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Dear Simon,

E.S. Cornwall Memorial Scholarship – Second Quarterly Report – Reena Kwong

Please find enclosed my second quarterly report as part of the E.S. Cornwall Memorial Scholarship for the period 2nd June to 2nd September 2009 during my employment with National Grid.

During my second three months of placement with National Grid, I have been able to gain an insight into the Power Factory analysis package for which loadflow results are to be used to facilitate the evaluation of the wide range of possible generation scenarios on required transmission capacity in the Great Britain network. As part of the Power Factory work, I have obtained some experience in modelling the Great Britain network with the appropriate generation and demand scenarios in preparation to obtain more detailed results from voltage and transient stability analyses.

I welcome any constructive feedback from all interested parties in relation to this report.

Kind Regards,
Reena

TABLE OF CONTENTS

EXECUTIVE SUMMARY 3

NATIONAL GRID SYSTEM STRATEGY TEAM 3

INFORMATION ON RESTRUCTURE 3

WORK EXPERIENCE 4

SYSTEM STUDIES FOR OFGEM REPORT 4

POWER FACTORY TRAINING 6

POWER FACTORY WORK TO DATE 7

FUTURE DIRECTION 9

Executive Summary

My proposed program under the E.S. Cornwall Memorial Scholarship is aimed at gaining international experience in the integration of wind farms into an electricity market. Specifically, exposure to the network planning required to be considered by the system operator/s in order to cater for large amounts of wind farm output is sought, as well as investigating the issues, and solutions to such issues, which may arise in the integration of wind farms in a market.

The period of my scholarship is from March 2009 to September 2010. My first placement is with National Grid, the system operator of Great Britain (GB), from March 2009 to March 2010. During my 12 month term with National Grid I will be involved in their Blueprint 2020/2030 Project. The Blueprint Project relates to a major review of National Grid's commercial framework and technical standards to accommodate large volumes of renewable, leading to the redrafting of their Security Standards.

This report is the second of six reports, and outlines my work experience within the second three months of employment, 2nd June to 2nd September 2009, with the System Strategy Team (previously known as the Strategy Review Team before the restructure) in National Grid.

National Grid System Strategy Team

Information on Restructure

In my first report I noted that National Grid were considering a restructure of the Strategy Review Team to facilitate the co-ordination of smaller, more specialist teams to undertake the reinforcement proposals and system design studies in earnest. This restructure has now been implemented with Future Technology, Technical Performance and Strategy Development forming the specialist teams of the System Strategy group.

I have been assigned to the Strategy Development team which has the following major responsibilities:

- analysing, summarising and reporting on the electricity network reinforcements previously identified through the work undertaken for the Electricity Network Strategy Group (ENSG) to facilitate changing generation patterns out to 2020, 2030 and beyond
- undertaking the analysis and producing the annual publication of the Seven Year Statement (SYS);

- undertaking the analysis and producing the new Offshore Windfarm Development Statement – a 20 year plan on the development and integration of offshore windfarms;
- the development of a long-term regulatory incentive mechanism supporting efficient and timely investment in the electricity transmission network for the price control review which includes producing strategy papers and high level investment proposals for approval through the investment management procedure; and
- reviewing the Smart Grid technology through the production of a road map for developing a 'Smart Grid' and its incorporation into network strategies.

My responsibilities until March 2010 will be focussing on the first three tasks identified above.

Work Experience

System Studies for Ofgem Report

As mentioned in my first E.S. Cornwall report, I was performing DC powerflow system studies investigating the North Wales network thermal capability with the proposed reinforcements identified by National Grid in their report *Our Electricity Transmission Network: A Vision for 2020* provided to the Energy Networks Strategy Group (ENSG) in March 2009, see Figure 1. The reinforcements required form the basis of meeting the EU renewable targets in a timely manner and failure to deliver the increased level of transmission capacity is likely to also result in a reduced level of security of supply to customers.

The thermal capability studies on North Wales were completed, as well as studies on the other regions of the Great Britain (GB) network and a further report was presented to the UK regulator Ofgem, at the end of July which summarised system boundary capacities that critical reinforcements could provide in the GB network with the associated level of renewable and/or nuclear generation connections.

