Eskom

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NUCLEAR 1

COMPARISON BETWEEN THYSPUNT, BANTAMSKLIP AND KOEBERG SITES

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1 INTRODUCTION

This report serves two related but distinct purposes, namely: (i) to provide context for the required local generation in the Cape, and (ii) to assess of the best location of the Nuclear 1 power plant between three sites, which are Thyspunt (near Jeffreysbay), Bantamsklip (near Pearly Beach) and Koeberg (in Duinefontein). The possible sites for the Nuclear 1 plant are shown in Figure 1. It must be understood that this report does not encapsulate Eskom's rationale for investigating nuclear power among other technologies, nor does it give the background regarding the identification of the sites currently being investigated.

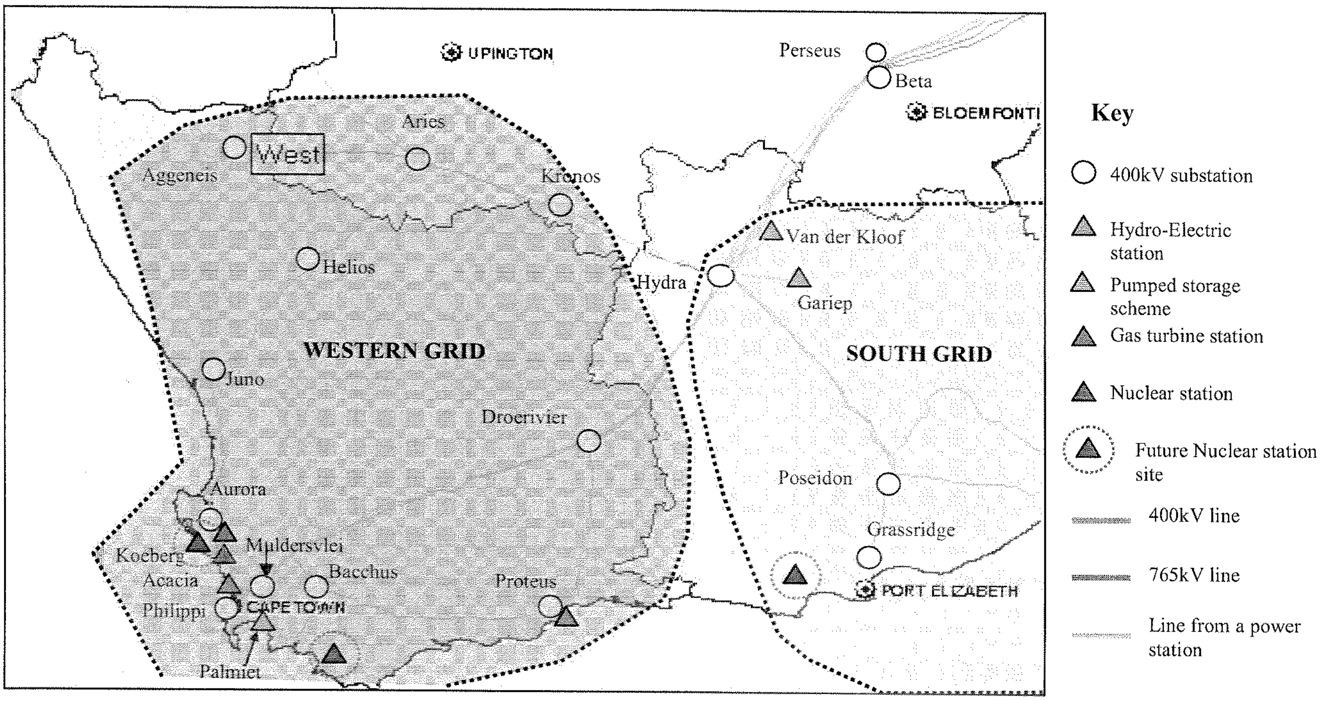

Figure 1: Locality map for the three possible nuclear sites

2 BACKGROUND

Eskom is conducting a feasibility study of new conventional nuclear generation in the greater Cape region, with potential sites at Thyspunt (near Jeffreys's bay), Koeberg (Duynefontein) and Bantamsklip (near Pelly Beach). The first phase of the conventional nuclear project is called "Nuclear 1" and is planned to be fully commissioned by 2017. The Thyspunt site is roughly 110km from Port Elizabeth. Grassridge and Dedisa are the nearest Transmission substations. The substations nearest to Bantamsklip are Palmiet, Bacchus and Proteus and they are respectively 76km, 100km, 220km from the said power station. The Koeberg site is very near the existing Koeberg power station.

