POWER DELIVERY ENGINEERING

EIT Training Review:

Progress Report

Name: Masienyane Masienyane Prince

Unique Number: 4553001

Review Period: 6 months

Mentor: Lethoko Motsoeneng

Date: 19 October 2018

Table of Contents

1. Introduction 4

2. Training Activities 4

2.1 HV Plant 4

2.1.1 POWERTECH 5

2.1.2 Transformer basics task. 6

2.1.3 Development of an evaluation criterion for an online moisture removal system for use on power transformers and reactors. 7

2.2 GIS 7

2.3 DBOUS- Design Base & Operating Unit Support 11

2.3.1 Standards reviewed 12

2.3.2 Standard Implementation (SI) 12

2.4 Integration 13

2.4.1 What I have learnt during my stay with Integration 13

2.5 Lines Engineering Services 14

2.6 Substation Engineering 16

2.7 PTM&C 16

2.7.1 Control and Automation Technology 17

1.7.2 Planning and Project Support 19

1.7.3 Protection 19

1.8 Modelling Task 20

2. Summary 24

3. Conclusion 27

APPENDIX A – Evaluation Criterion for Onsite moisture removal system 28

APPENDIX B – Material Inspection Feedback Form. 31

APPENDIX C – Modelling Task. 32

Table of Figures

Figure 1: PDE Structure 4
Figure 2: 400kV Reactor and Charge generator 5
Figure 3: Typical HV Power Transformer 6
Figure 4: GIS Data types 8
Figure 5: Eskom Tx Network from ESVA Base Viewer 8
Figure 6: Candover and its Coordinates 10
Figure 7: Normandie Substation 10
Figure 8: Area of Apollo 10
Figure 9: DBOUS Structure 11
Figure 10: Integration Structure 13
Figure 11: LES Structure 14
Figure 12: Bended Bolts 15
Figure 13: PTM&C Structure 16
Figure 14:Tx Architecture 17
Figure 15: Dx Architecture 18
Figure 16: VBA Task results 18
Figure 17: Impedance Protection setup 19
Figure 18: Current Differential Setup 20
Figure 19: Scatter Plot of the Load profile 20
Figure 20: Polynomial approximations from order 1-7 21
Figure 21: Order 21 Approximation 21
Figure 22: Order 21 Vector Equation 22
Figure 23: Area of actual and estimate profiles 22
Figure 24: Actual Demand profile and the one with renewables 23
Figure 25: Residual between Normal demand profile and the profile with Renewables. 23
Figure 26: Duck Curve 33

List of Acronyms

BIL	Basic Insulation Level
CAISO	California Independent System Operator
CoE	Centre of Excellence
DNP3	Distributed Network Protocol 3
Dx	Distribution
EIT	Engineer In Training
ESVA	Enterprise Spatial Viewer and Analysis
FSP	Fibre Switching Panel
GIS	Geographic Information System
GUI	Graphical User Interface
LES	Lines Engineering Services
LI	Lightning Impulse
MES	Maintenance Engineering Strategy
NCC	National Control Centre
PDE	Power Delivery Engineering
RTU	Remote Terminal Unit
RGCC	Regional Control Centre
SCADA	Supervisory Control And Data Acquisition
SI	Switching Impulse
Tx	Transmission

1. Introduction

This report is meant to give an overview of the training covered for the first six months of the engineer in training (EIT) programme at Eskom within Power Delivery Engineering. The training was rotation based whereby I get the chance to train under most of the departments that constitute PDE. Details of the training covered in each department are explained in Section 2 (Training Activities).

2. Training Activities

As mentioned in the introduction training was done within PDE, rotating through different departments of PDE, the duration within each department differed, it could be anywhere from 1 week to 10 weeks. This section highlights what the training covered for each respective department. The following diagram shows the structure of PDE.

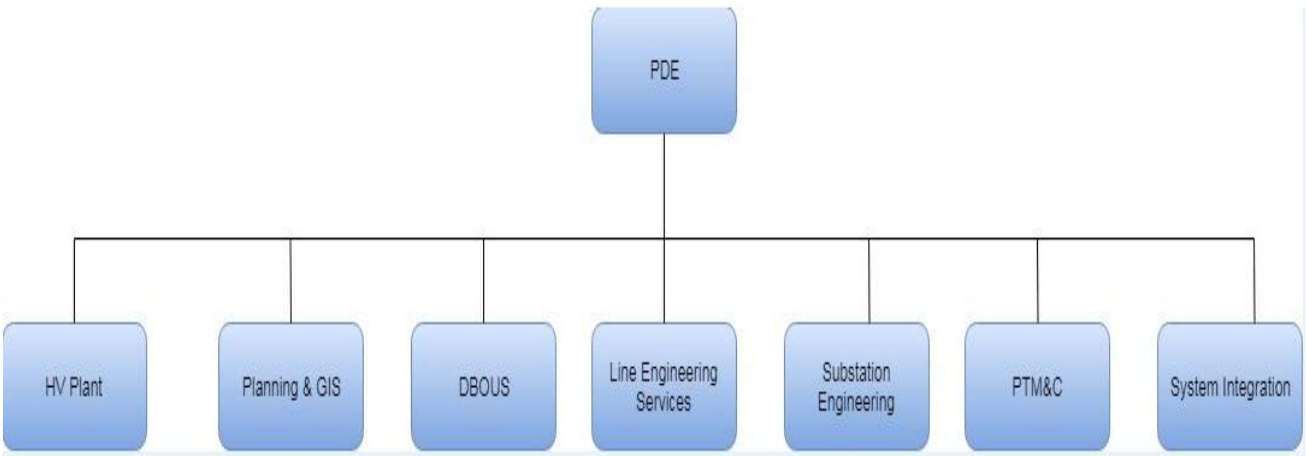


Figure 1: PDE Structure

2.1 HV Plant

Level of Responsibility: **Exposure and Participation**

Standards/SOG/Procedures:

SANS : 60076-3 : 2014

Previous Training Used

Pro-activity:

2.1.1 POWERTECH

400kV Reactor dielectric tests.

Lightning strikes are common in transmission lines because of their height, these strikes on the line conductor cause impulse voltages. The terminal equipment of transmission lines such as power transformers and reactors then experience these lightning impulse overvoltages. During switching operations overvoltages in the order of 3 times the normal system voltage also occurs. These tests are meant to ensure that the insulation system of this equipment can withstand these overvoltages.

A shunt reactor is a device that minimizes overvoltage and limits the transfer of reactive power in the network. The following figure shows the setup used for carrying out the impulse tests, it shows the reactor and the charge generator.

Figure 2: 400kV Reactor and Charge generator

2.1.1.1 Lightning Impulse test (BIL = 1425 kV)

This test is meant to ensure that the reactor insulation can withstand lightning surges. The following table shows the results from the LI test, the values on the left are IEC specified values and the ones on the right are the actual test values.

IEC Specified Values	Test Values
U_{pk} = 1425kV (+- 10%)	1.14 MV
T_1 (Front time/time to peak) = 1.2 us (+- 30%)	1.872 us
T_2 (Tail Time/time to zero) = 50 us (+-20%)	49.333 us
β < 5% (10 % standard)	9.20%

Table 1: LI Results

2.1.1.2 Switching Impulse test (BIL = 1050 kV)

This test is meant to ensure that the reactor insulation can withstand switching surges. The following table shows the results from the SI test, the values on the left are IEC specified values and the ones on the right are the actual test values. With the test values voltage was applied with a range of percentages of the BIL, 60% to 100%.

IEC Specified Values	**Test Values**		
	60% (630kV)	**80% (840kV)**	**100% (1050kV)**
T_1 (Front time/time to peak) >= 100us	124.346us	124.527us	124.708us
T_d >= 200 us	230.664us	230.294us	229.924us
T_2 >= 500us	996.053us	998.468us	999.658us

Table 2: SI Results

2.1.2 Transformer basics task.

This was a short task given to help me familiarise myself with the Power transformer and its components and give a feedback based on my findings.

A Power Transformer is a static electrical device with two or more windings that transforms voltage and current to different values at the same frequency for the purpose of transmitting electrical power. The following picture shows a typical power transformer.

