Engineering Practice Report

Name:

Student Number:

Course: Electrical & Electronic Engineering, 3rd Year

Employer: Ergon Energy

Period: 1st December 2003 to 20th February 2004

1.0 Executive Summary

For a period of 12 weeks, I was employed by Ergon Energy Corporation Limited to work as an Engineering Co-operative student in the Far North Network Planning and Development group in Cairns. Ergon Energy Corporate is responsible for the distribution of electricity to some 570,000 customers situated primarily in the company's franchise area covering 97% of Queensland. The retail arm of the company also successfully retails power in the Queensland, NSW, ACT and Victorian electricity markets.

During my period of employment I was given a range of tasks that proved themselves to be both interesting and challenging. A select number of projects I was involved in included:

- The isolation of a number of SWER schemes located in the Atherton Tablelands
- The investigation of voltage unbalance conditions along a feeder in Charters Towers
- The development of a number of contingencies for Cairns' rapidly developing southern corridor
- The modelling of SWER schemes to derive the operating conditions that were representative of abnormal or undesirable load profiles
- Formal training in DINIS and specific application investigations including load allocation, SWER modelling and data validation
- Use of applications including Active Factory, Connect, Powerview, Smallworld and PSS Adept
- Presentation to peers

As well as involvement in current projects, I also completed general tasks such as feeder demarcation, photocopying, scanning and retrieving / validating data when requested.

Over the 12 weeks I've been positioned at Ergon Energy I've gained an invaluable insight into the operations of the utility industry. I am now proficient at reading system diagrams, in their various formats, and cross correlating them with other data streams. I have further developed my skills in utilising Microsoft Excel, which is heavily implemented in data presentation / transfer as well as general calculations. I've become competent at using the network modelling program DINIS, as well as other applications aforementioned. The experience I've gained in this placement has proven invaluable and has put me in good stead as I approach my final year, laying a solid foundation which will facilitate development as my course places an increased emphasis on Power Engineering in the 4th year.

2.0 Table of Contents

3.0 Introduction

From the 1st of December 2003 to the 20th of February 2004, I was employed by Ergon Energy to work in their Cairns office at 109 Lake Street with the Far North Network Planning and Development division.

During the course of my placement, I was involved in a number of projects which all proved to be quite interesting, while providing some unique challenges. These projects, some of which have been aforementioned, identified key issues that are paramount to ensuring the successful design of a distribution network. These issues include, but are not limited to, ensuring reliability and quality of supply, the safety of the public and work staff and the protection of network assets. While meeting these fundamental criteria, an onus is placed on the designer to minimise environmental impact and maintain positive relationships with stakeholders where possible. Highly publicised outages during the recent state election campaign emphasised the political and public pressures and expectations the corporation is subject to. Political and public stakeholder issues are able to be focussed during elections whilst forums like REC (Regional Electricity Council) and stakeholder meetings are conducted on a more regular basis and address a wide range of issues.

I worked directly with the strategic distribution planning engineer for the northern region (encompassing the Far North, Northern and Mackay divisions), Peter Bacic along with a number of other engineers and asset / planning officers. On many of the tasks I was assigned I worked alongside Richard Laws, a fellow 3rd year electrical engineering student from the University of Queensland, who was working as a cooperative student within the Regional Asset Management business unit. This partnership allowed me to gain an insight into the operations of the RAM's group and see how the two functional divisions interact to achieve projected goals.

4.0 Background

Ergon Energy was formed in 1999 as the result of the amalgamation of the six regional electricity boards, although the distributor still retains the Far North, North Queensland, Mackay, Capricornia, Wide Bay and South West regional divisions.

Ergon Energy’s network infrastructure of nearly $2.8 billion includes more than 135,000km of poles and wires, over 70,000 substations, and covers one of the largest areas serviced by a single distributor in the western world.

Ergon Energy is broken into two subsidiary companies, Ergon Energy Corporation Limited and Ergon Energy Proprietary Limited. Ergon Energy Corporation Limited is responsible for the distribution of power to the franchise area, being the rural and regional communities of Queensland which make up some 97% of the state. Ergon Energy Retail, in contrast, is responsible for the acquisition of contestable customers. Contestable customers being those customers who are thus eligible to buy electricity directly from the host retailer, another retailer or from the wholesale electricity market.