Since this report has not yet been published on external websites, I feel I am not at liberty to provide detailed comments on the results at this stage. However, in general, I have learnt that when undertaking transmission planning studies of this magnitude, there are many network assumptions while implementing transmission reinforcements that can influence a system boundary's capability. Some of these assumptions can interact producing unfavourable results unexpectedly; therefore, all possible avenues must be thoroughly investigated to achieve a desired outcome while still maintaining a cost-benefit approach.

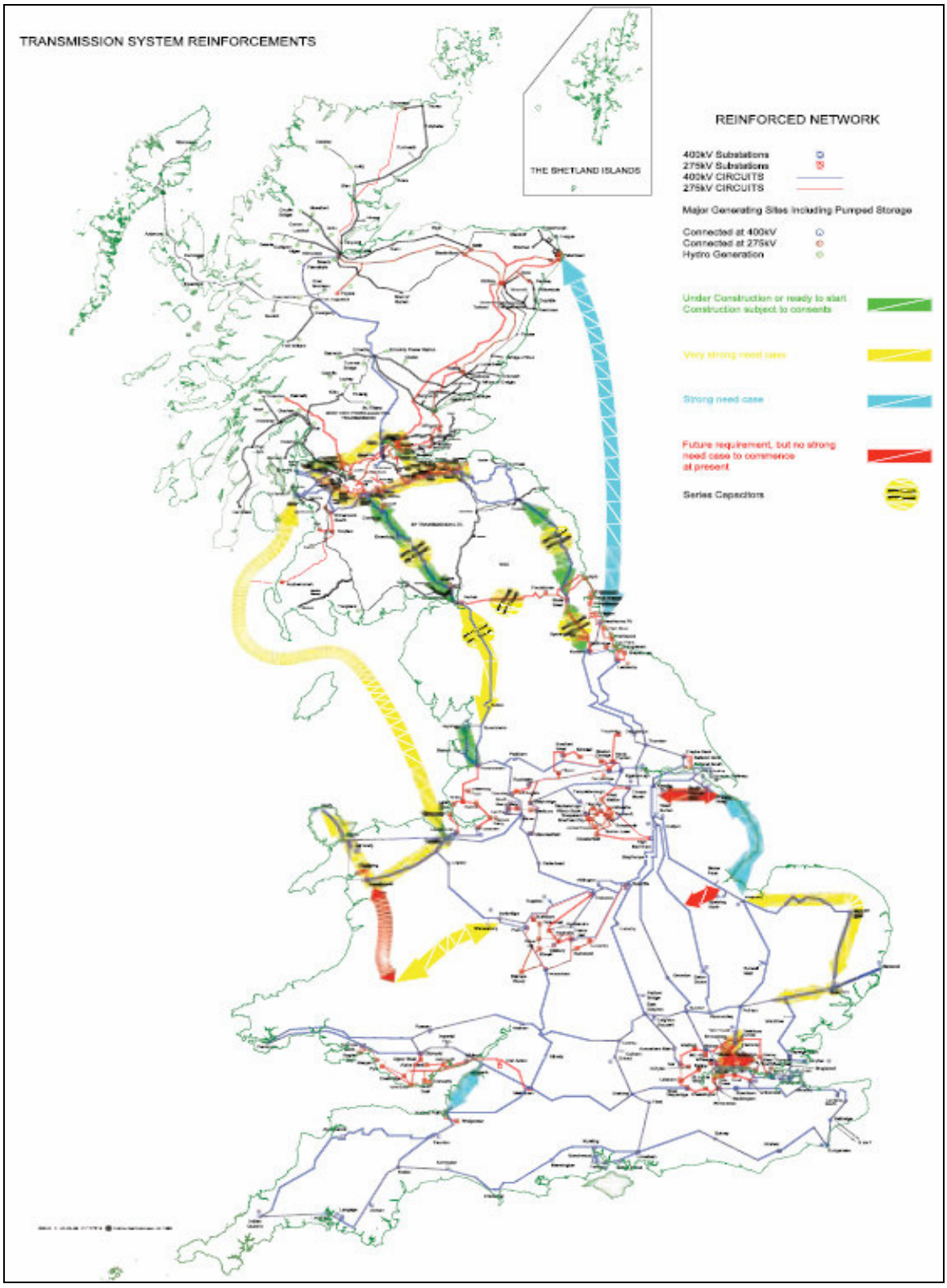

Figure 1 – Proposed GB Transmission Reinforcements[1]

