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12 September 2014

Dear Professor Bartlett,

Final Report – E.S. Cornwall Memorial Industry Scholar – Robyn O'Connor

Please find enclosed the final report for the E.S. Cornwall Memorial Industry Scholarship. This report outlines my period of employment from 2nd April 2014 to 12th September 2014.

During this period my responsibilities have included:

- The development and delivery of CBRM enhancements
- The development of The Transform Model for a New Zealand distribution network company

I would welcome the committee's feedback on my report.

Yours faithfully,

Robyn O'Connor

REPORT

E.S. Cornwall Scholarship Report

Robyn O'Connor

Date: 12 September 2014

Background to the Report

This report was prepared by Robyn O'Connor as the final report for the E.S. Cornwall Memorial Scholarship. My tenure of scholarship commenced on 1st October 2013 and concluded on 1st April 2014. This report details the work undertaken during my voluntary second placement, at EA Technology, based in Capenhurst, United Kingdom during the period April 2014 to September 2014. My program was aimed at gaining exposure to Condition Based Risk Management (CBRM) developments overseas and the implementation of Publicly Available Standard (PAS) for Asset Management, PAS-55.

The scholarship was awarded in Australia by the University of Queensland, and therefore comparisons to the Australian electricity industry may be made to provide context for Australian readers.

Contents

1. Introduction

EA Technology are an employee-owned organisation specialising in asset management solutions for owners and operators of electrical power plant. EA Technology originated in 1966 as a UK Electricity Council's Research and Development Centre and was restructured as an independent commercial enterprise in 1990, becoming 100% employee-owned in 2004. EA Technology provides consulting services to electricity generation, transmission and distribution companies, together with major power plant and operators in the private and public sector.

My role at EA Technology has included supporting the Advanced Network Solutions team and the Strategic Asset Management team. The Advanced Network Solutions team form part of the Future Networks Department and are responsible for techno-economic modelling (the Transform model), understanding the impact of low carbon technologies on networks, evaluating network performance and assisting in the definition of industry policy and standards. The Strategic Asset Management team are responsible for enhancements and delivery of CBRM projects are a member of the Institute of Asset Management who are responsible for assessing and issuing ISO55000 accreditation.

I have enjoyed working for both departments as it has broadened my skill set and I have seen how different EA Technology models were used to inform DNOs submissions to Ofgem under RIIO-ED1.

2. Definitions

CBRM	Condition Based Risk Management
DECC	Department of Energy and Climate Change
DNO	Distribution Network Operator
EATL	EA Technology Limited
ENWL	Electricity North West Limited
EV	Electric Vehicle
ISO	International Organisation for Standardisation
LCNF	Low Carbon Network Fund
LCT	Low Carbon Technology
LCTs	Low Carbon Technologies
NIA	Network Innovation Allowance
NIC	Network Innovation Competition
Ofgem	Office of Gas and Electricity Markets
PAS-55	Publicly Available Standard 55
RIIO-ED1	Revenue, Incentives, Innovation and Outputs. Electricity Distribution price control one, period 2015- 2023
Risk	Function of CI and HI

SGF	Smart Grid Forum
Totex	Total Expenditure (summation of capital and operating expenditure)
UK	United Kingdom

3. Regulation

The draft determination from Ofgem for the DNOs for RIIO-ED1 was issued on 30th July 2014 and highlighted several areas for improvement in the DNO's business plan. The majority of DNOs that were not fast tracked reduced their expenditure and improved their justification of certain areas of their business plans prior to resubmission. In total, the ten slow-track DNOs reduced their requested totex by £711m. Ofgem used three economic models for benchmarking, a top down totex model, a bottom up totex model using aggregated drivers and a disaggregated activity based model. The disaggregated activity level model was given 50% of the weighting whilst the other two totex models were given 25% each.

One of the key findings from Ofgem about the difference between the fast and slow track submission was the assessment of asset replacement strategies. For the fast track assessment, Ofgem put approximately one third of asset categories into the age-based model and used historical run rates for the remaining two thirds. However for the slow track assessment, two thirds of asset categories were run through an aged based model and a more detailed qualitative assessment of the whole asset base was undertaken to assess the volumes and unit costs of asset replacement and more health index data was utilised in the volume assessment.