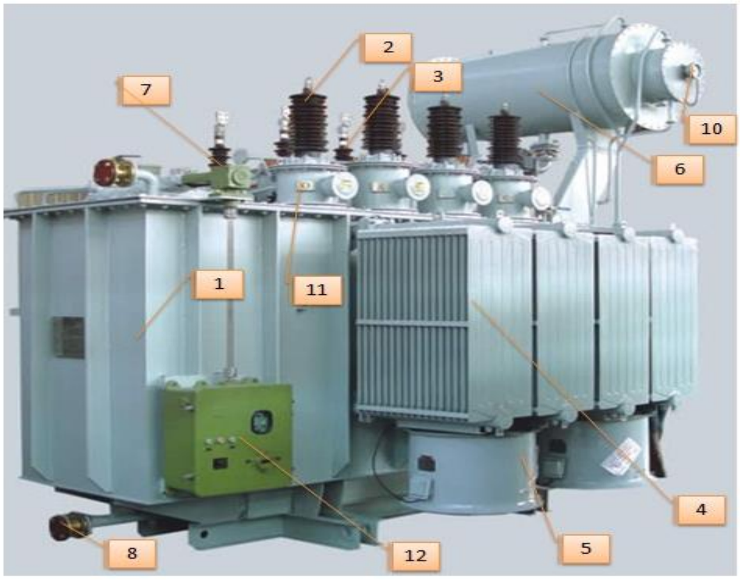


Figure 3: Typical HV Power Transformer

2.1.3 Development of an evaluation criterion for an online moisture removal system for use on power transformers and reactors.

Moisture is present in power transformers and reactors due to factory process and could also be absorbed from the atmosphere through leaks or other exposures. This reduces the transformer's life expectancy by degrading the insulation. This implies that moisture levels in transformers should be monitored and managed. Possible ways this could be done:

> **Workshop drying** – This method requires transformers to be removed from service, transported off site and dried in an Oven. This requires long outages, is expensive, reduces the transformer's life expectancy and involves transportation risk.
>
> **Low frequency heating and vacuuming on site** – this also requires long outages and specialised equipment.
>
> **Drying using mobile filtration plant** – this method required site establishment and short outages, can result in over drying.
>
> **Permanent online moisture removal system** - With this method the drying system is embedded to the transformer or reactor.

The permanent online moisture removal system is considered to be the most economical and practical solution for keeping transformers and reactors. Refer to Appendix A for the actual evaluation criteria.

2.2 GIS

GIS CoE provides geospatial solutions, products and services to meet the diverse needs of the business. This CoE collaborates with the Government and the Private Sector to ensure that they keep abreast with technologies and trends.

Level of Responsibility: **Exposure**

Standards/SOG/Procedures: None

Previous Training Used

Pro-activity:

In this department I got an exposure as to what the department entails and what types of CAD systems are in place currently, and the types of data the department works with, namely Rasta and Vector data types. The following images shows the two data types.

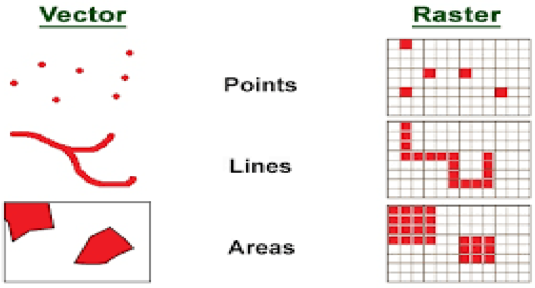


Figure 4: GIS Data types

Some of the Web apps developed by GIS for Eskom I got exposure to are :

ESVA Base Viewer – A web based application with different information layers available for viewing. It also allows a user to perform measurements, coordinate calculation, area calculations and draw lines.

The following figure shows the Eskom Transmission network from the ESVA Base Viewer.

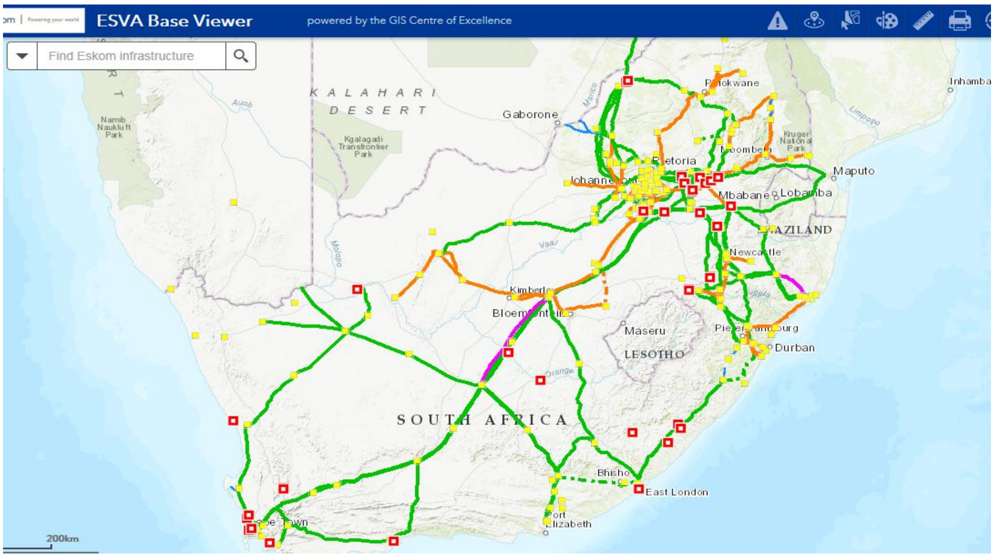


Figure 5: Eskom Tx Network from ESVA Base Viewer

From figure 5 above, different colours and shapes have meaning, and they are as follows:

 - Red squares represent Power stations.

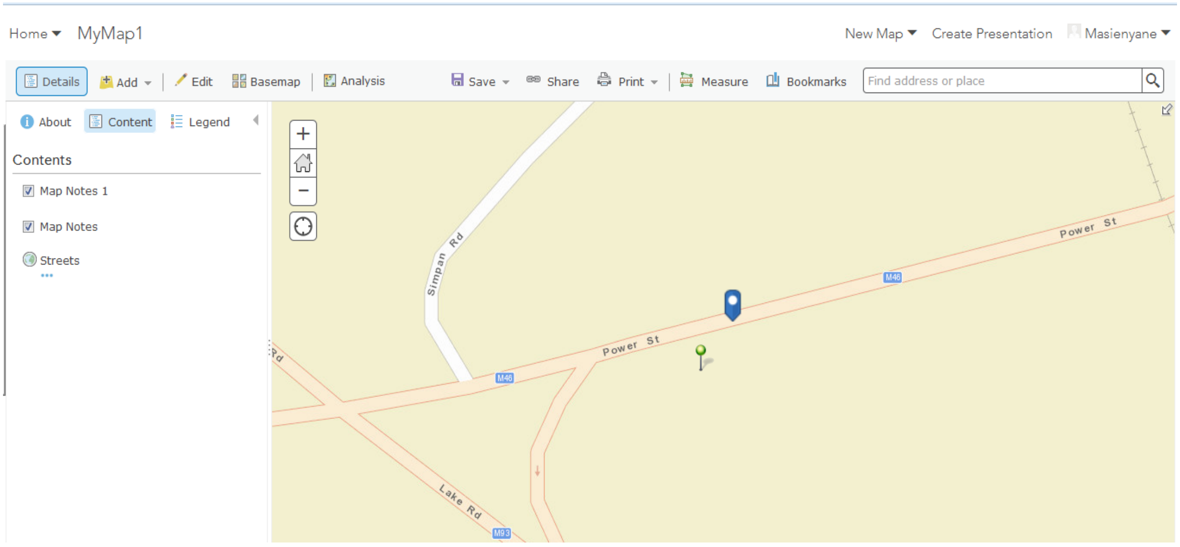
 - Yellow squares represent Transmission substations.

 - Green Lines represent 400kV Lines.

 - Purple Lines represent 765kV Lines.

 - Orange Lines represent 275kV Lines.

ESVA Portal - A web App that allows user to add content maps (lines and map notes), with an additional feature of sharing the "edited Map".



MVON – Medium Voltage Opportunity Network web app, an application mainly used by planning to check the network profile and helps in checking the load on a line.

The opportunity could be checked with respect to:

Voltage

Current

Number of Customers

Colour codes of opportunity :

Opportunity to add more load.

Approaching the full capacity of the line.

Reached the full capacity of the line.

During my stay at GIS I was given an ESVA exercise, and the questions were as follows:

- Find Candover Substation as well as its coordinates.
- Find Normandie substation as well as its coordinates.
- Find the perimeter of Apollo Substation.

