffs | Block Tariffs |
| | Rebate Tariffs | Rebate Tariffs |
| Demand Response | Time of Use Tariffs (TOU) | Static TOU |
| | | Dynamic or Real-Time Pricing |
| | | Semi Dynamic Pricing |
| | | Critical Peak Pricing |
| | Direct Load Control | Direct Load Control |
| | Load Limiting | Load Limiting |
| | Generation Dispatch | Generation &/or Storage Dispatch |

***Table 1 - Energy Saving and Demand Response Products***

Demand Response (DR) products are likely to provide greater benefits for Network Operators. Some of the DR products are relatively old concepts, for example Direct Load Control (DLC). Different variations of DLC have been in use for some time, for example as a means of reducing demand in constrained sections of network during peak periods. Typically, consumers are offered an incentive, such as an annual participation payment or a reduced standard consumption tariff. In exchange, the consumer allows for a particular load within their premise to be directly controlled by the external party

The popularity of Time-of-Use (ToU) tariffs has increased in recent years. There are a number of variations of this product and for Subtask 3 four sub-categories were created to help highlight general differences. These sub-categories are distinguished from each other by the amount of lead-time given to the consumer and the frequency of tariff fluctuation.

For confidentiality reasons, more thorough descriptions of each of the products cannot be provided.

My major contribution to Subtask 3 was the development of the Technical Architecture required to help deliver the products outlined above. The development of the technical architecture was intended to help determine indicative costs associated with delivering each product. Considering these costs along with the respective potential benefits for energy savings and/or demand response would then aid Task XIX members with the selection of appropriate products for implementation.

My initial step was to define various Technical Architecture Components (TACs). A brief outline of each TAC is given below:

- Controller - responsible for interpreting instructions and modifying the End Use Demand accordingly.
- Consumer Interface - provides the consumer with information that will motivate the desired demand response.
- Response Monitor (Meter) - responsible for recording consumer loads (energy usage and possibly demand) from which the energy savings and demand response can be assessed.
- Internal Communication - the means by which communications are made within the consumer premises, between the communications gateway and other internal TACs.
- Communications Gateway - the link between internal and external communication.
- External Communication - the means by which communications are made to and from the consumer premises, including communication between external parties

By defining the TACs in this way, the scope for potential solutions was quite wide. Many of the products could be delivered in a variety of ways with some more sophisticated “gold plated” solutions than others. Therefore, I found it useful to also determine higher and lower sophistication scenarios, where sophistication was in terms of their ability to reduce demand and/or provide energy savings. With this information, the next step would then be to evaluate the likely difference in benefits delivered from these scenarios. This would then allow Task XIX participants to take two approaches to the assessment of potential benefits: the benefit delivered for a given cost or the cost of delivering a desired level of energy savings/demand response.

To try and determine varying levels of sophistication, each TAC was assigned as set of functionality dimensions. For example, the Controller dimensions were:

- Trigger Mode – how the change in end use demand is triggered
- Demand Modification – how the end use demand is modified
- Location – where the controller is located in relation to the end use demand

The trigger mode was established to help distinguish between how the controller was activated. For example, the controller could be as simple as a switch on a General Purpose Outlet (GPO) that the consumer must switch manually. A more complex solution would incorporate an automatic central control system with in-built logic that could be programmed to respond to a change (e.g. in price or system frequency) according to consumer preferences. For this dimension, manual switching was considered to be less likely to deliver benefits as it was reliant on the consumer to not only be notified but also be motivated to switch. Automatic controllers could receive notification of a desired demand response and automatically adjust end use demands as required. Once set (according to consumer or third party preferences), these controllers would likely be more effective at delivering benefits, as they react without the need to continuously notify and motivate the consumer.

