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TRANS-AFRICA PROJECTS

CLIENT: *MOYENG ENERGY*

PROJECT: *RHEBOKSFONTEIN WIND ENERGY FACILITY*

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DESCRIPTION:

Electrical Integration Information

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TAP Project Number :
P1230-1383
Document Number :
P1230-1383-100-04-04-002-R

Rev	Description	Date
0	First Draft	18/05/11
1	Final	19/05/11

EXECUTIVE SUMMARY

Investec requested Trans-Africa Projects to prepare a Concept Network Integration Plan for the Rheboksfontein Wind Energy Facility (WEF) near Darling in the Western Cape, based on a new turbine layout.

The new layout caters for 48 turbines, each with a capacity of 2MW.

To collect and integrate the Rheboksfontein WEF generated power into the Eskom network, connection to the 132kV network is proposed.

The load flow studies show satisfactory results for voltages and line and cable thermal capacities. Fault levels on the network are also within limits for standard equipment at 33kV. Reactive power compensation is not needed for voltage control within the WEF network. The designed network allows for the transfer of at least halve the power under N-1 contingency between Eskom and the WEF. Installing redundancy on the network is unlikely to bring justifiable financial benefit.

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1 INTRODUCTION AND TERMS OF REFERENCE

In 2010 Trans-Africa Projects (TAP) did an integration study for Moyeng Energy PTY Ltd. The WEF was then proposed to have a total generating capacity of 170MW.

The EIA for this WEF was not approved and more information is needed.

The new facility is now planned to consist of 48 Turbines of 2MW each.

The work done therefore comprised of the following:

- Development of a conceptual network of the WEF integration. The network should connect the high voltage side of the turbine step-up transformers to the Eskom 132kV network.
- High level network studies to prove feasibility of the concept.

2 PHILOSOPHY USED FOR THE INTEGRATION STUDY

The Rheboksfontein site is located relatively close to two Eskom network voltage levels, i.e. 132kV (30-40 km) and 400kV (on site). The cost of 400kV transformation would be significantly more than integration at 132kV level at Dassenberg (Refer Suurplaat Integration Study of 2009). This 400kV option is therefore discarded for pre-feasibility study purposes because the total capacity of the WEF does not warrant a 400kV injection.

The site is situated on hilly terrain. This complicates the establishment of large substations. Furthermore many restricted zones exist, such as vineyards, wet areas and farm houses. The turbine locations are not contiguous, thus necessitating the use of more than one collection substation. On the positive side, the soil is fairly deep and sandy, thus enabling the laying of underground cables. These aspects will have a determinant impact on the location of the substations and the type of network to be developed to integrate the WEF.

Figure 1 - Rheboksfontein Site and Existing Eskom Network

In order to collect more site-relevant information, a pre-study site visit was conducted by the Consultant. The inspection confirmed the non-suitability of various options that could otherwise have been considered for the integration of the WEF, mainly due to the topographical nature of the area.

In order to reduce the number of options, an initial study was performed to determine the appropriate integration site/lines and voltage.

The integration at 132kV could be done basically as one of two options:

- Integrate at Dassenberg Substation
- Integrate at Aurora substation

Eskom preferred the integration of the WEF to be done at Dassenberg substation due to Eskom's network conditions. Therefore only this connection option is considered in this document.

It was furthermore assumed that the following environmental restrictions would apply:

- Only underground cable would be considered for the 33kV collection network
- The visibility of overhead lines and substations should be minimized
- All substations will be of tubular outdoor design to reduce visibility.

3 CREATING THE WEF CONCEPTUAL NETWORK MODEL

3.1 Collection Network Philosophy

The collection network concept is illustrated in Figure 2 and explained as follows:

- Each wind turbine is rated 2MVA, 33kV with fault current contribution of approximately five times its rated current (280 A) [1].
- The issue of network reliability was investigated. Due to the high cost involved in order to provide network redundancy, it was decided not to provide a dual network connection to each turbine. All collection network infrastructures are therefore radial.
- Wind turbines were grouped in five to eight units using cables over a short distance (<10 km). Therefore wind turbines in the same group were chosen to be in close proximity and/or in a line towards the nearest substation. The number was influenced by considering standard available cable and transformer sizes, in order to end up with a configuration that utilizes standard equipment.
- The cables will be routed close to the road infrastructure on the WEF.
- Each wind turbine group (WTG) had a main cable that connects the WTG to the transformation substation.
- There are a total of two 33kV/132kV transformation substations planned, thus reducing the size of each substation terrace and allowing any of the turbines to be relatively close to a substation.