Results from the ESVA web app for the above questions:

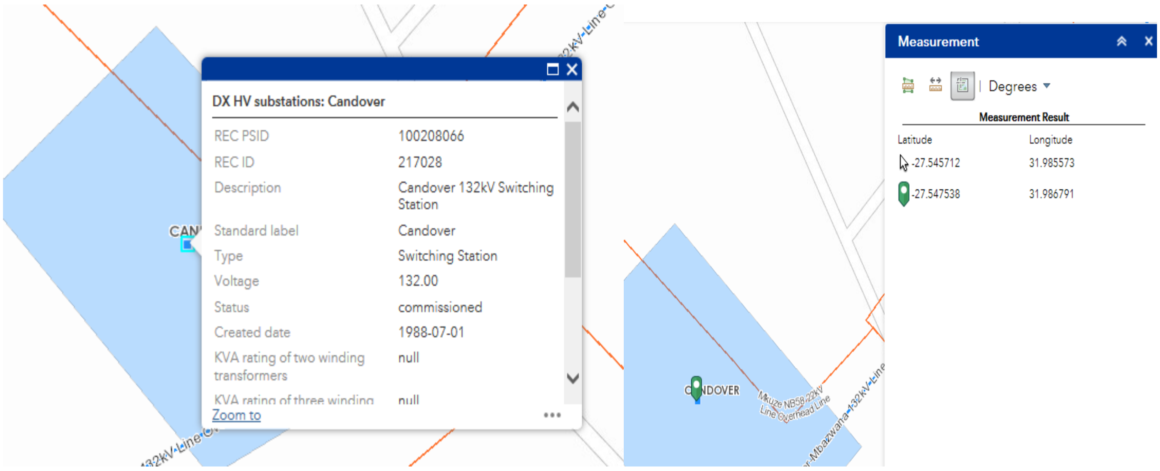


Figure 6: Candover and its Coordinates

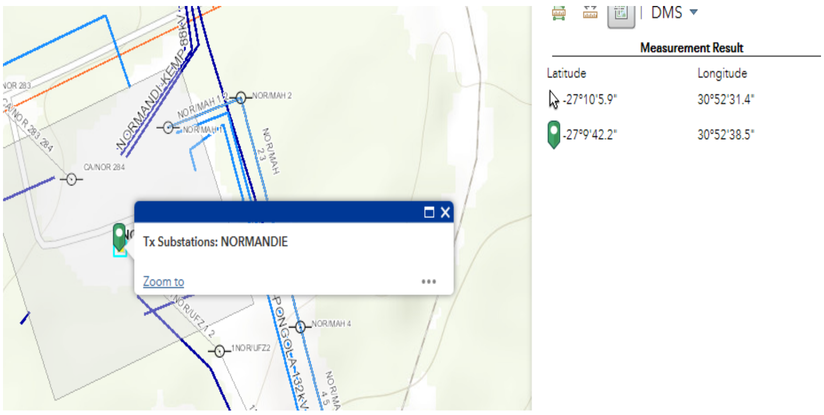


Figure 7: Normandie Substation

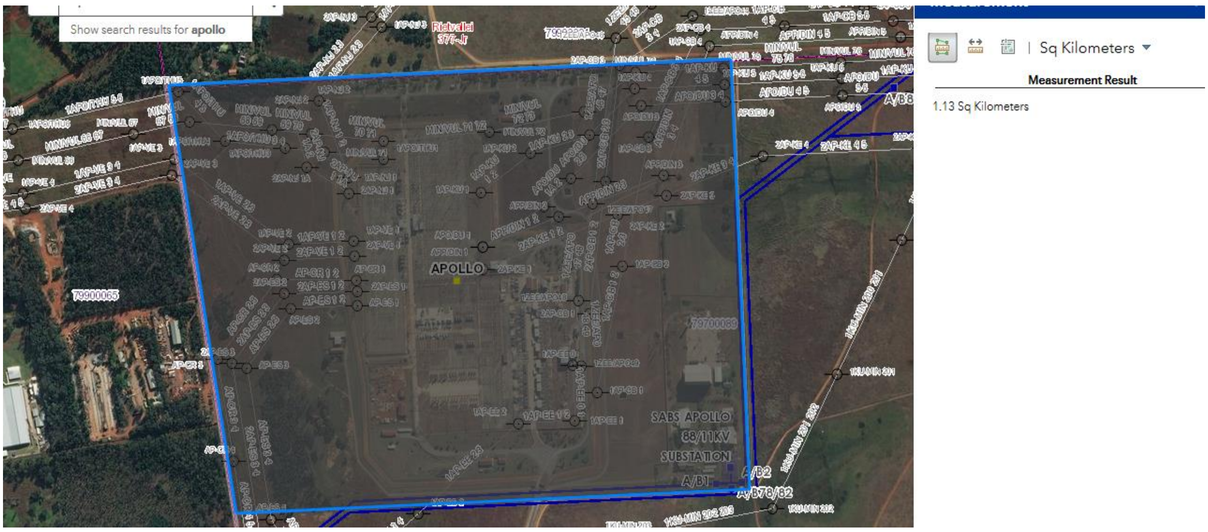


Figure 8: Area of Apollo

2.3 DBOUS- Design Base & Operating Unit Support

DBOUS is responsible for defining, documenting and interpreting the design base for all PDE assets, maintenance of the design base of Eskom's PDE assets, management of the effectiveness of governance structures for PDE (e.g. SCOT operations and DRT's) and also implementation of standards. The following diagram shows the structure of DBOUS.

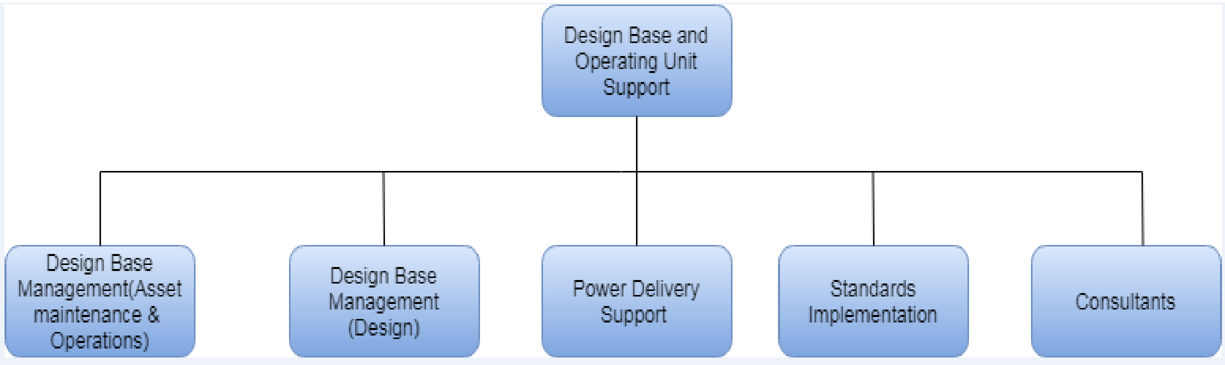


Figure 9: DBOUS Structure

Level of Responsibility: **Exposure and Exercises**

Standards/SOG/Procedures: **240-78388334**

240-69387838

Previous Training Used:

Pro-activity:

The task given in Design Base Management was to review the maintenance engineering strategy (MES) and the maintenance Execution Strategy then highlight possible Gaps.

The MES refers to part of the engineering design process that defines the:

Minimum critical spare requirements.
Maintenance task definition.
In-service inspection and test requirements.

The MES is then customized to form the maintenance execution strategy, based on specific plant functional location:

The plant environment.
Criticality to the network
How the plant is used.

2.3.1 Standards reviewed

MES- Maintenance standard for power transformers and reactors (>1MVA and >1000V) - **240-69387838**

Task Manual- Oil sampling from the transformers.- **240-78388334**

This task manual clearly defines the procedure of how the oil sampling is to be carried out, as well as the three sampling points, which are:

- Samples from the Buchholz relay
- Sampling from main transformer tank and Selector Switch.
- Samples from tap changer diverter switch.

One important thing to also be noted before sampling can be done is to check the oil level in the conservator, if the level is not 1/3 then it should be topped up before sampling can take place.

The gap I had identified in the task manual was that infrared scanning of the conservator could also be incorporated to verify correct operation of the oil level indicator, however I was made aware that there is a separate Task Manual in place for doing infrared scanning and other one for oil level visual inspection as part of the routine substation inspections.