Ergon Energy Corporation Limited, being a monopoly distribution service in its franchise area, is privy to customer power consumption information that would give Ergon Energy Retail an unfair advantage over its competitors. Thus the flow of information between the two subsidiaries is regulated through tight ring-fencing laws. Consequently, the subsidiaries exist as two separate entities.

5.0 Tasks & Duties Performed

During my 12 weeks at Ergon Energy, I was allocated the following tasks:

5.1 Familiarisation with Regional Network

With the protection settings at Hartley Street Zone Substation operating at their ceiling limits and unable to be raised due to feeder cable rating limitations, one of my tasks was to prepare a series of contingency plans for the area in preparation for the summer peak. Unplanned outages are costly to the distributor often resulting in public dissatisfaction, investigations by internal specialists (external bodies where required) and direct revenue and customer business losses as a result of the failure to supply the affected area. It is therefore important for a distributor to prepare procedures for alleviating the number of effected customers in the event of a fault along a network.

To prepare for this project it was first necessary to familiarise myself with the network in this area. This preparation involved acquiring the system diagrams for the area and demarking the high voltage backbone of the three 22 kV feeders that run between Hartley Street Zone Substation (132/22 kV) and Edmonton Switching Station (22 kV), as well as the three feeders that continue on from Edmonton S/S to supply Gordonvale Substation (22 kV). To complete this task I had to become competent at reading system diagrams in both the schematic and geographic formats and be able to quickly correlate between the two forms.

In order to understand how the network would respond in the event of a fault, it was necessary to read the internal report "Edmonton Switching Station: Protection Relay Setting Report." This document provided the phase over-current, earth fault and sensitive (high impedance) earth fault settings for the sending and receiving end relays that control their respective circuit breakers at Hartley Street and Edmonton. In understanding how each of these relays operated, it was possible to comprehend the existing protection operation philosophy and derive the sequence of events that would occur for a fault along a select feeder. In understanding the condition of the network after a given fault, it is then possible to devise a suitable means to mitigate the outage, repair the fault and restore the network to normal operation.

5.2 Preparing Contingencies

Once satisfied with the operation of the system, on consultation with my supervisor, Peter Bacic, we investigated a number of network conditions on the simulation software PSS Adept. These models pertained to the switching out switched shunt capacitor banks at Edmonton and Gordonvale, the loss of select feeder exit cables at the Edmonton Switching Station and faults along key sections of network on the White Rock, Hardy Road and Forest Gardens 22 kV distribution feeders.

On consultation with the system response co-ordinator, Alex Farquharson, a presentation format was agreed upon and I commenced work on modelling the network under DINIS for the varying operable states. This was achieved with an acceptable degree of agreement between DINIS and PSS Adept results after it was found the library for an underground conductor utilised heavily in the drawing was invalid and corrected.

For each of the system contingencies a number of network configurations to mitigate the problem were simulated on DINIS including no load transfer, feeder tie-on transfer, load management, embedded generation, curtailable load, sustaining an outage for overhead or performing load shedding. Unfortunately, due to time constraints this study could not be fully completed and formalised. However there was a network failure and the data streams were used for system re-configuration. The problems inherent to the southern corridor should be rectified when the proposed 2×50 MVA 132/22 kV transformers are commissioned (Nov. 2004) at Edmonton Switching Station, providing the main source of supply into the network.

5.3 Charters Towers Study

After line profiler recordings revealed a voltage unbalance condition along a Charters Tower feeder that was beyond statutory levels, Peter Bacic conducted an investigation into possible sources of the problem. Initially I was requested to convert a series of comma separated polylogger data streams taken at a voltage regulator on the feeder and present the data as an excel spreadsheet coupled with respective graphs. As a further task to assist Peter, I was instructed to model a SWER scheme that tapped off the feeder and was believed to be contributing to the unbalance.

By forming a Microsoft Excel spreadsheet, I was able to break the SWER's load current into its constituent components consisting of its capacitive line charging current, transformer magnetisation current, customer load current and reactive current. (The SWER scheme was sufficiently long at 410 km that three 50 kVA reactors were necessary to compensate for the capacitive line charging current.) With the charging and magnetisation currents effectively forming constants, the total SWER line currents were derived for variations of customer load and the number of on-line reactors.