The integration to the Eskom network must be achieved at 132kV level. Therefore transformation to 132kV is also required.

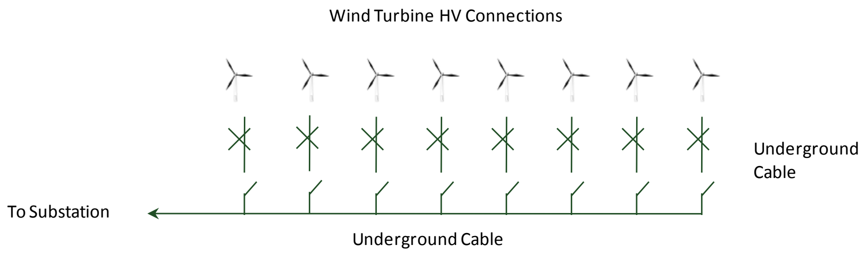

Figure 2- Group of 8 wind turbines and 33kV cable leading to transformation substation

3.2 Planning Criteria and connection to Eskom Network

The integration was analyzed using load flow and fault level studies. After an iterative process the wind turbine groupings, cable sizes, busbars arrangements and transformer ratings were chosen.

Rheboksfontein WEF needs to be linked by one line, which is approximately 45 km long, to Eskom network at the Dassenberg Substation 132kV busbar. Figure 3 indicates the proposed positions of the two 132/33kV substations. More detail is shown in Annexure A.