2.3.2 Standard Implementation (SI)

SI is responsible for reviewing and commenting on drafts standards as well as reviewing published standards and determining their applicability throughout the operating units (OUs). The task given in this section was Material Inspection at Rosherville RDC, this inspection was based on Small Power Distribution Units (Ready boards) to identify any defects and provide necessary recommendations. The feedback inspection form is attached in Appendix B.

2.4 Integration

Integration is a section within the Power Delivery Engineering Department (PDE) that ensures technical integration between disciplines as well as integration to other stakeholders involved in Projects. The following diagram shows the break down on the integration Section:

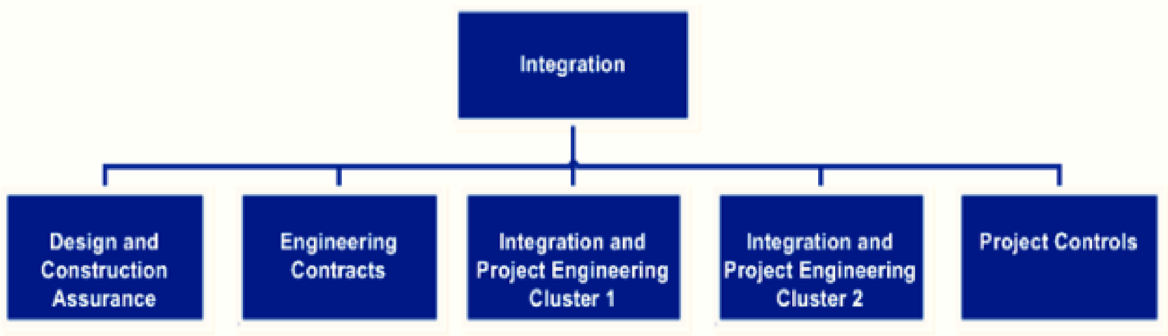


Figure 10: Integration Structure

Integration is responsible for overall management of the integrated design solution development and some of the specific responsibilities Include:

Interface to customers for the receiving of all Capital engineering work
Integrated resource planning and execution (external and internal)
Co-ordinate all PDD / Capital / TX work requests
Integration of discipline specific design solutions
Establish effective project controls and reporting
Integrated solution for TX refurbishment projects
Manage PDE delivery of capital work

2.4.1 What I have learnt during my stay with Integration

2.4.1.1 The integration processes

During the week I spent in Integration, I was introduced to the processes that are used in this section. For every project introduced to integration, the project is required to go through three phases, with each phase being a prerequisite for the next phase. These three phases are:

Concept Design Process in order to achieve Definition Release Approval.
Critical Inputs to Integration at the start of the Concept Design Process are:
Approval (WBS number).
URS.
Originators Report.
Detailed Design Process in order to achieve Execution Release Approval.
Critical Inputs to Integration at the start of the Detailed Design Process are:
Approval (WBS number).
Approved Asset Spec (CRA).

Approved TS for Definition Phase.

Execution Process in order to achieve Construction of assets.

Critical Inputs to Integration at the start of the Execution Process are:

Approval (WBS number).

Approved TS for ERA.

Confirmation of Purchased equipment.

2.4.1.2 Compiling a Work Request

I also got exposure to how a work request is compiled using the User Requirements Specification (URS). The work request was for the 100 MW Humansrus (Redstone) CSP Plant. This is a strengthening project which entails equipping a 132kV feeder bay at Olien Substation, which will be used to export 100MW of CSP generation from Humansrus CSP Plant.

2.5 Lines Engineering Services

LES is the Transmission lines Centre of excellence within Power Delivery Engineering, responsible for developing:

Standards,

Specifications,

Maintenance and Operating philosophies of Transmission Lines.

The following diagram shows the structure of LES.

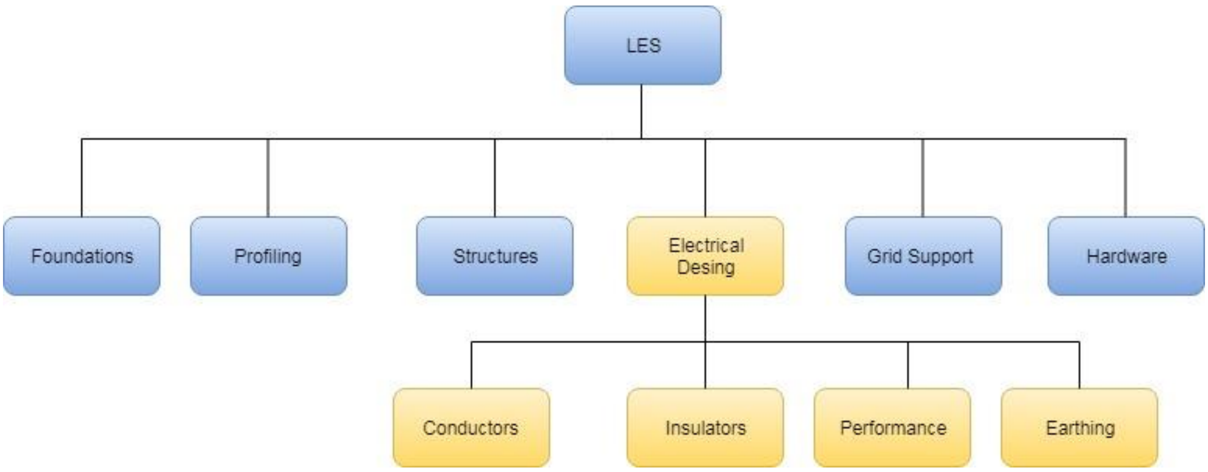


Figure 11: LES Structure

<u>The LES Design Process</u>

The LES design process comprises of 3 stages which are:

Concept Design Process

New Project Initiated, studies are carried out for corridor Selection and Concept design Formulated.

Detailed Design Process

Final Design Kick-off Meeting, reviewing of LIDAR Survey & Mapping then signing off of specifications and construction profile.

Execution Process

Tender evaluation process, Review of Construction documents, inspections during construction, prior to energizing the line and a year after energizing.

How Projects are normally initiated in LES

Planning performs load flow studies and forecasting, of the entire network, projects are then initiated by planning to be carried out by LES. These projects can be results of:

- New loads
- Additional generating Capacity.
- Need to reduce transmission losses.
- Or refurbishment of existing system

The presentations given about each hut or subsection within this department gave me an insight as to how different disciplines are integrated to efficiently design transmission lines. I also got the opportunity to go to the tower testing facility based in Rosherville, the tower test planned couldn't take place because of the bolts used couldn't withstand the pulling force which was required, below are some pictures of the bended bolts.

Figure 12: Bended Bolts

2.6 Substation Engineering

Substation Engineering is responsible for the civil and electrical design of new substations as well as refurbishment or extensions of old ones. Projects are categorized into two groups, namely green field and brown field. Green field projects refer to brand new substations and brown field projects refer to projects on existing substations, whether its refurbishment or upgrading.

For every project initiated the one line drawing is the initial drawing, the one line diagram is a drawing that shows the electrical connection of the high voltage equipment (typically the busbars, feeders, transformers etc.) and it forms the basis of the single line diagram. A single line diagram is a diagram that shows the electrical connection of high voltage equipment and other equipment such as instrument transformers, earth switches and surge arrestors.

In this department I was also briefed about designing for contingency (N-1). The idea with designing for contingency is that should a line or maybe a transformer be out of service for whatever reason it should be possible to supply the entire load. I was also given a task to verify if the naming of the actual equipment on site corresponds with the naming used on the operating diagram (OD) for Boundary substation, while doing this task I was able to familiarise myself with the symbols used for representing the equipment on site (Transformers, busbars, CT's, VT's, etc.). Another task given was to read and familiarize myself with different isolators used in Eskom.

2.7 PTM&C

PTM&C (Protection, Telecommunication, Measurements and Control) is a department responsible for secondary plant technology management, engineering planning & project support, as well as applications within Eskom. The following figure shows the PTM&C structure.