As DNOs move into the RIIO-ED1 period, there will be more of a focus on managing asset profiles on a risk basis. Please refer to Section 6 for more detail.

4. Innovation Funding Incentive

The Innovation Funding Incentive (IFI), was initiated by Ofgem after four Distribution Price Control Review (DPCR) periods, twenty years of privatisation. This was due to the reluctance of DNOs to invest in research and development due to the lack of short term gain realised in the five year DPCR periods. IFIs allowed DNOs to realise benefit within a DPCR period by granting DNOs a fund that was use it or lose it, Ofgem funded 80% of the projects and DNOs funded the other 20%. This scheme incentivised DNOs to invest in innovation in DPCR5.

IFI is aimed at projects with stages two to eight of the Technology Readiness Level. The Technology Readiness Level (TRL) was first developed by NASA in 1974 to assess the maturity of evolving technologies. The TRL encompasses everything from step one – basic technology research or blue sky research, where things are developed with little to no understanding of how they will be implemented through to step nine where new technologies are integrated fully into business as usual. The challenge with only funding part of the TRL is that projects will be developed but not fully implemented and tested as business as usual to determine the resulting network implications.

Stage eight of the technology readiness level, when the system is completed and qualified through tests and demonstration, allows DNOs to implement trials and demonstrations however without the process in place to fully implement these procedures as business as usual for the longer term benefits the true benefit realised from these projects is hard to quantify.

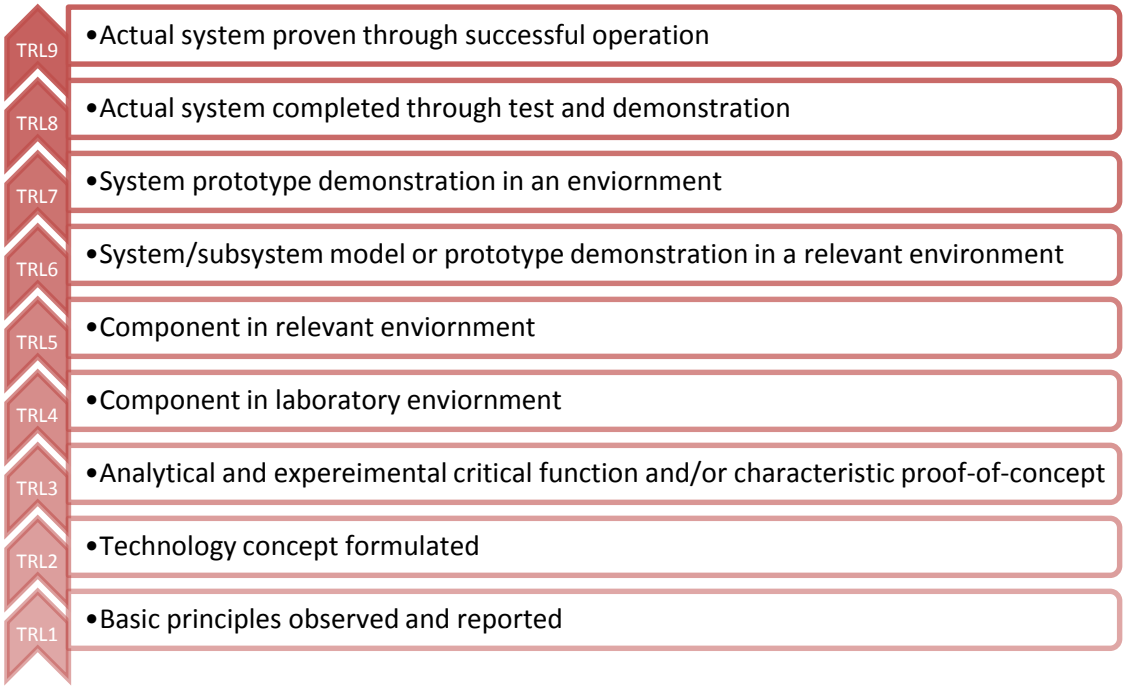

Figure 1: TRL Scale

The IFI budget in DPCR5 allowed DNOs to allocate 0.5% of revenue to fund innovation projects. As the DNOs move into the RIIO-ED1period, Ofgem have increased the amount of funding available to fund innovation projects. This is dependent upon the DNOs providing sufficient justification for the projects that they will undertake. The revised maximum cap on this funding is now up to 1% of revenue can be allocated to fund innovation projects.