Similarly, the Demand Modification dimension helped to distinguish between controllers that simply switch out a load completely and those that are able to modulate the load in some fashion. Typical examples of the latter include variable heating loads. Intuitively speaking, a controller that switches a load out completely is certain to deliver more benefits than one that only partially reduces the load. Furthermore, a simple On/Off controller would be far easier to implement and would therefore be less expensive. That being said, there are some loads where it may be unsafe to switch out the load completely. Furthermore, the consumers may only be willing to allow a partial reduction in load due to inconvenience (e.g. interruptions to industrial processes) or discomfort (i.e. air conditioning). In these cases, the only option may be to partially reduce or modulate the load. For this subset of loads, the controller able to partially reduce the load would provide more benefits than one that could not.

The Internal and External Communications TAC dimensions were somewhat restricted as the associated costs are also largely dependent on the implementation environment for example the level existing infrastructure, telecommunications and population density. For the initial analysis, the Communications dimensions were focused on distinguishing which products were reliant on simplex or duplex communication. The chosen communication medium was another important consideration identified, particularly for Internal Communications. The most cost effective Medium used for communications is largely dependent on the type and number of controlled loads, existing infrastructure within the consumer premise and potential standards for future “smart” appliances.

Similarly, each TAC was given a set of dimensions and within each dimension a range of potential solutions of varying sophistication. For confidentiality reasons, these dimensions cannot be elaborated upon any further, however an outline is provided in Table 2.

| Technical Architecture Component (TAC) | Functionality Dimensions |
|---|---|
| Controller | • Trigger Mode – how the change in end use demand is triggered<br>• Demand Modification – how the end use demand is modified<br>• Location – where the controller is located in relation to the end use demand |
| Consumer Interface | • Information - what information is provided to inform/motivate<br>• Notification - how the consumer if provided with information/motivation<br>• Notification Frequency - how often the notification occurs<br>• Input – does the interface allow the consumer to modify their end use energy and/or demand directly |
| Response Monitor (Meter) | • Type – how the demand and/or consumption is recorded<br>• Data Transfer – how the data is collected<br>• Tariff – how the meter handles multiple tariffs |
| Internal Communications | • Signal Flow – the direction/s that the communication singles flow<br>• Medium - Communication medium |
| Communications Gateway | • Signal Flow – the direction/s that the communication singles flow<br>• Situation – where the gateway is located and if required, any TACs that are housed in the same device |
| External Communications | • Signal Flow – the direction/s that the communication singles flow<br>• Medium - Communication medium |

***Table 2 - Outline of TAC Functionality Dimensions***

My involvement with this project has provided invaluable experience in line with the objectives of my scholarship program. This project was particularly useful for:

- Clarifying the differences between different DSM schemes
- Understanding technical components requirements for delivering various DSM schemes
- Understanding the roll that DSM might play in a Smartgrid
- Identifying DSM measures/products can be taken/implemented without the need for a smart meter (despite common perceptions that the smart meters are needed)
- Understanding typical meters in use around the world and key differences

The extensive scope of my task gave me a good overview of some of the difficulties associated with choosing the right solution. Nowadays, the technological restrictions are no longer the major issue. Adequate technologies are available now and more advanced technologies are being developed.

One of the major difficulties with DSM programs is predicting the benefits of DSM programmes that are reliant on motivating the consumer. This is particularly true for domestic consumers. In my opinion there are a lot of potential benefits to be gained from the domestic sector however they are reliant on educating consumers of the benefits of participation in these types of schemes. Furthermore, initial and ongoing motivation of the consumer will also be critical. The major consumer motivational mechanisms will likely be derived from identifying and quantifying environmental and financial benefits.

Another major learning for me was how often the wider population confuse energy savings with demand reduction and misplace where their true benefits lie. There is a tendency to combine all DSM measures together and quote carbon emission reductions as the major driver and benefit. It was surprising for me to read publications or hear from government bodies, environmental groups and other supposed experts that were suggesting schemes/solutions that were not likely to solve their intended problems. That being said I was also pleased to find clever variations of particular DSM schemes which were tailored to particular localised problems. This highlighted to me how important it is to communicate issues clearly. Network Operators need to be proactively express DSM issues to not only consumers but other stakeholder's as well.

