SECTION 10 : TRANSMISSION SYSTEM

10.1 INTRODUCTION AND ASSUMPTIONS

Three different sites on the Okavango River in the vicinity of Divundu have been identified for the possible construction of the Popa Falls Hydro Power Plant. The various sites will have different options for different weir heights. This will result in different power operation capacities. For the purpose of this study, it was assumed that the generation capacity would be 24 MW maximum. The turbine configuration would be 9 x 3 = 27 Hydromatrix turbines (installed in groups of 3 per gate (= one Module). The generation voltage is assumed to be 3,3 kV and the transmission voltage to be 132 kV.

10.2 THE POWER TRANSMISSION SYSTEM

For each site the power transmission system will consist of the following elements:

- 3,3 kV cables from the generator control panels to 3 step-up transformers. These will each be sourced in 3,3 circuit breaker panels sized for 15 MVA i.e. 263 A. These would incorporate all transformer protection as over current / earth fault, temperature, Buchholtz and differential protection. Additional items such as VT's and metering with summation must also be included in these panels.
- Two 30 MVA 3,3 kV to 132 kV transformer with automatic tap changers.
- Two 132 kV transformer bays with CT's to allow for over current / earth fault, differential and bus zone protection.
- 132 kV double configuration overhead bus bar.
- Space for 4 x and one equipped 132 kV line feeder bays with CT's to allow for over current / earth fault and distance protection
- Space for 2 reactors each 7 MVAr.
- One 200 km 132 kV line to Rundu with a 132 kV line feeder bay in the Rundu supply substation.
- The Popa Falls 132 kV equipment would be installed on a 170 x 170 m large switchyard situated as close as possible to the power station.
- This would be equipped with security fencing, foundations, trenching, surfacing and stoning as well as an earth mat to the required specifications.
- A control building would be required to house 3,3 kV equipment as well as 132 kV switch gear controls and transformer control panels.
- Auxiliary supplies would be required. First a 400 volt 3 phase supply via a 3,3 kV / 400 V tertiary winding (this must be sufficient to drive all local operations including cranes, lighting, chargers and tools etc).

- Secondly a 110 volt battery supply sufficiently sized to supply all protection, metering, controls and emergency lighting.
- The whole system must interface into the NamPower SCADA system. This can be achieved by a fibre optic interface and a fibre optic cable contained in the overhead earth wire.

10.3 SWITCH YARD

Each of the three preferred weir sites were investigated to establish the best location for the switchyard. An area of approximately 170 m x 170 m is required for each switchyard. The switch yard must be as close as possible to the end of the weir embankment to avoid unnecessary cable lengths as these are expensive and result in losses. The sites for the switchyards must be as flat as possible and should not interfere with existing infrastructure.

The sites selected have a very even topography. These selected sites are relatively flat with only a few rock outcrops which can be avoided to a large extent.

The position of these switchyards were selected on the right bank of the Okavango River. because the existing 32 kV power line and district road D3402 is located on this side of the river. A switch yard in this position will therefore facilitate an easy connection to the transmission line to Rundu.

In the selection of the switchyard sites, care was taken that existing infrastructure and rural settlements were avoided. This proved to be no problem as the sites were not located in densely populated areas.

10.4 ESTIMATED SWITCHYARD COSTS

Based on the 170 m x 170 m size and a 6 bay 132 kV configuration, the cost for the civil works for the switchyard are estimated to amount to the following:

Area Preparation:	28 900 m²	N$ 433 600,00
Fencing including gates:	850 m	N$ 127 500,00
Covered trenches:	480 m	N$ 57 600,00
Foundations:		N$ 420 000,00
Building:	120 m²	N$ 360 000.00
Stone Yard:	10 000 m²	N$ 500 000,00
Earth mat:	2 000 m	N$ 120 000,00
Auxiliary power and lighting:		N$ 380 000,00
Lighting masts:	(3 x 25 m)	N$ 150 000,00
Sub Total		N$ 2 528 500,00
15% VAT		N$ 379 290,00
Sub Total		N$ 2 907 890,00
Contingencies:		N$ 100 000,00
Total		N$ 3 003 890,00

10.5 TRANSMISSION EQUIPMENT

As outlined above, transmission equipment starting from the 3,3 kV generator supply to the Rundu 132 kV supply feeder has been included in the costing of this project. All this equipment has been accounted for in the cost calculations for the hydro power systems.

10.6 TRANSMISSION LINE

There is at present a 66 kV transmission system in place from Rundu to NamPower’s Mahango Substation near Divundu. However, this system is insufficient for the envisaged 24 MW to be transmitted.

Therefore a transmission line from Popa Falls to Rundu is to be provided. This line, which will have a length of approximately 200 km, and is to be operated at 132 kV, is estimated to cost N$ 45.0 Mil. This forms a large cost component in the project. It is however debatable whether this line should be seen as an integral part of the Popa Falls Hydro Power Scheme. As it is the aim that the Caprivi will be tied into the Namibia transmission grid, the line between Rundu and Popa Falls must also be seen as a future pure transmission link into the Caprivi Region. At present, however, this line would have the sole purpose of connecting the Popa Falls hydro power plant to the Namibian grid.