The Low Carbon Network Fund (LCNF) is aimed at funding projects that are in stages six and above of the TRL, to drive DNOs to implement solutions into the business as usual. The LCNF also requires that project partners and sponsors disseminate their information throughout the project and on completion with other project partners and sponsors. This information is shared through the writing of functional specifications and delivery of key reports at project milestones. The LCNF is funded 90% with customers' money with a requirement of the sponsors to invest 10% of the funding upfront. Certain funding incentive mechanisms are in place, such that if the DNO meets all milestones for a project the funding initially put up by the DNO (the 10%) will then be available to be claimed back from Ofgem, provided strict regulatory conditions and checks are in place.

The main difference between the IFI initiative, LCNF and the new funding regime the Network Innovation Allowance (NIA) and the Network Innovation Competition (NIC) is that unlike the LCNF, funding available through the NIA and NIC is available for any project DNOs wish to undertake, not just projects that are considered to directly influence the DNOs ability to reduce carbon emissions. The bidding process for LCNF projects is very similar that of the new NIC process. The NIA funding is shared between the transmission and distribution companies, so up to £100m/year of funding could be made up of all DNO projects or a combination of transmission and distribution projects.

5. PAS55 to ISO55000

I had the opportunity to attend the Institute of Asset Management (IAM) yearly conference in Liverpool 14th – 16th July. This conference showed me the breadth of asset management in engineering and construction industries in the public and private sector. It demonstrated that good asset management principles and techniques can be applied to any industry or sector to better manage assets; be they staff, physical assets or information. Numerous presenters spoke of the impact that PAS-55 or ISO55000 had on their organisations and the positive changes that the integration of the standard had led them to implement, either PAS55 or ISO55000.

Various presenters highlighted the differences between PAS55 and ISO55000 and the move towards achieving asset management excellence. In order to achieve ISO55000 competence, an organisation needs to demonstrate that it systematically and consistently achieves the requirements detailed in ISO55001. The next stages of asset management excellence were defined at the conference as optimising and excellent. In this circumstance optimising is defined as an organisation that can demonstrate it is systematically and consistently optimising its asset management practice in line with the organisation's objectives and operating context and excellent is defined as an organisation that can demonstrate that it employs the leading practices and achieves maximum value from the management of its assets, in line with an organisations objects and operating context. Whilst these asset management objectives are outside of the parameters of ISO55000 certification it showed that there were significant industry drivers for organisations to outperform the ISO standard.

There were several sessions that really captured my interest, but one I feel most relevant for Energex would be the 'ask the assessors' session. This was a panel session where ISO55000 assessors were asked what the typical drivers for certification are, what do organisations typically struggle with and what do organisations do well in the assessment against the standard. The panel represented various global regions and also showed stages of development and adoption of asset management in different industries. A summary of the panels' responses is detailed below:

1. What are the typical drivers for ISO55000 certification?

The drivers for certification are normally regulatory driven however as the awareness of the standard progresses, certain industries and organisations are moving towards having more commercially led drivers for implementing the standard. For some organisations the drivers to implement ISO55000 are for a direct business or safety improvement as the standard can highlight areas of weakness in the organisation if they are trying to prevent an incident or event from reoccurring.

2. What do organisations typically struggle with?

It can be challenging for organisations to have a clear line of slight between the on the ground staff and the policies and strategy of the company.

The concept of silos was also considered to be something that was challenging for companies. A silo being a group of people in an organisation with a certain knowledge base. The idea being that certain silos would naturally form around the organisation based on skill sets and interaction between staff. These silos would make it more challenging for staff to share information and work efficiently between silos and this lack of dissemination and integration would inherently make asset management challenging within the organisation.