One of the major barriers for implementation of demand response programs are the often conflicting interests of stakeholders, such as Suppliers and Network Operators. The reduction in demand has a direct impact on a Supplier's revenue and hence they are typically reluctant to encourage any such reductions. That being said there are times when this would be beneficial for Suppliers. Furthermore, there are also regulatory barriers that discourage DSM options for a Distribution Network Operator (see discussion below of Ian Povey's Presentation in *Other Experience*).

*STP Module 5 – "Smart Meters: Next Steps"*

In my second Quarterly report[1] I gave an overview of the status of Smart Metering in the UK. As outlined in that report, the Department of Energy & Climate Change (DECC) released another consultation document. The consultation covered a wide range of issues however it particularly sought responses on:

- The Delivery Model
- The Communications model
- The Meter functionality specification

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[1] http://www.escornwall.com.au/ESCornwall/Downloads/Reports/Q1-Report-Aidan-Roberts.pdf

The Electricity Network Association (ENA) responded to this consultation on behalf of the DNOs. They ENA has been actively involved with Smart Grid and Smart metering activities in the UK. Earlier in 2009, the ENA established a Network Futures Group to help meet future challenges and identify opportunities for UK Network operators. ENA members are also represented on the Electricity Network Strategy Group (ENSG). The ENSG was established to help support the government with the long-term energy challenges of climate change and ensuring secure, clean and affordable energy. The ENSG is co-chaired by the Department of Energy and Climate Change (DECC) and the Office of Gas and Electricity Markets (Ofgem) and consists of representatives from key stakeholders for electricity networks in the UK. One of the work areas covered by the ENSG is Smart Grids. The ENSG's work on smart grids has identified Smart Metering as a key enabler for particular smart grid applications.

Based on the work conducted by these groups, the ENA submission stressed the importance of considering the Smart Meter rollout in the wider context of Smart Grids. Their submission was supportive of a central communications model provided network operators had sufficient access to metering data. The ENA also supported a coordinated meter rollout on a town-by-town or parish-by-parish basis with the involvement of DNOs. This approach was favoured in order to bring forward Smart Grid benefits that would only be realised with a geographically coordinated rollout. This was pushed as justification for a DNO led rollout given the existing distribution systems areas (DSAs) and the DNOs experience with large scale engineering projects. The ENA submission also included functional specifications for the Smart Metering System. The additional functional requirements required to deliver DNO benefits was seen as only a marginal incremental cost when considering the additional benefits to be gained. The ENA metering functionality specifications were the focus of my STP project.

Following the ENA submission, a Smart Metering project was proposed to the STP steering committee. After further discussions with the Project Champion, it was agreed that the project scope would be limited to:

- Critically evaluating the ENA Metering Specification;
- determining the information streams likely to be available from the GB metering system that may be of use to DNOs; and
- considering the integration of these information streams into DNO network management practices.

The Project Champion, (a representative from CE Electric) was also one of the members of the ENSG.

The first objective was to critically evaluate the ENA metering specification. The specification had been developed under a tight time schedule and so my task was to raise any key issues, identify any omissions and make recommendations where necessary. Overall the ENA specification was relatively comprehensive and described a metering system that was capable of delivering many potential DNO applications. However, some of the specifications were quite high level and vague which I felt could lead to misinterpretations by the less technically inclined audience at DECC.

The secondary objective was to determine the information streams that a smart metering system might provide for DNOs. My approach was to first develop a "wish list" of potential

DNO applications before determining the required information streams. The next step was then to differentiate the information streams. For example, identifying information that could only be provided by a smart metering system and information required from additional and/or alternate sources.

