BLACKWOOD 75 MW SOLAR ENERGY FACILITY

BLACKWOOD CONNECTION STUDIES

Prepared by Trans-Africa Projects (Pty) Ltd, an ISO 9001 and ISO 14001 registered company.

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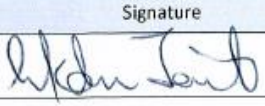
Chris Du Toit	Chief Engineer		Dec 2013

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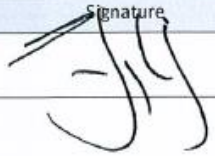
Jan Greyling	Manager: Renewable Energy		Dec 2013

Revision Control

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List of abbreviations and definition of terms

CSP	Concentrating Solar Power
GA	General Arrangement
GWh	Gigawatt-Hour
HV	High Voltage (44kV to 132kV)
kV	Kilo Volt (1 000 V)
LV	Low Voltage (<1000 V)
MTS	Major Transmission Substation
MV	Medium Voltage (1 to 33kV)
MVAR	Mega Volt-Amperes Reactive
MW	Mega Watt (1 000 000W)
NECRT	Neutral Earthing Compensator and Resistor Transformer
OHL	Over Head Line
Ra	Attractive Radius
SLD	Single Line Diagram
TAP	Trans Africa Projects
VAR	Volt-Ampere Reactive
VT	Voltage Transformer
SEF	Solar Energy Facility

1 INTRODUCTION

1.1 Background

VentuSA Energy has requested Trans-Africa Projects (TAP) to conduct network studies for the connection of a renewable energy facilities to the Eskom network. The site is called Blackwood and is loacated in the Kimberley area (Eskom's NC Operating Unit), approximately 20km from Boundary Substation (28°53'46.10"S, 24°56'14.64"E). The maximum generation capacity of the site is estimated at 75MW. The technology to be used for the Blackwood Energy facility is Solar (SEF).

Most of the network around this area (Kimberkey) is rated 132 kV and are supplied from Boundary MTS.

Figure 1: Geographical layout of existing network and SEF site

The purpose of this study is to simulate connections proposed by the Client. Simulations were carried out to assess the performance of the network before and after the connection of the energy facility to the Eskom network in order to determine compliance with South African Grid code and Eskom Transmission and Distribution network standards where applicable.

1.2 Study Methodology

The preferred connection points of the Blackwood SEF are as follow:

- A direct connection to the Boundary substation via a dedictated 132 kV line.
- A Loop in/out of the Kimberley DS / Skietpan switching station 132 kV line which crosses the western part of the site.

The general approach adopted in assessing the connection of the SEF with respect to the existing network is to analyse the network around the proposed connection point for various load conditions. Such load conditions are defined as off-peak and peak load. The two load scenarios are derived from the base load as obtained from the Eskom case file.

Depending on the renewable energy facility with respect to existing network, line contingencies were also analysed to determine technical requirements (if any), especially those related to VAR compensation and thermal loading of lines.

This site is treated individually and does not take into account the prospect of competitors' energy facilities in the vicinity. The results of loadflow studies are presented in the following sections.

The required VAR compensation for a SEF should be able to have the capacity to adjust the power factor within a range of ±0.90 as per the Distribution Standard for the interconnection of Embedded Generation.

1.3 Blackwood SEF Connection points

Boundary substation is equipped with two 250 MVA transformers, 2 × 275 kV incoming overhead lines (OHL) from Perseus MTS.

Two preferred connection points were looked at for this study, a direct connection to Boudary MTS and the loop in of the Kimperly DS – Skietpan line. The type of line used for the connection of the Blackwood 75 MW SEF is a 132 kV OHL with a Kingbird conductor.

Option	Connection Point	Voltage	Distance from SEF
BW1	Boundary	132 kV	20 km North
BW2	Kimberley DS / Skietpan switching station	132 kV	Crossing part of the site

2 BLACKWOOD SEF CONNECTION ANALYSIS AND RESULTS

2.1. Prior Connection of the 75 MW Blackwood SEF

Simulations of the existing network around the point of connection of the 75 MW SEF shows that there is no voltage or thermal loading issues in the network. During off peak (assumed 60% of the nominal) load conditions, the 132 kV busbars are well within the normal operating conditions.

2.2. Post Connection of the 75 MW Blackwood SEF

Connection 1 (BW1) and 2 (BW2) have similar results under normal operating conditions. The voltage remains within allowable limits. During off peak, there is a slight increase in voltage at the 132 kV busbars but these remain within 5% of the nominal voltage.

2.3. Contingency analysis

Prior to the connection of the SEF, the 2 × 250 MVA Boundary transformers and overhead lines from Boundary to Kimberley are loaded above 50% of their capacity and therefore do not comply with the N-1 reliability criteria.

The configuration of the 132 kV side of Boundary substation is such that the 2 × 250 MVA transformers are not paralleled. This configuration will therefore cause overloading issues on either transformer under contingency.

This contingency analysis is based on the loss of one of the two OHLs from Boundary substation supplying the Kimberley Zone.

N-1 considered prior connection of the SEF:

- During peak: No loadflow convergence.
- During off peak: Low voltages are recorded on all 132 kV B/Bs around the Kimberley area. The remaining Boundary – Kimberley OHL and transformer at Boundary are overloaded.

N-1 considered post connection of the SEF:

- During peak: both connection BW 1 and BW2 result in the transformer at Boundary as well as the remaining OHL to Kimberley to overload. BW1 is proven to be the worst because the loss of Boundary – Kimberley 132 kV OHL causes a voltage drop around the Kimberley area.
- During off peak: the loss of one Boundary-Kimberley 132 kV OHL results in overload of the remaining line and voltage drop around Kimberley for BW1. Connection 2 (BW2) results in overload of the 250 MVA transformer and the remaining Boundary – Kimberley line during off peak but no under voltage problems are recorded.

3 CONCLUSION

Both connection points studied seem theoretically adequate for the evacuation of 75 MW into the Eskom Network.

During peak and off peak periods, when the voltages are expected to respectively be at their lowest and highest values, the network around Boundary does not experience under-voltages or over-voltages.

To satisfy the N-1 Criterion, provision has to be made for a third 132 kV OHL between Boundary and Kimberley DS, a new 250 MVA transformer at Boundary and an arrangement to parallel the transformers at Boundary.

The network simulation indicates that no VAR compensation is required for the connection of Blackwood 75 MW SEF to maintain grid compliance during peak or off peak load.