Ensuring control over the outsourcing of contracts was identified as another challenging area.

3. What do organisations do well?

Typically organisations perform well at operations and stakeholder engagement as well as legal compliance. It was also highlighted that if organisations have a change management program in place that this is the sign of an advanced asset management system.

The outcome of this session was if organisations work with the assessors early in their asset management accreditation process, to undertake a gap analysis or have an assessment of their organisation undertaken then organisation will improve on their weaker areas and not improve areas that they are already proficient in which can be another common occurrence in organisations aiming for accreditation.

6. Condition Based Risk Management

As detailed in my previous reports, the Electricity North West Limited CBRM project has been driven by changes to the regulatory reporting requirements required by Ofgem. Previously, where DNOs reported their asset replacement strategies based in health indices, they will now be reporting based on health indices and criticality indices which are used to form a risk score. The functionality of ENWLs' CBRM package has been extended to include enhanced reporting on a risk basis. This work has been encapsulated under the CBRM Criticality 2 project.

I have continued to support the CBRM Criticality 2 project with Electricity North West Limited (ENWL) delivering the upgrades to CBRM as detailed in my previous reports. This work has proved beneficial to both Electricity North West and EA Technology as I am familiar with the client specifications. I have enjoyed delivering the software improvements, writing detailed design specifications for the software tool and testing the application in its entirety. The integration of risk into the tool and using CBRM as a reporting tool will allow ENWL to meet their reporting requirements for Ofgem and have been the key modifications undertaken by this project.

I have also gained exposure to other companies' implementations of CBRM and the different ways in which the tool can be used to drive business investment and regulatory submissions. The enhancements to the CBRM tool can vary widely but the algorithms and principles of ageing assets using a health index remains the same. CBRM can interface with other corporate systems to allow the user to load and retrieve data after CBRM analysis. This has made the tool very versatile and customisable allowing clients to easily load and report on thousands of rows of assets data.

I have realised the importance of accurate asset data at all voltage levels. Without accurate asset data it is very difficult to inform planners and regulators of the current state the network and hence justify why additional investment in network assets is required. The calibration settings and modifications that can be made to CBRM drastically affect the results of the tool, so it is vital to have processes in place to ensure that these settings are not misrepresenting the position of the asset base.

The use of CBRM to drive network asset investment is pivotal to the planning submissions of the majority of the UK DNOs and is the tool endorsed by Ofgem for asset replacement strategies. The methodologies behind CBRM are rigorous and inform DNOs very accurately as to the likelihood of an asset failing in future years. CBRM has been used by DNOs to defer asset replacement and reinforcement and also allows them to manage asset replacement and reinforcement using risk values as detailed in my previous report.

7. Smart Grids

EA Technology are involved in a number of the smart grid projects funded by Ofgem, the largest of these being the My Electric Avenue project. EA Technology and Scottish and Southern Energy Power Distribution (SSEPD) are working together with partners under the Ofgem Low Carbon Network Fund (LCNF), Customer Led Network Revolution (CLNR) project to develop an EV charge control system to balance out the charging cycles of Electric Vehicles (EVs) at times of network stress. To test the distribution system, clusters of electric vehicles have been setup to mimic expected future network demand caused by EVs. Members of the public are renting electric vehicles at a reduced rate for 18 months with their neighbours to simulate the streets of the future. There is estimated to be approximately one million electric vehicles on UK roads by 2020. At the end of December 2012 there were over three thousand applications made through the plug-in car grant scheme. This is an Office for Low Emission Vehicles grant to incentivise public sector bodies in the UK to install plug-in vehicle charging infrastructure.

Under the My Electric Avenue Project, the charging stations for all of the electric vehicles will be controlled and the data collected and recorded whilst capturing the clients' feedback to quantify the 'range anxiety' they may experience by not having complete control over the EV charger.

The My Electric Avenue project will provide essential learning about the anticipated increase in electric vehicles. This will allow DNOs better manage the proposed strain on the distribution network caused by large uptakes of EVs. The EV charging control system will deliver a cost-effective solution to DNOs that will reduce the need for costly and disruptive network investment and allow distribution networks to manage a faster uptake of electric vehicles.