The first step was to create a list of Smart Metering enabled applications. The applications in this list were a combination of applications currently in use by existing metering systems along with some likely/obvious potential future applications. These applications were then categorised into the categories shown in Table 3:

| Category | Application |
|---|---|
| Network Planning | Demand Forecasting |
| | Network Investment |
| | DSM Opportunities |
| | Voltage Compliance |
| | Quality Compliance |
| | Phase Unbalance |
| Network Operation | Demand Monitoring |
| | Dynamic Ratings |
| | Islanding |
| | Planned Outage Notification |
| | Unplanned Outage Notification |
| | Demand Side Management |
| | Preemptive Contingency Plans |
| | Outage Detection |
| | Fault Location |
| | Controlled Load Restoration |
| | Voltage Regulation |
| | Voltage Regulation Settings |
| Regulatory Reporting | Planned Outage Reporting |
| | Unplanned Outage Reporting |
| | Losses Reporting |
| | Utilisation Reporting |
| Other | Energy Forecasting (Losses) |
| | Use of System Charges |
| | Reactive Power Charges (Power Factor) |
| | GSS Payments |

***Table 3 - Potential DNO applications enabled by a Smart Metering System***

There is nothing particularly sophisticated about the raw data being monitored and/or captured by “Smart Meters”. It is quite straightforward to see how the data from a smart metering system would enable most of these applications. Many of these applications are already utilised at higher voltage levels using existing metering points. Some applications are already provided by alternate means however the smart metering system would simply be able to provide more accurate/realistic data.

Each of these applications was linked to the raw data provided by the metering system. Indicative annual data volumes were then calculated for each application based on a total customer base of 1 million. Where possible, further volumes were also estimated for applications based on aggregated data at different network levels. The data was aggregated based on typical network configurations and design principles such as the maximum and average consumers per LV feeder, the number of LV feeders per distribution transformer, and the total number of distribution transformers. It is worth noting that the aggregated data would only be useful for some applications. For example, at an LV feeder level it would not be useful to aggregate the voltage data of each LV consumer connected to that feeder however it could be useful to aggregate demand information.

Some of these applications are also dependant on data from additional information systems. Automated Guaranteed Service Standard (GSS) payments may require consumer account details to be attained from Supplier information systems. In the UK part of the license conditions requires the DNO to make payments to consumers if certain levels of service are not achieved. For example, a consumer is entitled to a set payment if they are without power for more than 8 continuous hours. Currently, investigating and implementing these payments can be a lengthy process. Furthermore, the onus is on the consumer to make a claim which is sometimes perceived as one of the flaws of the existing GSS scheme. From a DNO perspective, automated GSS payments could mean an increase in costs (i.e. based on the inclusion of consumers who may not have put in a claim under the existing arrangement). That being said, it could also be argued that information from accurate GSS payments might help the DNO to make more informed investment decisions in the long term.

An indication was also given about the availability of these applications in the short and medium to long term. The difference between associated timescales was largely dependent on the level of rollout required. For example, Losses reporting for a DNO could only be done if each LV consumer within the DNOs DSA has a “Smart Meter” installed. Similarly, LV forecasts/monitoring can only be done if all consumer on the LV feeder have smart meters installed. These prerequisites and approximate timescales were given for each application.

The third major objective was, to evaluate the potential volumes of data involved with a Smart Metering System. There were two distinct parts to this section. In the first instance, the total amount available data was calculated. The second stage was then to determine the optimum (minimum) amount of data to be collected, transmitted or stored in order to enable each application. This analysis provided a good basis for future work including potential data storage configurations, meter sampling rates, and the calculation of data storage/transmission costs.

## *Other Experience*

*Demand Side Management Workshop*

Toward the end of my contract, I was also given the opportunity to attend a workshop hosted by EA Technology. The workshop was entitled “Is DSM the answer?” and included participants from across the UK and other International Representatives from the IEA DSM Program.