The initial stage of the Nuclear 1 project will consist of either 2x1600MW machines or 3x1117MW machines. It is not clear (at this stage) how additional nuclear plants will be rolled out in the medium to Long-term. However, it is understood that the intension of Eskom and that of Government to diversify the fuel options may result in the number of Nuclear Power Plants reaching a total capacity of 20GW in the next 20-40 years, located at various sites.

3 THE VALUE OF LOCALIZED GENERATION

The current model for electricity generation in South Africa is dominated by centralized power plants in the Highveld near the coal-fields. One nuclear plant is located in the Cape Peninsula and supplies only 5% of the current demand for electrical power in the country. Hydro and pumped storage schemes are installed in the Cape and KwaZulu Natal and they supply 5% of the country's power demand. Open Cycle Gas Turbine (OCGT) plants are installed in the Cape for use primarily during peak demand periods. The installed capacity can supply roughly 6% of the current demand. However, due to the high running cost OCGT's are not economical for base-load supply.

From the above outline, it is can be shown that coal-fired plant in the Highveld supply in the range of 95% (low demand period) to 85% (peak period) of the country's demand. For the Cape, 55% of the region's power requirements are supplied through the transmission network, except on occasions when the OCGT plant is dispatched concurrently with the regional peak. Due to the shortage of "base-load" generation in the Cape, an extensive transmission system is required to cater for the future power requirements of the region. A long transmission network has the following inherent weaknesses:

3.1 High technical losses

The current system losses in the Cape network amount to roughly 400MW. This amount of power is approximately 80% of the total peak demand of the East-London area. While it is physically impossible to eliminate technical system losses, the design of the power system in the country must be such that it keeps these losses to a minimum. The development of a new base-load power station in the greater Cape region would contribute to the reduction of technical losses, leading to a more efficient power system. The present value of the savings in system losses associated with the proposed nuclear plant in the Cape is of the order of R4 Billion rand [TSP Report 08/42].

3.2 *Significant environmental impact due to technical losses*

The technical losses mentioned above are fed by coal fired power stations which emit greenhouse gases such as $C0_2$. With global warming on the increase, governments and power supply enterprises worldwide are seeking alternative methods of generating electricity to minimize further environmental damage in future. As previously mentioned, additional base-load generation in the Cape would lead to reduced technical losses, and hence, less CO_2 emissions.

3.3 *Significant environmental impact due to servitude requirements*

Transmission lines supplying the Cape Town span a distance of about 1400km. One 765kV line requires servitude of 80m in width. This means that one line takes up roughly 11,200 hectares of land. If the local base-load power station is not built, one additional 765kV line would be required around 2017. In contrast, a local power station in the Cape Peninsula area (i.e. using the Koeberg option) would result is transmission servitude requirements of roughly 1,100 hectare (i.e. only 10% of the land requirement for a comparable transmission line). The servitude requirements increase with the number of transmission lines required to service a remote area.

3.4 *Quality of supply challenges*

Due to long transmission lines, remotes areas are prone to problems such as voltage instability and harmonics. While engineering solutions to such problems exist, the system becomes vulnerable during times of outages of certain equipment. In some cases the solution entails increased redundancy on the transmission lines, which in turn leads to environmental impact mentioned above.

The expected increase in industrial load in the Port Elizabeth coast would result in increase in quality of supply and network security requirements of coastal supplies, which can be met best with coastal base-load generation.

Centralized generation has the following inherent weaknesses:

3.5 Limited Islanding Ability

During significant system disturbances it is sometimes desirable to "island" a part of the network from the remainder of the system. Islanding allows a part of the network to remain stable and able to supply the local load while other parts of the network are being restored. Centralized generation puts all or large parts of the network at risk as there is no ability to isolated localised networks with their own generation. Centralized systems are more vulnerable to a "black-out" situation. In the case of a blackout, restoration time is longer for networks that don't have significant local generation.

4 COMPARISON OF THE THREE CAPE SITES

4.1 Key Assumptions and considerations for this study

The following key assumptions were used:

- The 2009-2018 TDP was used as a reference
- Nuclear 1 phase focuses on Thyspunt, Bantamsklip & Koeberg
- Approved and planned Transmission projects on the main Cape corridor will be in place by 2015 (See Appendix A)
- Major step-loads in Port Elizabeth (Smelter, IDZ, etc) will have materialized by 2017
- No EIA fatal-flaws exist on any of the sites & associated corridors
- No major "step-load" increases in the Western Cape. Load growth based on "natural growth".