With reference to a recent load profile recording taken at the SWER's isolator, the customer load was adjusted to be reflective of the schemes recorded operation. Hence from the table it was interpolated that the current and voltage recordings were reflective of a scheme that had no on-line reactors. This suggested all three reactors connected to the scheme were out of service.

The investigation conducted by Peter Bacic later found the governing factor in the voltage unbalance condition was incorrect regulator HV connections, an intermittently failing controller and optimising settings on the voltage regulator. To develop an understanding of the function, operation and configuration of voltage regulating apparatus I read a number of voltage regulator manufacturer manuals from both McGraw Edison and General Electric.

5.4 Voltage Unbalance

As an additional exercise, in order to develop an understanding of the theory behind voltage unbalance in three phase systems, I conducted studies to investigate the effect variations in a single and multiple number of phase voltages had on the resultant sequence components. From these sequence components, it was possible to determine the resultant line to line voltages across the three phases, as well as the shift in the neutral voltage that results from the investigated conditions of unbalance. The study also provided an indication as to the degree of variation that must exist across the three phases in order for the system to exceed statutory levels for varying contingencies and loads.

5.5 Isolation of Tablelands SWER Schemes

The Atherton Tablelands distribution network is characterised by a number of SWER (single wire earth return) schemes that generally radiate out from the end of their respective feeders. These 12.7 kV schemes are largely 22 kV un-isolated spur systems and as a result suffer from inherent sensitive earth fault protection problems as well as interfering with telecommunications through low frequency induction.

The isolation of a predefined number of these SWER schemes was a capital expenditure project set out for this financial year. Both Richard Laws and I were assigned the task of determining suitable isolation transformer ratings based on a combination of previous load profiles, recent energy figures, scheme constraints (i.e. existing reclosers) as well as applying a generic utilisation factor. From these data streams appropriate utilisation factors (based on the information available) were applied to the schemes providing a representative maximum demand.

With reference to the appropriate construction manual, it was determined that standard construction for 22/12.7 kV isolation transformers within Ergon Energy was 100 kVA and 200 kVA. This limited the available SWER isolator capacity to 100, 200 or 2×200 kVA. Each scheme was then assigned an appropriate isolator size by looking at the calculated maximum demand and accommodating for the dominant winter peak period as well as future growth. For each isolator, the matching recloser size was referenced and documented.

In order to determine if the existing design was suitable from a quality of supply and protection point of view, it was necessary to run both load flow and fault analysis on each of the schemes within the DINIS modelling software. This required performing an initial load allocation to obtain a model that was representative of how the SWER scheme and feeder performed during periods of maximum demand. (This required me to write a report on how to perform load allocation of SWER schemes within DINIS) The subsequent analysis revealed that the designs were sound from a protection point of view with extremity sensitive earth faults being visible from the recloser. One exception however, was the case where a scheme was found to have an isolator fault current that would exceed the maximum interrupting capacity of the existing hydraulic recloser. As a result the recommendation was made to replace the hydraulic device with an electronic equivalent that senses (via current transformers) rather than 'feels' the fault current.

Load flows however, revealed certain schemes were suffering from unacceptable low voltage conditions. While a small number of customers, generally located at the ends of the SWER schemes, have reported brownouts, the problem was not believed to be as significant as the DINIS load flow suggested. Thus it was believed that the utilisations interpolated in some of the schemes were too high. This was explained by the fact that the load profiles that were fundamental to the derived utilisation factors were taken in early 1998 before deregulation was imposed on the dairy industry. Considering many of the customers sitting on these SWER scheme are / were dairy farmers, while the schemes have grown in connected capacity, their utilisations have dropped as a large fraction of the dairy farms have been forced to close. The large degree of correlation in the load profiles of dairy farms further emphasises the extent to which a significant reduction in the number of farms has on the ADMD (After Diversity – Maximum Demand) of the scheme.

Consequently, on presenting our findings, I advised the principal designer that new line profiles had to be taken for those schemes that were either marginally suited to the calculated isolator size, or required 2 $\times$ 200kVA isolation transformers to meet the expected maximum demand. 2 $\times$ 200kVA isolators are non-preferred as Ergon policy requires an earth impedance of 0.3Ω before they may be commissioned. Such low impedances are typically difficult to obtain and often deep drilling techniques or long trench runs must be employed to obtain the specification. In the event the latest profiles of a SWER scheme do not warrant a downsizing in the isolator from 2 $\times$ 200kVA, I investigated the feasibility of splitting the scheme up or extending the three phase to transfer sufficient load off the relevant SWER scheme. These approaches were presented to the designer and will be reviewed as the data streams become available.