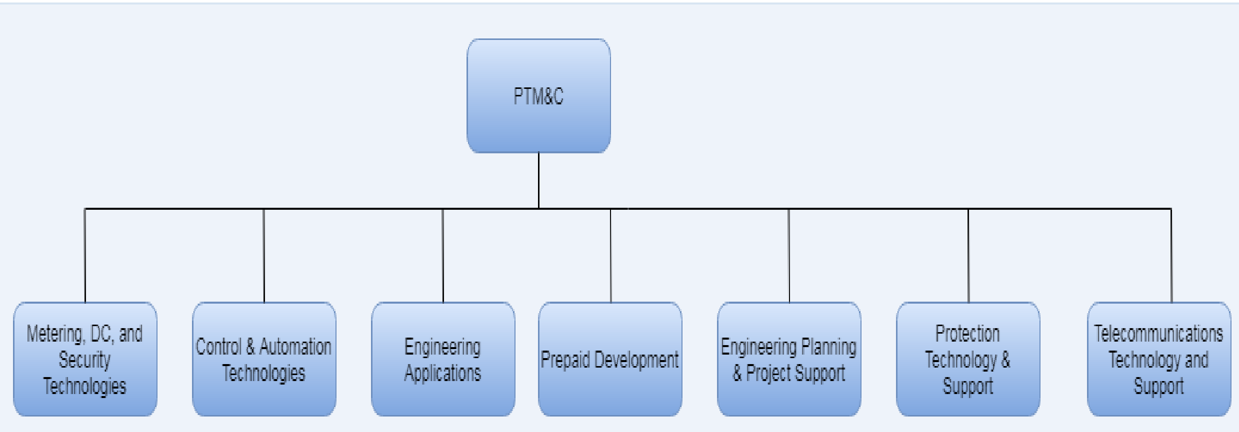


Figure 13: PTM&C Structure

2.7.1 Control and Automation Technology

Control and Automation Technologies, also known as CATs is a section within PTM&C that is responsible for researching and making recommendation of both software and hardware components needed for SCADA to benefit the business. Within this section I got to know about the different network architectures in place at ESKOM for both Tx and Dx, together with the respective communication protocols used for Tx and Dx, I also got to understand how SCADA is applied in ESKOM and its criticality in efficient operation of the business.

The following diagram shows the architecture of the Tx SCADA network. As can be seen from the figure the two communication protocols used in the Tx network are IEC 61850 and 101, 101 is from the gateway through the Telecommunications network to NCC and IEC 61850 is amongst the equipment within the control room. Different mediums for comms between equipment are employed, it could be plain copper from the protection panels via the IDF to the I/O cards through the station RTU to the FSP then to the gateway or it could be serially via RS232/RS485 or it could be fibre from the protection panels straight to the FSP then to the gateway, this depends on the protection scheme which is in use. Figure 12 below shows the Tx architecture

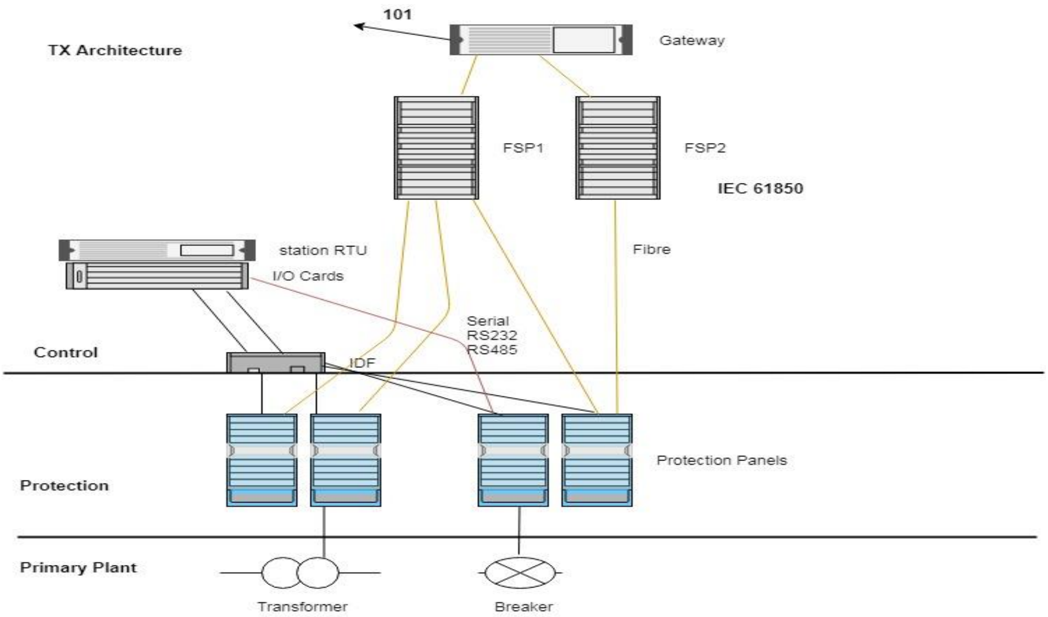


Figure 14:Tx Architecture

The following figure shows the Dx SCADA network architecture and this is slightly different from the previous architecture used by Tx. First difference to note is that there are no FSPs as in the case of the Tx architecture and another thing to note is that the communication protocol used amongst the equipment as well as out of the station to the RGCC is one and the same unlike that of Tx, and this protocol is called DNP3.

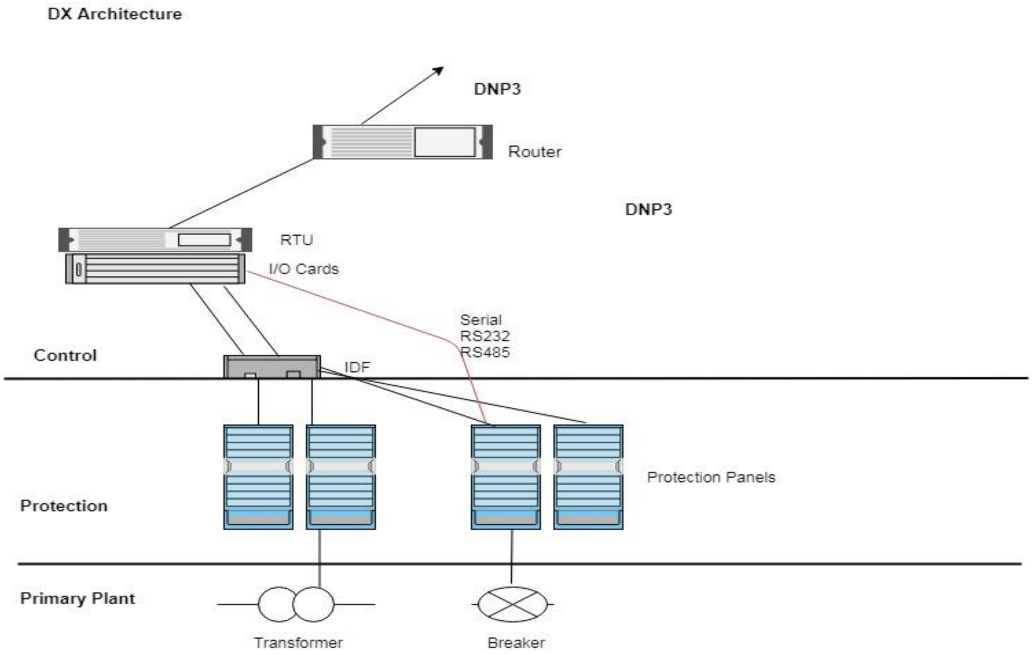


Figure 15: Dx Architecture

I was also briefed about the new Tx architecture which is a pilot project going on at Pinotage substation, with this new architecture there is more redundancy which improves reliability and it also incorporates the EADS (Engineering And Data Server Concentrator) which is a computer at site that gives access to all equipment in a substation remotely, this will make configuration of equipment remotely possible as well as collection of data from various equipment.

Excel Task

I was also given a Visual Basic Application task, this task required me to write VBA code to process an excel spreadsheet, with a GUI that a user can use to search and filter through the sheet and also be able to make plots. The following figure shows the results obtained from the written program.