[1] Our Electricity Transmission Network: A Vision for 2020; http://www.ensg.gov.uk/assets/1696-01-ensg_vision2020.pdf

Power Factory Training

In continuation with the System Strategy team's responsibility with the Blueprint 2020/2030 project, the upgrade to Power Factory for further optimisation through more detailed analyses on the GB network and proposed reinforcements is now underway. This optimisation may refine the timescales for reinforcements, or the exact amount of generation that may be accommodated within the GB system boundaries.

Power Factory is an analysis package designed to study electrical power systems and control analysis for planning and operational optimisation with a single line diagram graphical user interface, see Figure 2. Since the tool has not been widely used within the company, the System Strategy team completed a Power Factory training course provided by the application's software developer DigSILENT. This course ran for three days of each week for four weeks and provided information on:

- the components of the Power Factory database,
- tools required to build a network/project in Power Factory,
- how to run DC and AC analysis loadflows,
- performing contingency analyses as well as voltage and transient stability analyses,
- possible loadflow convergence errors and solutions to such non-convergence problems, as well as
- HVDC and AVR modelling.

The training course proved to be a very useful experience and the lessons learnt are now being applied in the development of the GB network as part of the pre-construction engineering process for the Blueprint 2020 Project.

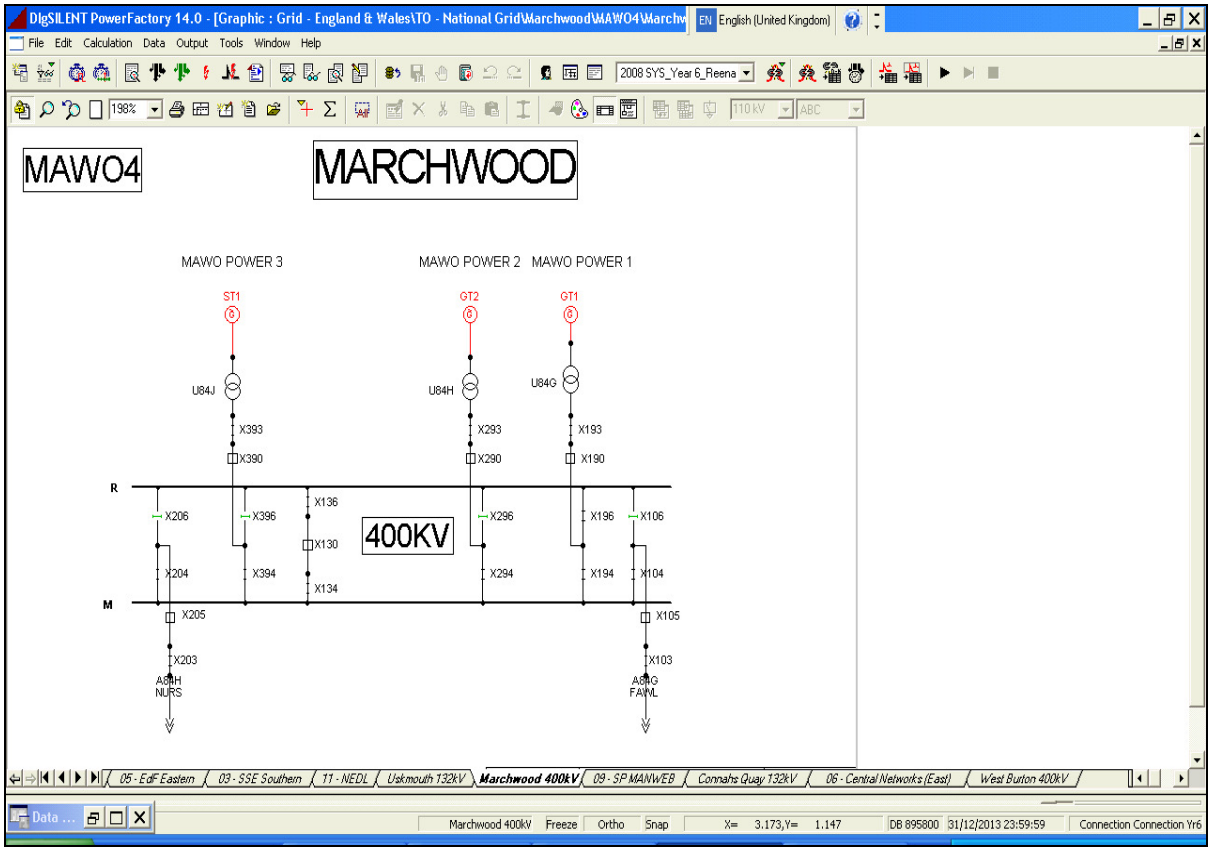

Figure 2 – Screen shot of Power Factory's Graphical User Interface

Power Factory Work to Date

Currently, National Grid has a GB network modelled in Power Factory based on the SYS (Seven Year Statement) data which consists of contracted generation and expected demand. This scenario differs to the Gone Green 2030 scenario which is based on National Grid's 'best view' business plan; information on how the Gone Green scenario was developed was provided in my first report. Since my role lies within the Strategy Development section of the System Strategy team, my involvement with Power Factory to date has included building a convergent and compliant GB network which incorporates the Gone Green scenario up to the year 2020. This also includes modelling the strategic reinforcements proposed as part of the Blueprint Project. At the time of writing this report, a 2013 network has been developed in Power Factory with the complete 2020 network expected to be available by November.