The following key considerations were used in the assessment:

- o A view to attain a long-term energy balance for each region
- o Integration/corridor requirements (Infrastructure, EIA & Land Acquisition, Cost, Implementation time-frames)
- o Technical performance based on Steady State and Transient stability studies
- o Consideration of future generation prospects (e.g. OCGT conversion, Renewable Generation Sources, etc)
- o Quality of supply and Network Islanding impacts

4.2 Load Forecast

Table 1 shows the load forecast for both the Eastern Cape and the Western Cape. It is to be noted that major step loads are expected in the Eastern Cape in the medium- to long-term Table 1 indicates growth figures assumed for the greater Cape area and Figure 2 presents the same in pictorial format.

Table 1: Load forecast for the Western and Eastern Cape provinces

Area Description	2007	2008	2010	2012	2014	2017	2020	2025	2027
Southern Grid (PE) (12% average)	943	1035	1116	1820	2377	4144	4565	4734	4950
Western Grid (3% average)	4122	4220	4421	4625	4831	5250	5605	5934	6280

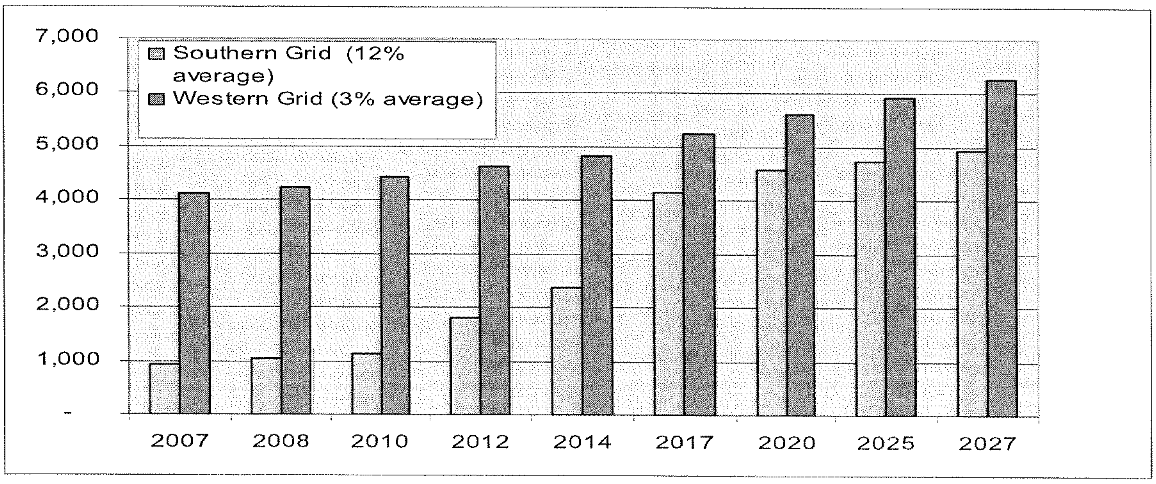

Figure 2: Graphical View: Load Forecast (Western and Eastern Cape)

The forecast for the Western Grid is based on assumption of constant growth of the existing load plus some new development in certain areas. Growth in this region is of the order of 3% per year. Growth for the Southern Grid, however, is based on knowledge of the possible developments. Major step load increases are expected mainly within the Port Elizabeth area and the Southern grid is expected to grow by an average 12% per year overall over the next 10-20years.

4.3 Deployment Pattern of Installed Generation in the Cape (2017)

The following Cape generation capacity was considered:

- Koeberg (2x900MW)
- Palmiet (2x200MW)
- Ankerlig (9x150MW), with four machines capable of SCO and
- Gourikwa (5x150MW), with three machines capable of SCO
- Port Rex (3x57MW) and Acacia (3x57MW), with all machines capable of SCO
- Total installed capacity: 4300MW (Western Cape) and 171MW (Eastern Cape)

For the purposes of this study it was assumed that the Highveld power pool was capable of supplying the imports required by the Cape grids. The Orange River Hydro Generation was excluded in this comparison as it is common to both the Western and the Eastern Cape.

4.4 Comparison between Western Grid and Southern Grid

The two sites are located in the Western and Eastern Cape. Two Koeberg machines are available in the Western Cape and no base-load generation in the Eastern Cape. This section provides a comparison between the two provinces to identify a preferred location of Nuclear 1. The comparison is done on the basis of the following key factors: Generation/Load balance, Quality of Supply and Security of Supply.