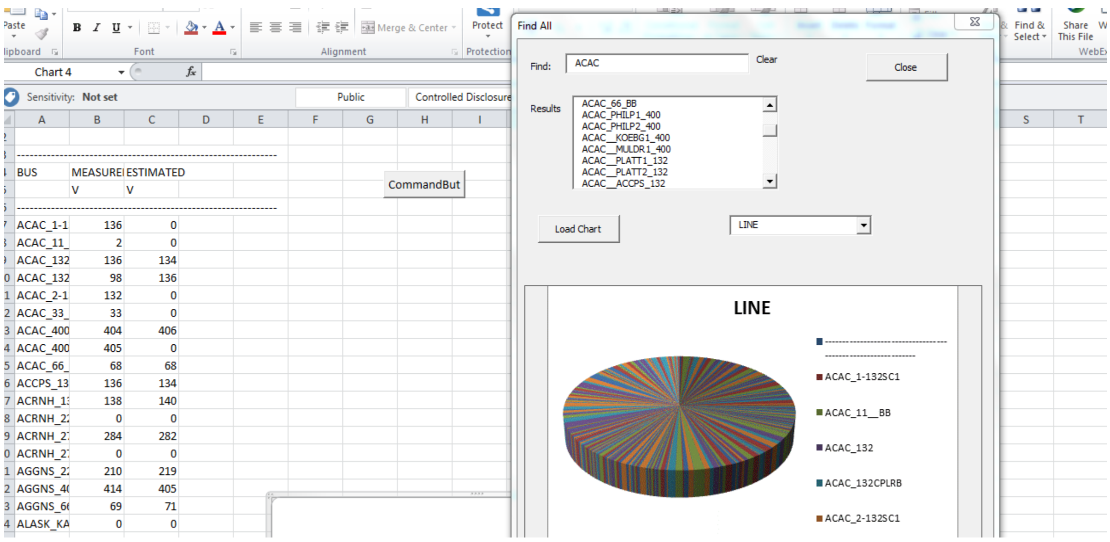


Figure 16: VBA Task results

1.7.2 Planning and Project Support

The Planning and Project Support section is responsible for providing PTM&C related project management functions to the business. Every engineering project that requires secondary plant design deliverables from PTM&C will be assigned to a project engineer within the Engineering Planning and Project support section.

Some of the things the project engineer is responsible include:

- Developing a concept design document detailing the PTM&C requirements (i.e. defining the PMT&C scope).
- Developing the secondary plant costing schedules.

In this department I got familiarised with how a Proforma is compiled as well as a Task schedule, these documents are available on request.

1.7.3 Protection

Protection refers to a system that constantly monitors the condition of the electrical plant to detect abnormal conditions and try to isolate them. The objectives of protection are as follows:

- Safeguard lives
- Protect the environment
- Protect equipment
- Optimise quality and reliability of supply
- Minimise lifecycle cost

I got briefed about current differential and impedance protection schemes, their operation and how they are normally applied in Eskom.

Impedance deals with zones of protection, with each zone covering a certain percentage of the line. This type of protection is normally employed for long lines (>30km). The zones of protection are as follows:

- Zone 1 - Forward, 80% of the line , instantaneous
- Zone 2 - Forward , 120% of the line, TD = 400msec
- Zone 3 - Forward, 150% of the line,
- Zone 4 – Reverse, 50 – 80% of the line, instantaneous

A typical setup of impedance protection is shown on the figure below

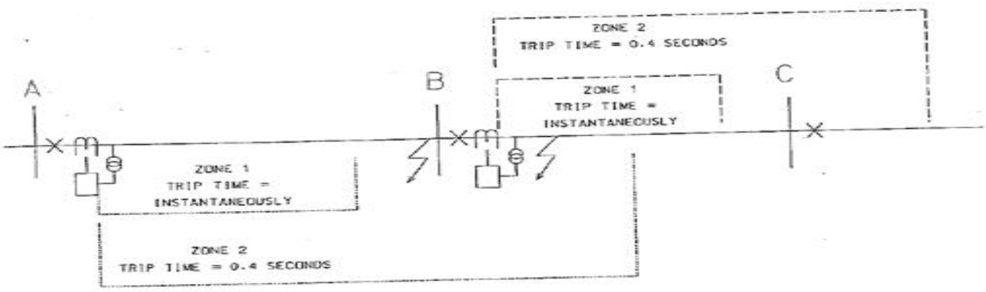


Figure 17: Impedance Protection setup

Current differential protection is normally used on shorter distances (<30km) because it's not economically feasible on longer distances. A typical application would be on a transformer unit protection where current going into and out of a transformer are compared and deviation would result in operation. The following figure shows a typical setup of current differential protection:

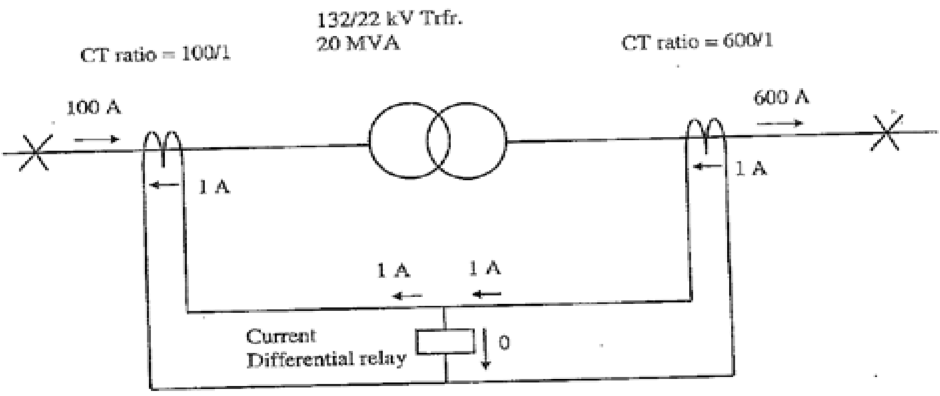


Figure 18: Current Differential Setup

1.8 Modelling Task

The CAISO has identified a phenomenon called the "Duck Curve" which refers to the shape of the load profiles as more renewable energy is integrated into the grid (see appendix C figure 26: Duck Curve). First part of the task was to take the hourly demand data, make a scatter plot using that data then model a polynomial function that would best describe the load profile of that data, the demand data used was not the actual Eskom data but rather that of CAISO, the idea was to have a model that would simply be "plug and play" should the demand data of Eskom be available. The following data shows the scatter plot of the data, a table of this data can be found in Appendix C.

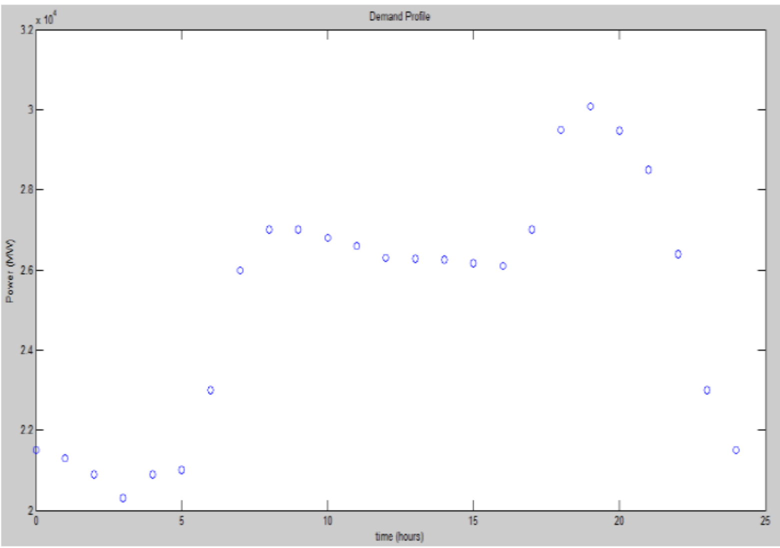


Figure 19: Scatter Plot of the Load profile

A number of high order polynomials were tested to see which one best fits the scatter plot above, figure 20 below shows some of the tested polynomials, eventually order 21 proved to be the best fitting polynomial, showed by figure 21 below.