In reality the future costs of the transmission line would have to be discounted to the net present value. This value should be credited to the costs of the Popa Fall Hydro Scheme.

10.7 TRANSMISSION LOSSES

The Namibia Transmission Grid is supplied from two main sources. One being the ESKOM grid via the interconnector from the south and the other being the Ruacana hydropower scheme grid coming from the north west of Namibia. To supply power to the north and eastern regions, long transmission lines are required which entail a high degree of electrical transmission losses.

Since the Popa Falls Hydro Power Scheme is situated in the north east of Namibia, it is ideally placed to reduce transmission losses. This is, however, dependent on the ratio of supply between ESKOM and Ruacana. **Table 10-1** shows the losses that can be saved with the introduction of the Popa Falls Hydro Power Scheme as it varies with the power generation at Ruacana.

Table 10-1 gives the results of the simulation and weighted system losses in MWh.

Table 10-1 : Transmission Loss Savings with Popa Falls Hydro Plant

		Ruacana Power Output and Operating Hours per Annum					**Total [MWh]**
Power Output [MW]		0	60	120	180	240	
Operating Time [hours]		296	2264	1910	2284	2006	8760
Popa Falls	0	26.3	18.1	14.1	13.8	16.8	76446.0

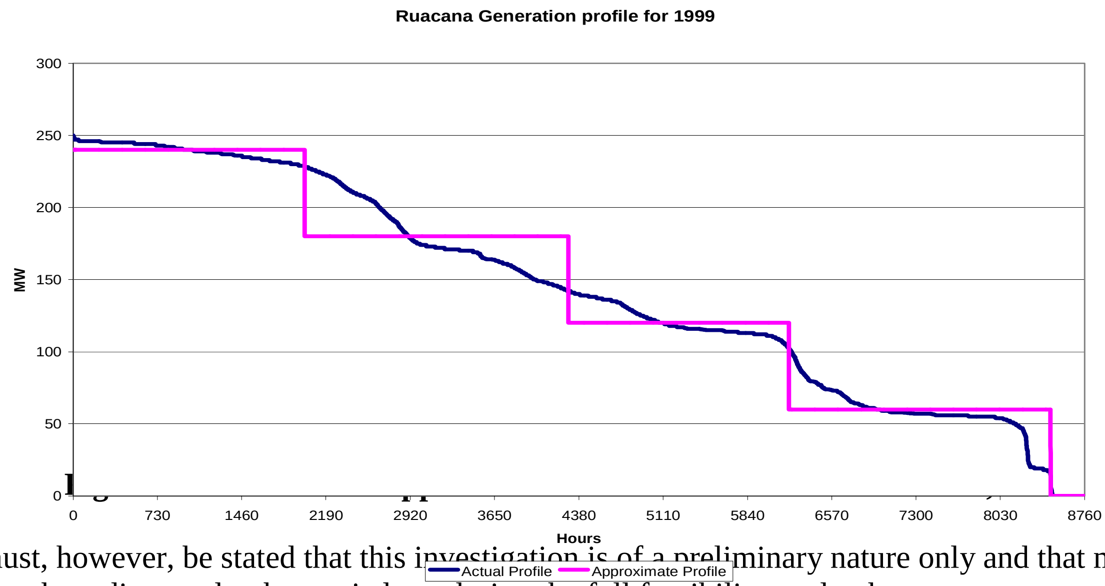
Output [MW]	24	22.8	16.1	12.8	13.3	17.2	71896.2
Losses Saving		3.5	2.0	1.3	0.5	-0.4	4549.7

To calculate the weighted system losses, a loss load loss factor (***LLF)*** of 0,5425 is used. This is derived as follows:

$$LLF = y \text{ x. } LF + (1-y) \text{ x } .LF^2$$

Where: LLF = Load loss factor
y = Multiplier (= 0.25)
LF = Load factor

The values given in the above table take into account the 1999 power generating profile of Ruacana as shown below in **Figure 10-1**. The 1999 profile was used as this represented approximately average values. With a load loss factor of 0,5425, which was based on a load loss factor of 0,70, an annual saving of 4549,7 MWh can be achieved. This was based on Popa Falls maximum power generation of 24 MW.



It must, however, be stated that this investigation is of a preliminary nature only and that more in-depth studies need to be carried out during the full feasibility study phase.

10.8 EVALUATION OF SELECTED TRANSMISSION SYSTEM (TECHNICAL, FINANCIAL, SOCIAL & ENVIRONMENTAL)

There are no differences in the design of the switch yard and transmission system between the three power station sites. The only differences lie in the impact of site construction and operation on the receiving environments at each site. These impacts have not been evaluated at this pre-feasibility study level, but will need further consideration during the detailed feasibility study phase.
There are, however, several different options available for the transmission line in terms of pole/pylon design, types of conductors and especially, the transmission line route. The latter could have variable impacts on the biophysical and social environments, with varying cost implications, all of which also need to be assessed ion detail in the next phase of the study.