4.4.1 System Adequacy, Security and Quality of Supply for the two regions

	Western Cape	Eastern cape
"Generation versus Load Balance" and System Adequacy	• Substantial generation Capacity already installed • 80% of Western Cape load can be supplied from local generation (during peak generation) • Nuclear 1 results in excess generation capacity (during peak generation)	• Existing OCGT in East London supplies only 4% of the Eastern Cape load. • Nuclear 1 plant supplies 70-75% of the Port Elizabeth load in 2017 (2x1600MW units)
Quality of supply Impact	• Limited improvement in QoS would be realized (as are fault-level	• Improved QoS – i.e. Better mitigation of harmonics distortion

	already high)	and voltage dips.
Security of supply	• Islanding capability already exists	• Islanding capability would be introduced in the network
Overall	➢ **Not preferred**	➢ **Preferred**

4.4.2 Transmission Integration considerations

Table 6 summarizes a transmission network point of view regarding the integration requirements and their influence on the suitability of each site at the Nuclear 1 phase of the rollout of the nuclear programme.

Table 6: Evaluation of the sites (Transmission Integration perspective)

Factor	Thyspunt Site	Bantamsklip Site	Koeberg Site
Line length required	500km of 400kV lines	990km (400kV and 765kV combined)	190km (400kV line combined with Cable)
Infrastructure Cost (R' Billion)	5.3	12.72	5.1
EIA and Servitude difficulty	Medium	High due to extensive 765kV network	Medium (but high between Acacia and Philippi)
Implementation time-frame	Achievable	Achievable (with difficulty due to long network required)	Achievable
System Transient Performance	Good (400kV network)	Good (with extensive 765kV infrastructure)	Good (with 400kV)
Impact on Grid Transfer Capacity	Defers 3rd Gamma-Grassridge 765kV line indefinitely	Defers 3rd Gamma-Omega 765kV line indefinitely	Defers 3rd Gamma-Omega 765kV line indefinitely
Overall	**Preferred option**	**Least preferred (due to extensive infrastructure)**	**2nd Best option**

4.4.3 Future Generation Possibilities

Generation Option Considered	**Western Cape**	**Eastern Cape**
Combined Cycle Gas Turbines	Kudu CCGT (~600MW)and/or OCGT conversion is a future possibility (1100MW)	Coega CCGT is a future possibility (1600MW)
Renewable Energy	Wind energy is being investigated in the Western Cape (2000MW)	No wind energy being considered for Eastern Cape (100MW)
Pumped Storage Schemes	Various sites possible (1600MW)	Eastern Cape (Mthatha area). 0MW in the PE area
Hydro Schemes	Grand Inga project may bring about 3000MW into SA from the DRC, with 1500MW being injected in the Cape Peninsula via HVDC link	No Hydro scheme being considered for Eastern Cape
Aggregate potential local "injection"	6200MW	R1700MW (excluding Port Rex which does not support PE load)
Potential end-state of "local" generation + HVDC "virtual power station"	10500MW (excluding Nuclear 1) = 167% of future load of 6300MW	1700MW (excluding Nuclear 1 and Port Rex) = 34% of Future Port Elizabeth load
Over-all future potential	**Good potential for future local generation**	**Limited potential for future local generation**

5 CONCLUSION

- A broad system perspective has been given to show the limitations of centralized generation and importance of "dispersed" generation in the country. The benefits of dispersed generation include the following:
  - Reduced system losses;
  - Reduced environmental impacts due to reduced carbon emissions (reduced technical losses).
  - Reduced environmental impacts due to transmission servitude requirements
  - Improvement in quality of supply in the remote load centres
  - Improved islanding ability and restoration times for the local areas.

- From a regional perspective, three broad areas have been considered in the analysis of the best location of the Nuclear 1 power plant within the greater Cape area. These are:

- System Reliability and Quality of Supply;
- Integration considerations, and
- Future potential of generation in each of the two provinces.

- The Eastern Cape (Port Elizabeth in particular) would experience substantial improvement in system adequacy and supply security due to a better "generation-to-load balance" in the local area, as it has no base-load generation.

- Transmission integration into the Port Elizabeth area is less complex as it requires 400kV transmission infrastructure compared to Bantamsklip which required extensive 765kV infrastructure.
- The is a vast potential for future generation or power injection into the Western Cape, in contrast to limited potential in the Port Elizabeth area.

6 RECOMMENDATION

- From a strategic point of view, it is recommended to install the Nuclear 1 plant in the Eastern Cape (Thyspunt). The Western Cape is already a stronger transmission network and also has various generation possibilities for the future.

- The Western Cape should be considered in future phases of the nuclear programme, provided a minimum of three machines have been installed in the Thyspunt site.

- The Koeberg site is ranked 2nd after Thyspunt for the Nuclear 1 phase.

APPENDIX A: CAPE EXPANSION PLAN (2009-2018)