8. The Transform Model

Background

As part of my work in Advanced Network Solutions, I worked on a project to implement The Transform Model for a distribution network company in New Zealand. The Transform Model was developed by EA Technology as part of work under the smart grid forum work stream three in collaboration with the Energy Networks Association (ENA) in 2011 and 2012. The ENA is represented on the Department of Energy and Climate Change (DECC) and the Office for Gas and Electricity Markets (Ofgem) Smart Grid Forum (SGF) setup in 2011 which considers how smart grids could be introduced to support the transition to a low carbon economy. As part of the smart grid forum, five work streams (WS) were setup to investigate the following:

- WS1 – Assumptions and scenarios
- WS2 – Evaluation framework
- WS3 – Developing networks for low carbon
- WS4 – Closing doors
- WS5 – Ways of working
- WS6 – Commercial and Regulatory

Some of these streams have been disseminated over time, whilst additional ones have been created. Work stream three, that drove the creation of The Transform Model looks at the impact of low carbon technologies and how to assess the network impacts from the assumptions and scenarios developed under WS1. The work under this stream has identified the scale of the savings, billions of pounds, to be saved if funding is available to implement 'smart' solutions on UK electricity networks. It also

states that delivering “a smarter network is critical to delivering a low carbon future affordably, securely and sustainably.”

As part of this work, two reports were produced "The Building Blocks for Britain's Smart Grids" and "Assessing the Impact of Low Carbon Technologies on Great Britain's Power Distribution Networks" which highlighted the potential investment strategies and uptake scenarios. These reports illustrate the impact of increased levels of low carbon technologies on the network and aided the development of The Transform Model.

Overview

The Transform Model is a techno-economic modelling tool that allows distribution companies to plan their anticipated future levels of network investment based on certain uptake levels of low carbon technologies. The Transform Model provides Ofgem and UK DNOs with the estimated investment profiles necessary to prepare current and future distribution networks for the future uptake of low carbon technologies. The Transform Model has been used to inform and evaluate the RIIO-ED1 price control submission.

The Transform Model has been described by Ofgem as:

“The best tool currently available to analyse the potential savings is a model (the Transform model) which DNOs developed under the Smart grids Forum.”

The Transform Model allows the user to model and compare different uptake scenarios for low carbon technologies and the effect of these technologies on distribution networks. The expected uptake level of low carbon technologies will not be uniform across distribution networks or areas and will pose different challenges to different network types, central business districts or rural networks for example. To assess and resolve the network constraints posed by low carbon technologies, network operators will need to employ a range of solutions to the network.