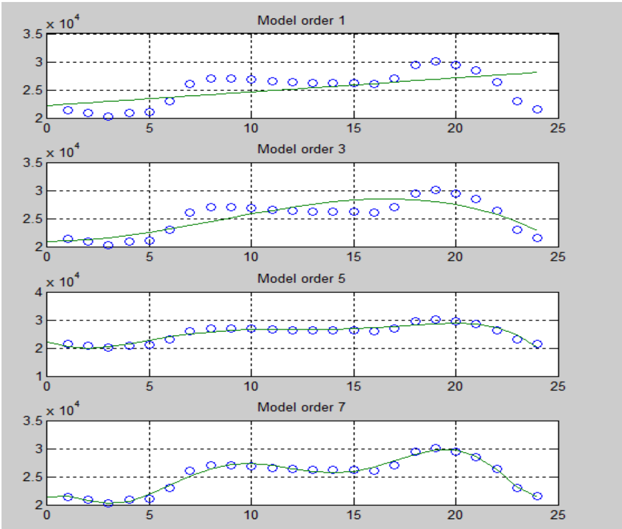


Figure 20: Polynomial approximations from order 1-7

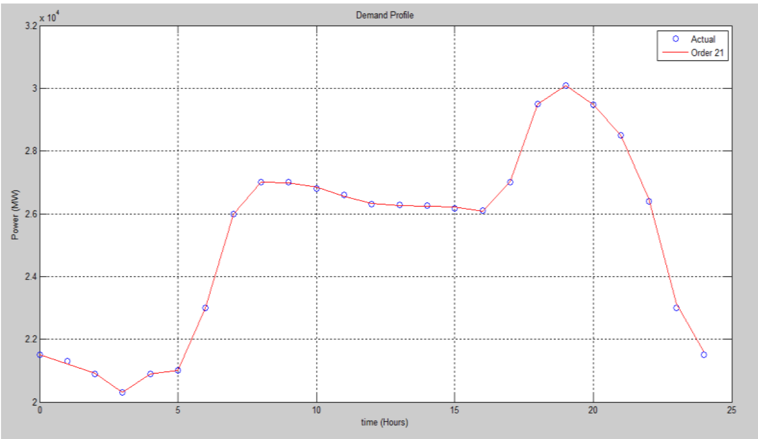


Figure 21: Order 21 Approximation

From the above figures it can be seen that order 21 was the best fit for the scatter plot, hence the one used to model the demand profile, this model was then used to generate a polynomial function in vector form using MATLAB the following figure shows the vector equation for this approximation.

```
fncn6 =

   1.0e+06 *

  Columns 1 through 9

    0.0000   -0.0000    0.0000   -0.0000    0.0000   -0.0000    0.0000   -0.0000    0.0000

  Columns 10 through 18

   -0.0000    0.0002   -0.0021    0.0151   -0.0844    0.3664   -1.2116    2.9654   -5.1434

  Columns 19 through 22

    5.9016   -3.9537    1.1464    0.0215
```

Figure 22: Order 21 Vector Equation

The second step of the task was to obtain the total area of the scatter plot as well as the total area of the approximation function; this would also help in verifying the accuracy of the chosen approximation function. The following figure shows the results of the area calculation, as it can be seen from the figure below the area of the actual profile is 607380MWhr and the polynomial estimate has an area of 607550MWhr.

```
>> trapz(time,demand)

ans =

      607380

>> trapz(time,model_order14)

ans =

   6.0755e+05
```

Figure 23: Area of actual and estimate profiles

The third step involved modelling renewable penetrations and then finding the residual energy between the two plots, according to CAISO the duck curve poses two problems which are over supply risk and short steep ramps, so it would be better if the energy could be stored and used in the evening when the demand is at its peak, so finding the residual would give an idea of how much energy can be stored. The following figure shows the normal demand profile and the one with renewable penetration on a stem plot.

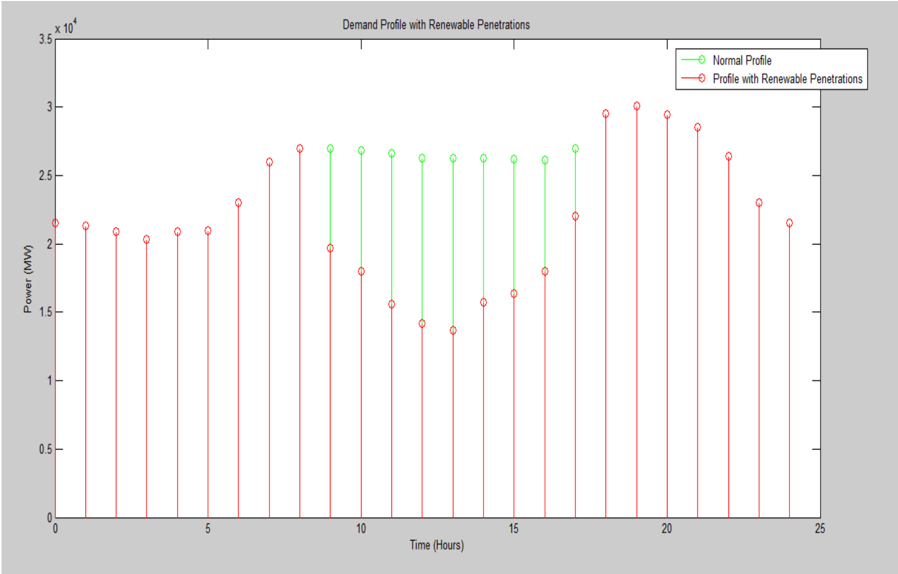


Figure 24: Actual Demand profile and the one with renewables

The residual was calculated by finding a functioned defined by the difference between the two functions on the figure above, and then using this function to find the area beneath it, the following results were obtained.

```
>> trapz(time,Residual)

ans =

   8.5071e+04
```

Figure 25: Residual between Normal demand profile and the profile with Renewables.

Additional Training Activities

Minor activities/courses completed:

Activity A

Online Course: **Transformer Fundamentals**

This course highlighted the basics of Power Transformers, I got to learn about the types of circuits a transformer has, the different vector groups and the two types of tap changers Power Transformers have and the importance of earthing.

Activity B

Sol Substation Site visit

I had the opportunity to go to Sol substation based in Secunda for a 132kv transformer investigation that has tripped on buchholz, a number of tests (SFRA, Moisture Assessment, etc.) were conducted and the transformer was declared serviceable but with further analysis of the results from the various tests performed it was then decided that internal inspection of the transformer had to be done to check if there is no damage internally and it was found that the other winding had been damaged and copper pieces were found all over inside the transformer. The transformer was then declared not serviceable and had to be scrapped.

Upcoming activities/courses:

- Basic Telecoms course
- Cyber Security course
- Spirent Network Test Center Training

2. Summary

This section summarizes each of the training activities in line with ECSA requirements and directly addresses the review questions posed by the review panel.

Extent of Training Activities

Broad issues covered during the program i.e. theoretical/ practical.

Table 3: Summary of training activities

THEORETICAL	
Department	**Description**
HV Plant	• An overview of some of the primary plant equipment. • Gained an understanding of where the department fits in. • Learnt about dielectric tests on shunt reactors.
GIS	• Learnt about where the department fits in. • Learnt about some of the different web applications developed GIS.
DBOUS	• Learnt about where the department fits in. • Learnt about maintenance standards and task manuals.
Integration	• Learnt about where the department fits in. • Learnt about the different approval stages for a project.
LES	• Learnt about the Line design process. • Where the department fits in. • Learnt about different components that make up an overhead powerline.

Substation Engineering	• Learnt about where the department fits in. • Learnt about the Single Line diagram and its symbols.
PTM&C	
Control & Automation	• Learnt about where the department fits in. • Learnt about the network architectures for both Dx and Tx as well as the new proposed architecture. • Learnt about the different communications protocols in Dx and Tx. • High level understanding of SCADA and its role within the organisation.
Planning and Support Engineering	• Learnt about where the department fits in. • Learnt about Proformas and task manuals.
Protection	• Learnt about where the department fits in and its importance. • An overview of the protections schemes used.
PRACTICAL	
Department	**Description**
HV Plant	• Went to PowerTech to witness the dielectric tests on a 400kV shunt reactor. • Developed and Compiled an Evaluation Criteria for an online moisture removal system for use on power transformers and reactors. • Modelling task using MATLAB to find a polynomial equation that best describes a load profile and also calculating residual energy between original profile and profile with renewable penetrations.
DBOUS	• Reviewing of a maintenance standard and Task Manual for Transformers to identify possible gaps. • Material Inspection at Rosherville RDC based on Small Power Distribution Units (Ready boards) to identify any defects and provide necessary recommendations.
Substation Engineering	• Verification of naming convention used on Operating Diagrams and on actual equipment.

Value Added During Training

<u>Value added to the Business:</u>

The objective of the training for the first six months is for the EIT to have a holistic view of the business, this was achieved by rotations within most of the departments that make up PDE and the time spent in each department varied from 1 to 10 weeks. Value added to the business was in means of small tasks given such:

- Compiling an Evaluation Criteria for an online moisture removal system for use on power transformers and reactors.
- Modelling task using MATLAB to find a polynomial equation that best describes a load profile and also calculating residual energy between original profile and profile with renewable penetrations.
- Verification of naming convention used on Operating Diagrams and on actual equipment.
- Reviewing of a maintenance standard and Task Manual for Transformers to identify possible gaps.
- Material Inspection at Rosherville RDC based on Small Power Distribution Units (Ready boards) to identify any defects and provide necessary recommendations.