5.6 Motor Start Analysis

In order to ensure quality of supply, for sufficiently large motor proposals, it is necessary for the distributor to model the impact the machine has on the network during normal operation and on start-up before allowing installation. Working together with Richard Laws and network maintenance officer Anthony Torrisi, I performed a number of motor start analysis concerning proposed installations in Innisfail and Atherton.

By performing a load flow within DINIS with an equivalent load, voltage sag along the network may be determined for normal operation. The locked rotor condition that occurs during start-up may then be simulated by placing a fault impedance, characteristic to the motor rating, and conducting a fault analysis. By monitoring the voltage flicker at the point of common coupling it can then be determined whether the proposal is first acceptable and then the frequency of motor starts that the customer is limited to with reference to standard tables.

5.7 Network Data Verification

In order for valid studies to be conducted on the Mackay network, which is currently under review, I was instructed by my supervisor to conduct an audit on the data streams available to ensure they accurately displayed the current status of the network. Of particular interest in the appraisal were the West Mackay and Tennyson Street feeders. With schematic diagrams, geographic diagrams, GIS data and DINIS drawings accessible, I was required to cross correlate between the data sources, ensuring the DINIS drawing reflected what I was seeing in the system diagrams. Of key importance were substation size and positions as well as the location of links and air break switches – particularly those switches that were normally open. Any discrepancies were labelled on both mediums for further review and correction. I was then required to transfer conductor data for the Mackay network from the GIS to the schematic and geographic diagrams.

As an extension to the task, I was required to complete a database detailing the feeder exit cables as well as the backbone overhead conductor for all feeders in the Far North region.

5.8 Field Trips / Meetings

For the duration of the placement, I was regularly taken on field trips to visually reinforce what was seen on schematic diagrams. Visiting Turkinje Substation, where Ergon distributional assets interface with the assets of the transmission company, Powerlink, provided an interesting overview of the transmission of power from the

Kareeya Hydroelectric Power Station and Ross Substation in Townsville, to the Turkinje Substation, via Chalumbin. Other sites visited include the Mareeba Zone Substation, Edmonton Switching Station, Gordonvale Switching Station, Kamerunga Zone Substation and the Babinda Switching Station.

Additional field trips I was involved with included the investigation of a low voltage complaint in Atherton resulting from an excessive low voltage run for the customer's peak load. A trip to Babinda was conducted to investigate options to alleviate an environmental issue with a three phase span as well as to inspect a circuit breaker that sustained damage during operation. Finally, I was instructed to take photographic evidence of a number of overhead spans that had been identified as being susceptible to vegetation infringement within the Edge Hill / Whitfield areas.

At various times Richard and I sat in on, and actively participated in meetings both person to person and through mediums such as teleconferencing and Netmeeting. The issues addressed in the meetings ranged from asset management, to distribution briefs and design proposals. I participated in a two day DINIS seminar which provided an in-depth overview of the package and its tools.

6.0 Experience Gained

This placement provided an invaluable experience in witnessing the sort of work performed by professional engineers in the Power Industry. Throughout the 12 weeks, the importance of team work in achieving project goals was continually reiterated to me both in the projects I was involved in, and by witnessing the work practises of my colleagues. Part of this teamwork involves fully utilising the company's personal / material resources in order to minimise the work required to achieve an acceptable outcome.

An additional key point I picked up upon during my employment was the importance of validating data before it is implemented. This avoids the unfortunate situation of having to continually revise work as corrections are made to the fundamental data streams.

The position gave an insight into the office environment and provided an opportunity for me to implement the engineering knowledge and skills acquired throughout my course on real world problems.

7.0 Conclusion

During my twelve weeks at Ergon Energy I feel that I have gained a valuable learning experience. I have a developed a better understanding of the issues paramount to Power Engineering and have become competent in a variety of tools / techniques widely implemented by electricity distributors. The tasks I have performed have re-enforced existing knowledge while forcing additional learning in a number of areas.

I have thoroughly enjoyed the position and the people I have worked alongside for the best part of three months. I'd like to thank the Ergon Energy, and Peter Bacic, for providing me with such an opportunity.

Figure 1: Turkinje Zone Substation