The work in Power Factory has been quite tedious and challenging, not only since I am the sole person in the Strategy Development group at this stage (extra resource requirements are being sorted) but also since the existing network in Power Factory consists of SYS background data which had to be compared and then modified to comply with the Gone Green background.

Such modifications were required on:

- all generation dispatch expected for each year including the commissioning of new generation and decommissioning of existing generation,
- committed existing transmission works as well as those expected for each year in the Gone Green background,
- the scaling of demand for each corresponding year

An AC loadflow analysis is then required for each year to ensure the GB network is compliant for that year. This requires attention to voltage profiles, generator control modes and fault level capabilities which has proven to be challenging for someone who initially was not very familiar with the weaker areas of the GB network.

My initial thought on the Power Factory package is that it is not the most user-friendly tool in non-convergence situations as the main reason for non-convergence is not specified in the output reports. Therefore, the user must identify the possible reason/s themselves which is where much time can be consumed if unfamiliar with general network problems. However, in National Grid's case where the previous loadflow analysis package, ELLA, was being used, Power Factory does have a number of advantages in the fact that it has a graphical user interface which provides powerflow results for each piece of equipment on the network once a loadflow has been initialised, where one can then work out the possible problem such as overloading of equipment or high/low voltage problems. More importantly for National Grid, AC studies for voltage and transient stability analyses can be performed at a higher level of accuracy than in ELLA.

Although this task has been challenging, it has also been very interesting work in regards to modelling a network within a new power system analysis tool as well as learning how to set up voltage profiles for particular areas and paying closer attention to the modelling of generator station control modes in order for an AC loadflow to converge successfully in Power Factory.