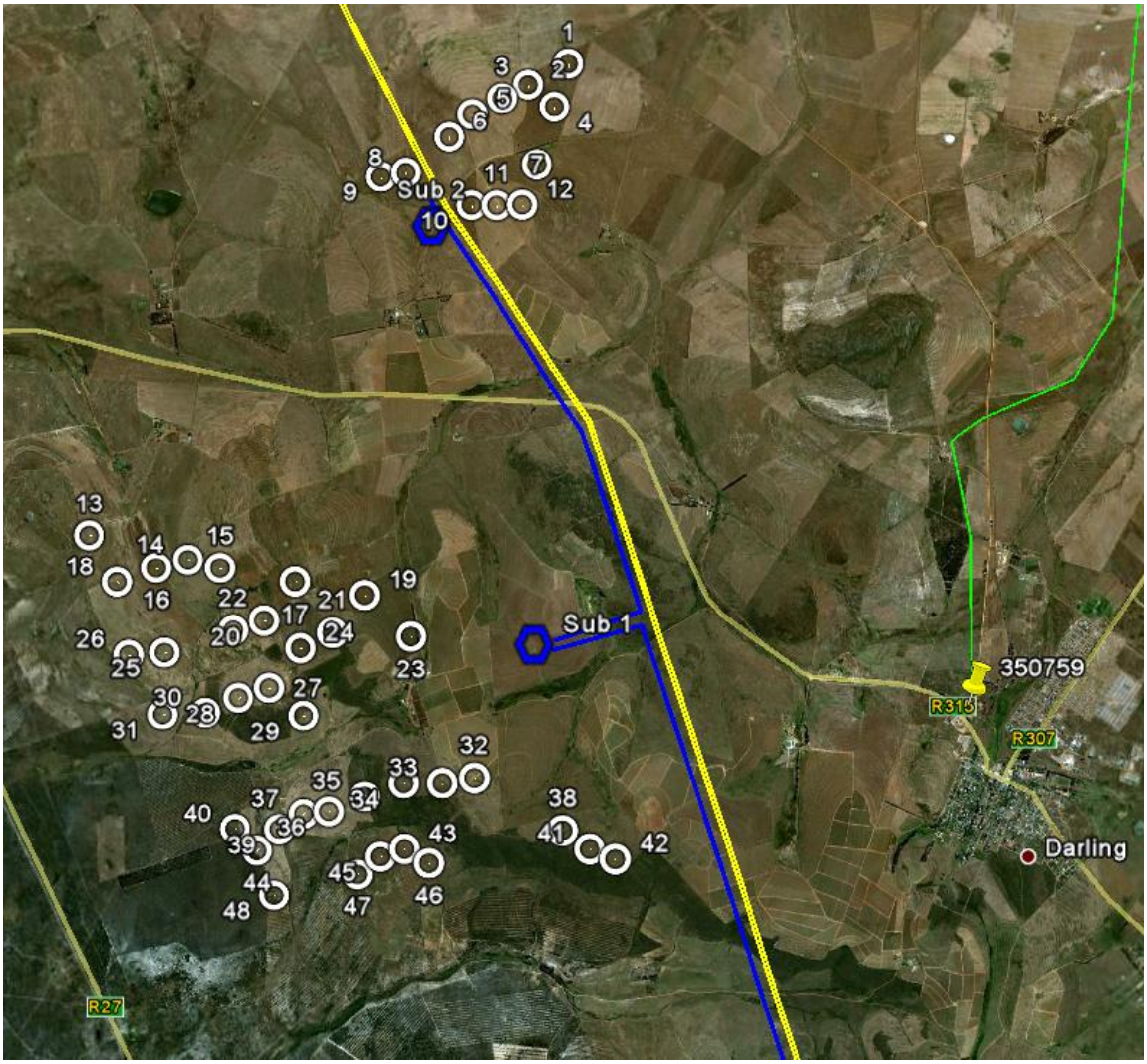

Figure 3 – Overall Layout and two Collection Substations

The use of Kingbird conductor on the 132kV circuits that connects the WEF to the Dassenberg Substation will enable up to 150MW to be transmitted on any of the circuits. A lighter conductor may therefore be considered, although this will increase the energy losses. The preliminary line route was chosen close to the existing 400kV lines and will need to be confirmed and negotiated with the various land owners after completion of the environmental impact assessment.

Substation 1 have been designed to allow up to two 40 MVA transformers, thus having each a total design capacity of 80MVA. The footprint size of this substation is estimated to be about 65×65m. Substation 2 will only have one 20MVA transformer, with an option to install a 2nd transformer later. The original footprint will be 40×30m, but if the second transformer is needed at a later stage the size will increase to 40×65m.

To better utilise transformers evenly, transformers of the substations are operated in parallel. They share common 33kV and 132kV busbars. The generation capacity at each collection substation is mainly a function of each turbine location. In turn the number of turbines connected to a collection substation defines the firm transformer capacity as shown in Annexure A.

The 132kV line capacity was not designed for N-1, thereby causing an outage for a circuit outage. However it is believed that 132kV lines would give adequate reliability to the WEF. In case N-1 redundancy is required, the number of circuits needs to be doubled.

4 CONCLUSIONS

The proposed Rheboksfontein WEF is planned for 96MW of installed capacity. The generated power needs to be transmitted and injected into the Eskom network at a 132kV voltage level at Dassenberg substation.

5 REFERENCES

1. KEMA Limited, The contribution to distribution network fault levels from the connection of distributed generation, British Department of Trade and Industry, 2005.