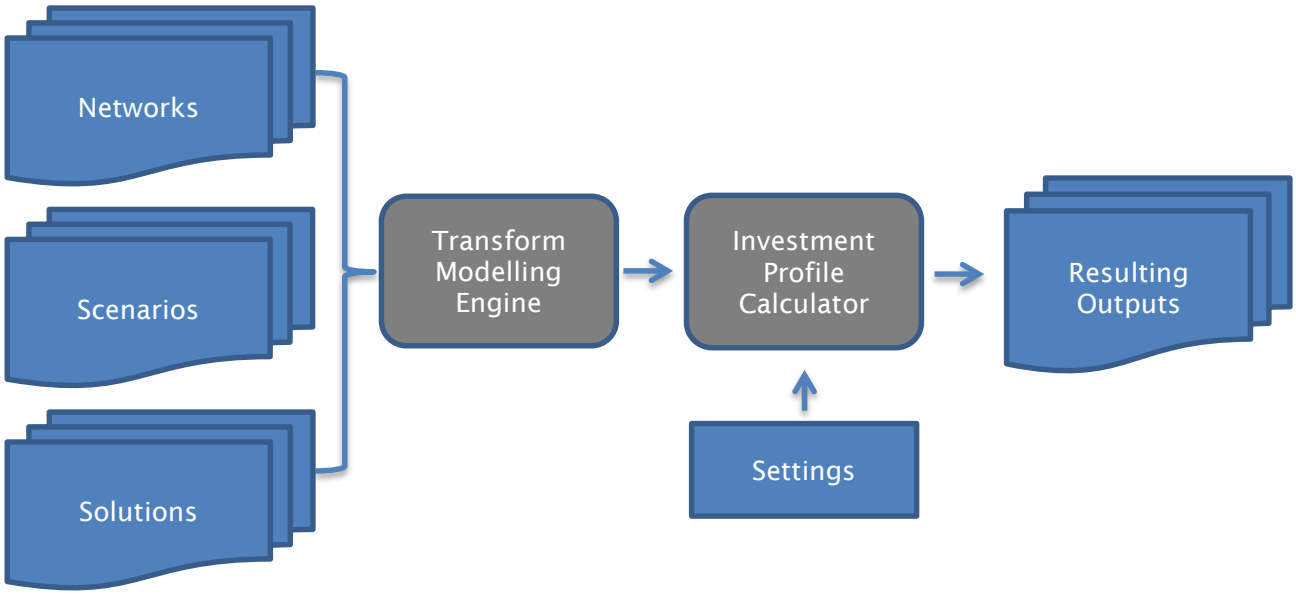

Figure 2: The Transform Model Overview

The Transform Model allows DNOs to model a mix of conventional and smart solutions available to reinforce the network to account for large uptakes in Low Carbon Technologies (LCTs). The Transform Model aids distribution companies in assessing the optimal network investment strategy whilst not compromising the quality and security of supply. The Transform Model has been used to inform DNOs as to their future investment requirements for regulatory submissions; it was used by all of the DNOs in the UK for their RIIO-ED1 submission (looking to 2023 and beyond to 2050). A

version of The Transform Model has also been implemented in DECC to inform government policy at the highest level.

Network Model

The Transform Model creates a parameterised version of a distribution network or networks. As not all networks are equal, The Transform Model allows the network to be represented by a series of representative networks. These networks allow different parameters to be incorporated to produce the most representative network as is practical. Factors used to parameterise these networks include the local geography of feeders, i.e. rural/urban networks, the customer type and density makeup of the feeders and the building specification is the network overhead/underground.

There is no such thing as an average customer, but by analysing real network data, the parameterised network in The Transform Model informs distribution companies as to where they are likely to experience network constraints due to the penetration levels of low carbon technologies.

Low Carbon Technologies

The Transform Model allows the user to model four different low carbon technology uptake scenarios in parallel. For example, the user could choose to set one scenario for a high uptake level of heat pumps and electric vehicles and solar photovoltaic and wind generation. Then this scenario can be isolated from a case where the expected number of electric vehicles is expected to be low whilst the other technologies are expected to maintain a high uptake rate. These scenarios are bespoke and provide the user with the ability to compare and contrast between different low carbon technology uptake scenarios. Within each of these scenarios the user can set three expected uptake levels for low carbon technologies, low, medium and high to encompass the expected uptake rates of the technology until 2060.

Solutions

The Transform Model uses the concept of headroom to determine when networks are reaching constraints, for example voltage or fault level constraints. This allows the model to compare the impact of different solutions on the network, their longevity and cost benefit.

The Transform Model has 150 smart solutions ranging from Real Time Thermal Ratings (RTTR), Demand Side Reduction (DSR) to deploying storage solutions. There are also approximately 80 conventional solutions including uprating transformers, splitting feeders and installing substations. The Transform Model performs a cost benefit analysis to determine the mix of conventional and smart solutions that will provide the optimum long term investment benefit. The Transform Model also accounts for the fact that some solutions require initial investment in technologies prior to deployment, a communication scheme may be required to implement RTTR for example. It is then possible for distribution companies to populate plans already in place to maximise the use of their electricity and telecommunications infrastructure.

The Transform Model does not act as a solution picker as it is broadly insensitive to specific solutions, rather it is a model that can be used to inform strategic investment decisions.