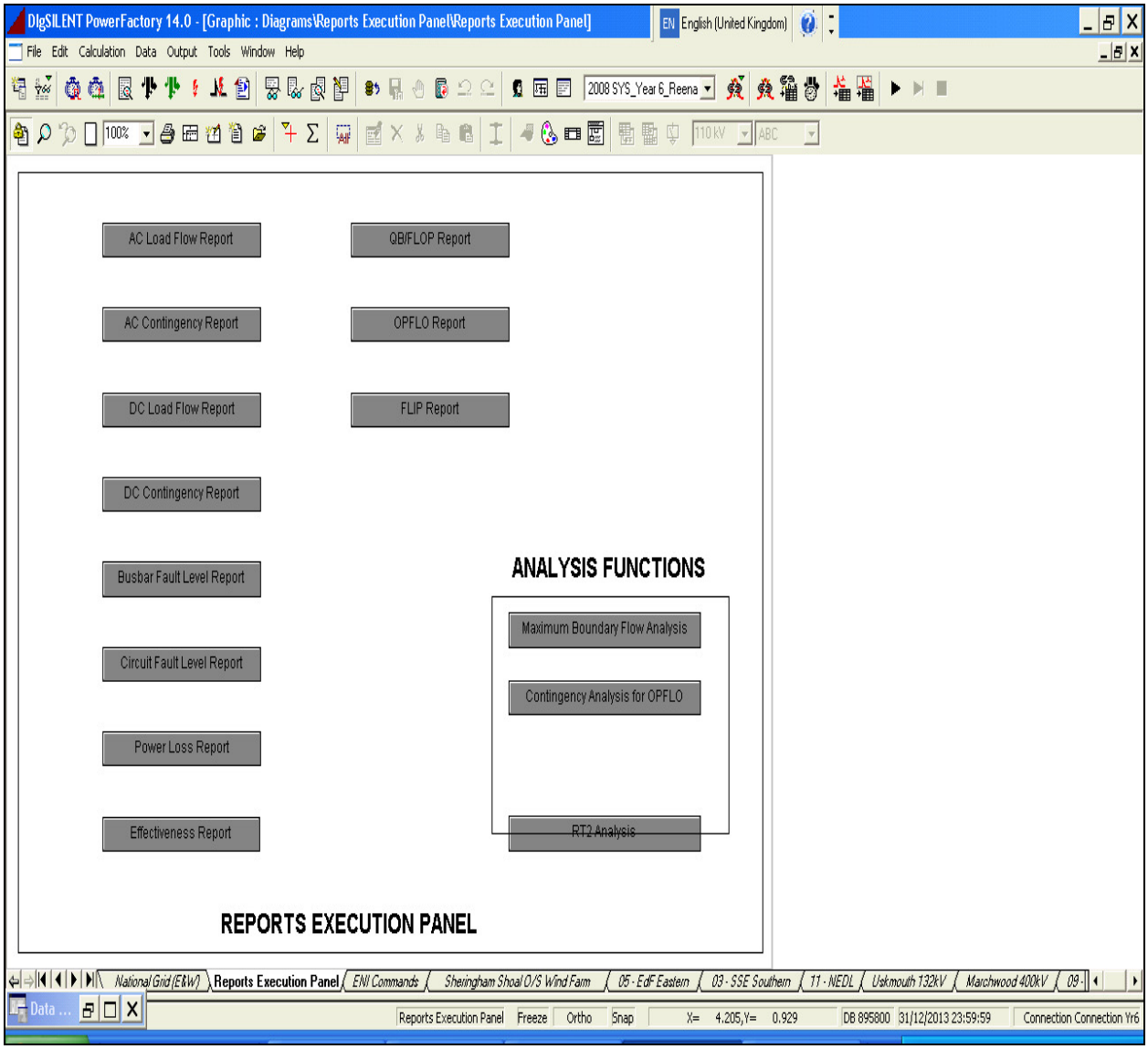

Figure 3 – Screen shot of Output Reports that can be produced in Power Factory

Future Direction

In the coming months at National Grid, I will be completing the GB network modelling in Power Factory up to the year 2020 to represent the Gone Green scenario as well as completing AC loadflow analyses on the developed network for compliance. Voltage and transient stability analyses will then be required to produce information on each boundary's network capability incorporating the strategic reinforcements proposed in National Grid's *A Vision to 2020* report so that the full impact of such reinforcements can be reported to the ENSG. This reporting is in order for the planned/proposed works to be provided with the appropriate funding to commence or continue.

In conjunction with the above task, the GB Power Factory network I am currently modelling will also be used as the foundation network for the newly set-up Joint Venture Project between National Grid and the Scottish transmission operators SHETL and Scottish Power in the Anglo-Scottish Upgrade which includes incorporating the Western HVDC link and series compensation near the border. Therefore, once the GB network is completed, a merge with the Scottish networks will be required in order for both parties to analyse the impacts of the proposed reinforcements relating to the Joint Venture Project.

I will also be involved in the preliminary analysis of system studies required to produce the annual Seven Year Statement due for final publication in April 2010, as well as performing studies required for the Offshore Windfarm Development Statement which is due for its first publication in December 2009 which will include the optimisation of integrating offshore developments with the onshore network. The Power Factory package will be utilised in performing the system studies to produce the results and information for both reports, and therefore I envisage further knowledge on the usefulness and practicality of the package as an analysis tool for these documents to be discovered.