6 ANNEXURE A: SINGLE LINE DIAGRAMS AND TURBINES GROUPING

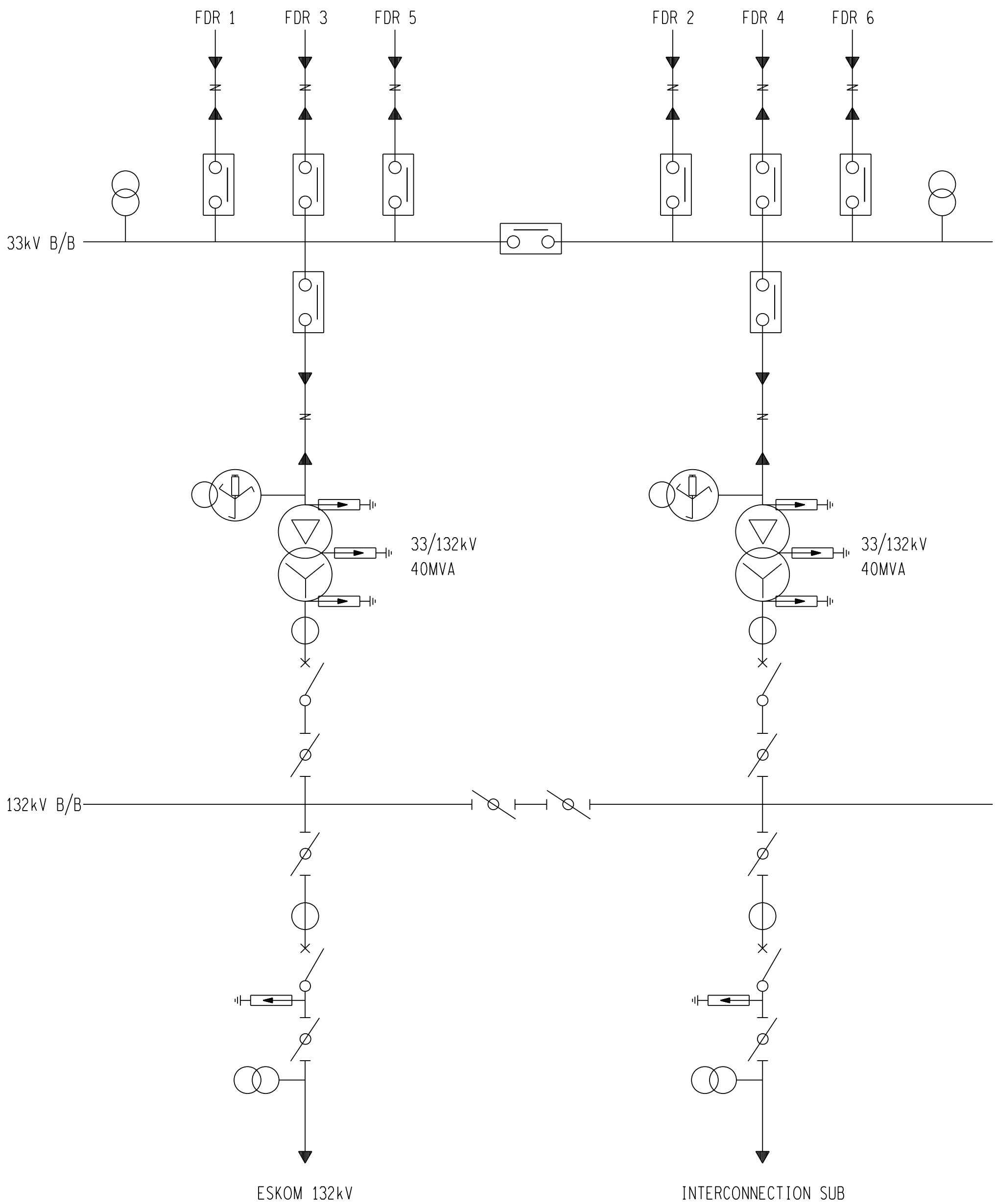

Figure 4 –Substation 1 Single Line Diagram