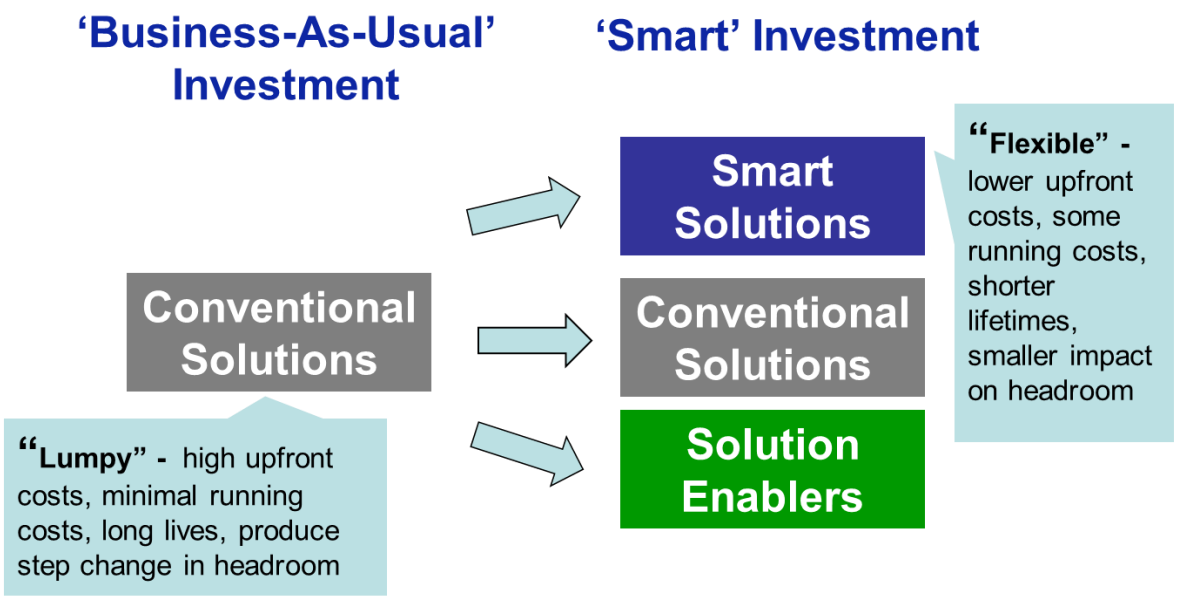

Figure 3: The Transform Model Solutions

9. Summary

During this six month period, I have taken the opportunity to learn about the changes to low carbon network funding, understanding how techno-economic modelling can be used to inform DNOs regulatory submissions and enhanced my knowledge of CBRM. I have also seen the development of a CBRM project from initiation through to delivery which has been a rewarding task.

The six month placement with EA Technology has broadened my understanding of the electricity industry, particularly new industry developments and the consulting environment. EA Technology and Energex have been very supportive of my placement and I greatly appreciate the opportunity to work outside of Energex to broaden my knowledge and experience new opportunities outside of Australia. I will be returning to Energex in October 2014 to continue my learning and development of CBRM, ISO55000 and the impact of smart grids on distribution network companies.

10. References

[1] Energy Networks Association on behalf of Smart Grid Forum Workstream 3: Assessing the Impact of Low Carbon Technologies on Great Britain's Power Distribution Network, EA Technology, Issued 31st July 2012

[2] http://www.energynetworks.org/electricity/smart-grid-portal/decc/ofgem-smart-grid-forum/decc/ofgem-smart-grid-forum-overview.html

[3] https://www.ofgem.gov.uk/ofgem-publications/89068/riio-ed1draftdeterminationexpenditureassessment.pdf

[4] http://myelectricavenue.info/about-project

Global Footprint

We provide products, services and support for customers in 90 countries, through our offices in Australia, China, Europe, Singapore, UAE and USA, together with more than 40 distribution partners.

Our Expertise

We provide world-leading asset management solutions for power plant and networks.

Our customers include electricity generation, transmission and distribution companies, together with major power plant operators in the private and public sectors.

- Our products, services, management systems and knowledge enable customers to:
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- Assess the condition of assets
- Understand why assets fail
- Optimise network operations
- Make smarter investment decisions
- Build smarter grids
- Achieve the latest standards
- Develop their power skills

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