The workshop was opened by the Chair of the IEA DSM programme, Hans Nilsson. Mr Nilsson had some very interesting points on “Change Agents” and “Policy drivers” and set the scene for the further discussions**.** The remainder of the workshop was separated into three sessions:

- Session 1 – Matching Demand to Inflexible Generation
- Session 2 – The Role of DSM in the development of Smart Grids
- Session 3 - The barriers of Profiles for Settlements and engaging small consumers

The highlight for me was a presentation from the Infrastructure and Service Development Manager for Energy North West (ENW), Ian Povey. His presentation gave an overview of DSM from a UK DNO perspective. Mr Povey began by describing the UK Electricity Supply Industry (ESI) and how central a role the Supplier plays. The Supplier:

- has contracts with Generators for the long term provision of electricity;
- appoints meter operators;
- has contracts with consumers for electricity supply; and
- provides pricing incentives to avoid demand in peak periods.

He also noted how a UK DNO has very limited interactions with the Supplier or the consumer.

The most interesting section was when Mr. Povey explained the shortcomings of the current UK regulatory framework in encouraging the adoption of DSM solutions. In the first instance, Mr. Povey explained that DSM was currently only seen as a means of deferring network reinforcement. He then explained that DSM payments were considered to be Operating Expenditure (OPEX) and called for equal treatment of OPEX and Capital Expenditure (CAPEX). Mr. Povey then went through an example of what a DSM solution was worth to a DNO under the current framework. A typical network reinforcement project was outlined with an estimated cost of £500k. If the DNO were to reinforce the network, then the annual return (including depreciation and Operating/Maintenance costs) would be around £62k per year. To defer this investment a total of 1MVA of DSM was required. Therefore, the DSM for this particular investment would be worth £62 per kVA per year or alternatively, a consumer that could provide 400kVA of DSM could be paid £28.4k per year.

Mr. Povey then explained some of the steps that ENW took to develop commercial DSM products and engage with consumers. He noted that consumer expectations of payments far exceeded the value to ENW under the current framework. He then closed by highlighting that Smart Meters and Smart Grids could extend DSM options, particularly for Domestic Consumers. Two highlighted DSM opportunities were in the management of electric vehicle charging infrastructure and in allowing DNOs to provide ancillary services to the TSO by acting as Virtual Power Plants (VPPs).

## *Looking Forward*

The major objective of this placement was to gain exposure to my areas of interest through participation in related project work. The projects undertaken during my time with EA Technology Consulting were very much in line with my areas of interest under the Scholarship. The International Energy Agency projects have provided me with an insight into some of the relevant issues and ideas from different countries around the world. It has also given me valuable experience participating in International collaborative work with a wide range of stakeholders. These stakeholders included all facets of the electricity supply industry but also included others such as research centres to Government departments.

The STP project gave me exposure to a wide range of Smart Metering issues in the UK, including the proposed metering specifications, communication options and rollout model. The project also gave me the opportunity to use my own knowledge and skills to provide Smart Metering advice to the UK DNOs. This project also gave me valuable experience working in the private industry and liaising with clients. In this environment, ongoing communication and adherence to agreed outputs, timelines and costs are critical.

My scholarship proposal involved a further two placements with a Technology Provider/ Manufacturer and a DNO. For my Technology Provider/Manufacturer placement I am currently in negotiations with Landis + Gyr (L&G). My proposed placement with L&G will be as a R&D Engineer with their lead development centre for Power Line Carrier (PLC) technology. This position will be based in Montlucon, France and this has caused the negotiation process to be been quite lengthy and convoluted. In early October I was assured that the process would take around 5 to 6 weeks to complete. As such I was happy to finish up with EA Technology and move down to London. I have since been staying with a friend while I wait for the Visa to come through. Unfortunately the Visa has still not been processed and as such I am still waiting to finalise and begin my next placement. My most recent correspondence with the French consulate indicates an answer by the 15th of January. These events have caused a major disruption to both my scholarship program and personal life. The additional “wasted” 2 months waiting for the Visa have now reduced the time available to complete my subsequent placement. One thing I can say, is that bureaucracy (particularly that associated with Visas) seems to be consistently poor the world over.

Despite the delay and the complications, I have been assured that my next placement will commence in January. If the Visa delay continues beyond January, I will be forced to seek an alternate placement, most likely with a Distribution Network Operator. I will keep the Committee informed of any further progress as it happens.