Value Added to ME:

Throughout my training period I have gained:

- An overview of what primary plant and secondary plant is.
- An insight as to how the different departments that make up PDE fit together.
- An opportunity to improve my MATLAB programming skills.
- An overview of SCADA and its importance within Eskom.
- Understanding of basic protection principles within Eskom.
- Understanding of Dielectric tests on Shunt reactors.
- Understanding of the importance of safety within Eskom.

Awareness and Application of Work Related Standards

During my training I got exposed to some of the standards used throughout Eskom, and I some were mentioned in previous sections in this report. I've also seen how some are applied, e.g. the *SANS: 60076-3: 2014* standard was used in PowerTech during dielectric tests of a shunt reactor as discussed in section 2.1.

OHS Act

During my training I have realised Eskom's commitment in insuring safety of people and the environment. With all the site visits PPE is a must before entering the substation and risk assessments are normally carried out before any work can commence. Eskom has also developed lifesaving rules to incorporate the OHS Act in the daily work carried out by employees, these rules are as follows:

- Rule 1: Open, isolate, test, earth, bond, and/or insulate before touch.
- Rule 2: Hook up at heights.
- Rule 3: Buckle up.

- Rule 4: Be sober.
- Rule 5: Permit to work.

Leadership Opportunities and Networking Achieved

Since the training is rotational this really helped in networking because I got to meet different people within different sections of PDE, this would help in future projects that involve multiple disciplines. So far within the first six months of my training I have not assumed any leadership roles but I believe as the training progresses I will be in a position to take on leadership roles.

Pro-Activity and Innovation

I always went an extra mile in researching about concept and terms that I'm always exposed to within different departments, especially high voltage concepts. I applied innovation in my modelling task using MATLAB where I had to find a polynomial equation that would best describe a load profile as well as modelling the profiles with and without renewable energy penetration.

Highest Level of Responsibility

During my six months training my highest level of responsibilities were:

- Compiling an Evaluation Criteria for an online moisture removal system for use on power transformers and reactors.
- Material Inspection at Rosherville RDC based on Small Power Distribution Units (Ready boards) to identify any defects and provide necessary recommendations.
- Reviewing of a maintenance standard and Task Manual for Transformers to identify possible gaps.

Awareness of Professionalism

Professionalism refers to the manner in which one takes accountability for their actions and following rules and policies put in place by the organisation. I have also done the declaration of interest which has to be done by every employee, and I also adhere to the rules put in place by the organisation.

3. Conclusion

The past six months have given me an insight as to how projects are carried out within PDE and how each department fits in the value chain. The training presented me with networking opportunities and helped me familiarize myself with some of the Eskom processes and systems. I look forward to the next phase of my training programme which will entail more project that will aid me in broadening my skills and knowledge.

APPENDIX A – Evaluation Criterion for Onsite moisture removal system

Parameter	Item to consider	Criteria			Score
		0	-2	-10	
Pressure	>=100kPa	>=100kPa	90-99kPa	<90	
Flow Rate	<400 litres/hour	100-400 litres/hour	401-500 litres/hour	>500 litres/hour	
Moisture removal	1-3ppm @40°C @rated flow rate	>1ppm	0.5-1ppm	<0.5ppm	
Filter moisture capacity	>= 3litres	>=3 litres	2-3 litres	<2 litres	
Auto start and stop	Yes	Yes	-	No	
Filter size	<5 micron	Yes	-	No	
Moisture Content sensor accuracy level	>= 99	Yes	-	No	
Alarm and communication reliability/ availability	>=99	Yes	-	No	
LED daylight visibility	Visibility @ 30m	>=30m	20-30m	<20m	
File download	Remote and	Remote +	Remote/local	Non	

enabled	Local	local			
Working and Readable local display screen	Yes	Yes	-	No	
Waste oil	=<5 litres	=<5 litres	5-7 litres	>7 litres	
IP 56 rating	Yes	Yes	-	No	
Operating temperature	Range 0°C-110°C	Wider	-	Narrower	
Supplier Support	Availability within 24 hours	>90%	70-90%	<70%	
Maintenance intervals	Align with that of the transformer	=>10 years	6-10 years	<6 years	
Re-starting equipment following critical failure	Ease of re-starting equipment following critical failure	Simple	Difficult	Complex	
Minimum mean-time between equipment failure	In a period of 12 months	0	1-2	>2	
Replacement parts availability	Lead time	<2 weeks	2-8 weeks	>8 weeks	
DGA removal	DGA removal	<2 ppm	2-5 ppm	>5 ppm	
Filter	While	Yes	-	No	

replacement	transformer is in service				

APPENDIX B – Material Inspection Feedback Form.

(Click on the file to view)

Eskom	Standards Implementation Project / Warehouse/Material Inspection Feedback Form (controlled disclosure)	Unique Identifier	240-70831485
		Document Type	Form
		Revision	1
		Effective Date	1 Oct 2013
		Engineering	Page 1 of 3

Requestor Name:	Stephen Nkwane
Requestor Designation:	Manager Standard Implementation
Request Date:	14 May 2018
Requestor Contact No:	+27 12 421 4853

Inspection Type: (tick relevant box)					
Project Assessment:		**Warehouse Inspection:**		**Material Inspection:**	X

Scope of Work:	To inspect the Small Power Distribution Units (Ready Boards) for any defects and provide necessary recommendations.

Project Assessment:	
Project Name:	N/A
Project No.:	N/A
Project Type:	N/A
Zone:	N/A
CNC:	N/A
Contractor:	N/A
Clerk of Works:	N/A
Project Manager/Consultant:	N/A
Eskom Prog Manager:	N/A
Date:	N/A

Warehouse/Material Inspection:	
Site Name:	Rosherville RDC
Area:	JHB/Vaal
Site Manager:	Nomakhosi Chawe
Date:	17/05/2018

Compliance Notes (Add Photographs / Drawing / Annotations if required)	
Item No.	**Description**

APPENDIX C – Modelling Task.

Table 4: Hourly Demand Data

Time(Hours)	Demand(MW)
00:00	21500
01:00	21300
02:00	20900
03:00	20300
04:00	20900
05:00	21000
06:00	23000
07:00	26000
08:00	27000
09:00	27000
10:00	26800
11:00	26600
12:00	26300
13:00	26280
14:00	26260
15:00	26180
16:00	26100
17:00	27000
18:00	29500
19:00	30080
20:00	29480
21:00	28500
22:00	26400
23:00	23000
00:00	21500

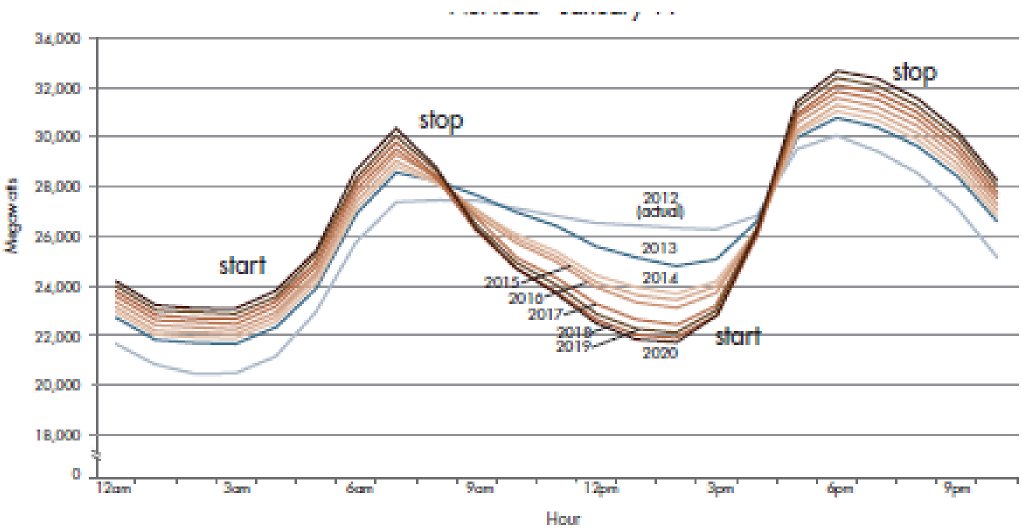


Figure 26: Duck Curve