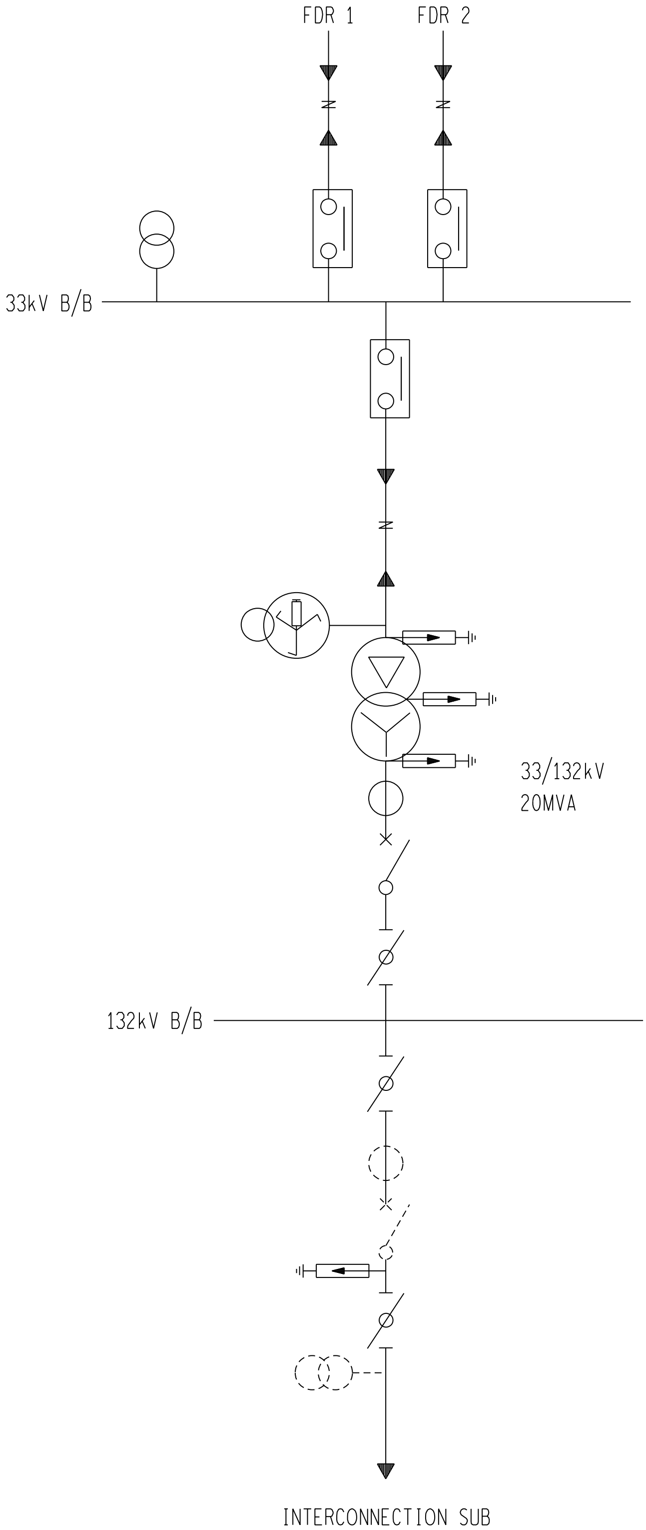

Figure 5 – Substation 2 Single Line Diagram

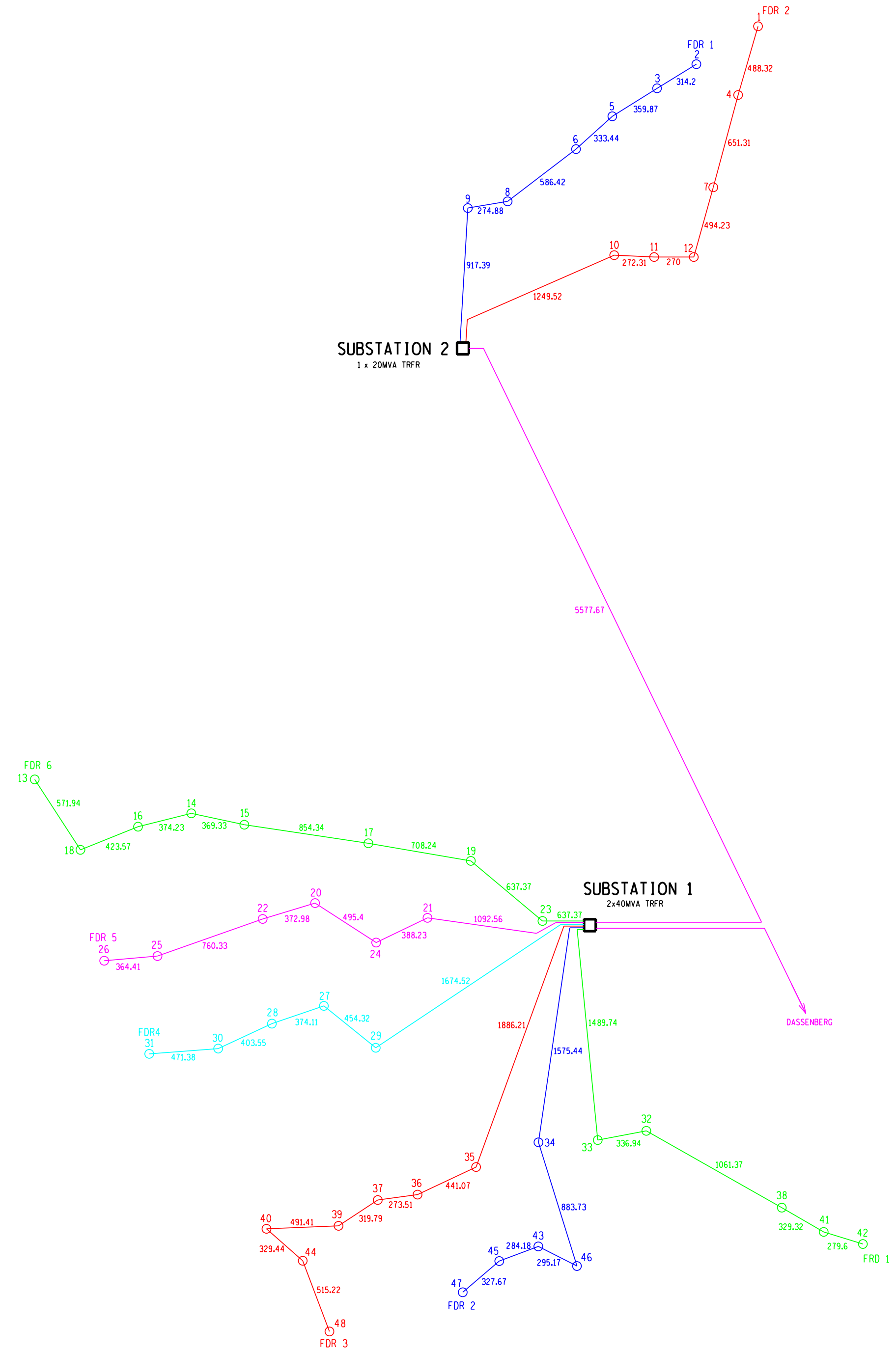

Figure 6 – Collection Network Schematic

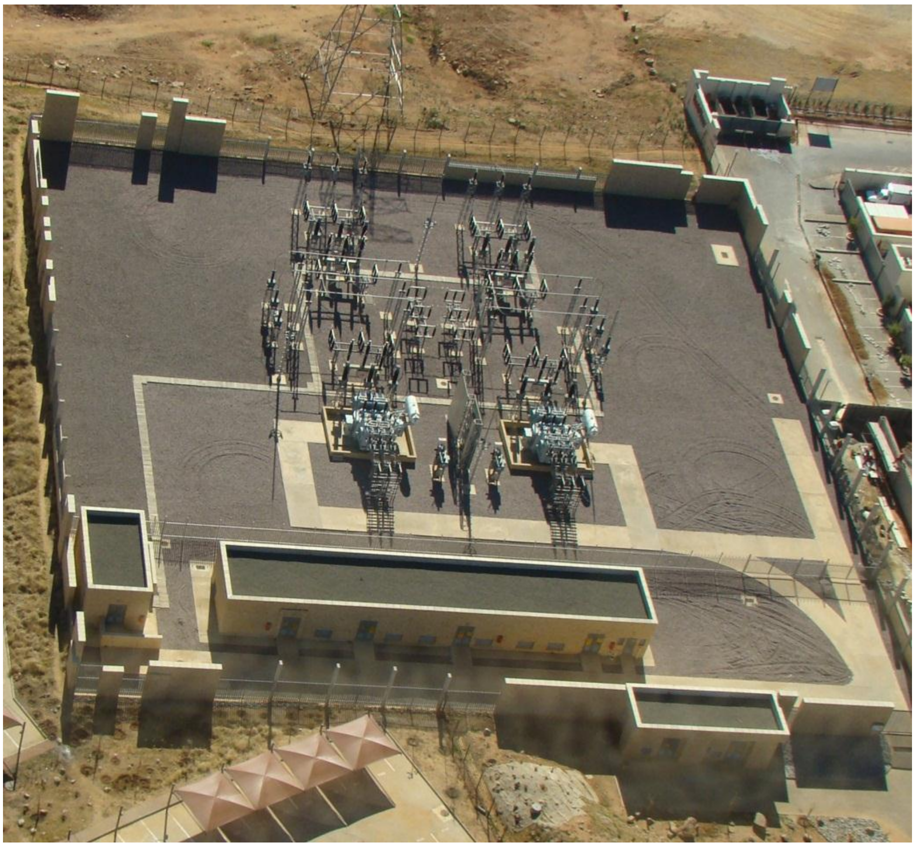

Figure 7 – Typical 132kV substation