6. Substation Design (Summary)

The following plans by the three countries and an overall planning for the region are summarized as follows:

**Burundi**

The HV transmission line connecting the hydro-electric power plant Rusumo Falls and Gitega has been determined as follows:

Rusumo Falls – Muyinga - Gitega

By this Muyinga has been defined as a future place of a HV substation before the line routing continues to Gitega. Furthermore another transmission line via Bujumbura is recommended in order to connect the existing power plants in the region (RWEGURA, RUSIZI I, Rusizi II) as well as planned power plants in the future (RUSIZI III, SISI 5 and gas power plants at Kibuye and Gisenyi) (see Annex 1.1 of the Executive Summary).

The (n-1) planning principle is fulfilled. In case of an outage of the transmission Rusumo Falls–Muyinga–Gitega it is possible to transport the generated power of the Rusumo Falls hydroelectric power plant using the planned transmission lines in Rwanda:

RusumoFalls⇒Kigali⇒Gisenyi⇒Kibuye⇒Bujumbura⇒Gitega

or

Rusumo Falls⇒ Kigali⇒Kigoma⇒Kibuye⇒Bujumbura⇒Gitega

The voltage level will be 220 kV. The line routing is very clear and the alternative near of the National park of Ruvubu was cancelled.

**Recommendation**

The voltage level of 220 kV is recommended because this will be the common voltage level for power transmission of the future in East and Central Africa. The existing substation in Gitega will be extended by

- reserve feeders
- bus sectionalizers
- 110 kV transformer feeder
- 220/110 kV transformer
- 220 kV feeder
- 220 kV reactor
Rwanda
The interconnection line from Rusumo Falls to Kigali is as follows

Rusumo Falls–Kigali New Airport–Birembo

The recommended line routing is via Kigali New Airport because with a future extension to Kibuye a transmission line circuit will be closed around Kigali. Furthermore, the new developing area near the new airport can be connected to the electrical grid (see Annex 1.1 of the Executive Summary).

The (n-1) planning principle is fulfilled as there will be various possibilities in the future to transport the generated power of the Rusumo Falls hydroelectric power plant using the planned transmission lines of Burundi:

RusumoFalls➡Muyinga➡Gitega➡Bujumbura➡Kibuye➡Gisenyi➡Kigali (proposed / planned 220 kV line)

or

Rusumo Falls➡Muyinga➡Gitega➡Bujumbura➡Kibuye➡Kigoma➡Kigali

If the new power plants RUSIZI III (140 MW), SISI 5 (205 MW), the gas plants at Kibuye (100 MW) and Gisenyi (100 MW) will be realized in a short term, than a 220 kV grid in this area is needed and as a consequence and as a good completion, also the lines from Rusumo Falls to Birembo shall be designed and operated in 220 kV.

Because the gas plants at Kibuye (100 MW) will be realized in a short term, a 220 kV grid is needed in Rwanda. It is assumed, that the 220 kV substations in Kigali (Birembo) will be realized with the ongoing line project.

The administration of Rwanda will decide in the near future of an eventually relocation of the end point of the Rusumo falls line, because the area around Birembo is now heavy populated and in the next years an additional increase of the population is expected.

The 220 kV substation Birembo will be needed in the near future. Because there are different ongoing projects, it should be decided by the Rwandan authorities and the financing institutions which project shall handle which part of the Birembo 220 kV substation.

For this stage we assume that this project will consist of one 220 kV feeder OHL and one 220 kV feeder reactor.
Tanzania
A new 400 kV system is planned from Mbeya in the south via Dodoma, Singida to Shinyanga, from Singida the 400 kV systems will be extended to Arusha and then an interconnection to Nairobi is foreseen.

Another branch of the 400 kV systems is planned up to Geita. In the far west from Tanzania a 220 kV grid is foreseen. The new Masterplan is still in discussion.

Another Study for the western Region of Tanzania was established by SWECO. There an interconnection from Geita to Nyakanazi and then to Rusumo Falls was proposed. A final decision is not yet taken.

In parallel to the Masterplan the private company Kabanga Nikel is planning a 220 kV line from Bulyanhulu to Kabanga Nickel near the Burundian border (see Annex 1.2).

These activities shall be coordinated with the NELSAP planning for the 220 kV transmission line from Rusumo Falls to Nyakanzi/Biharamulo which has been the result of the discussions and analysis between the representatives of TANESCO and the Consultant during the pre-feasibility stage.

The connection of the mine Kabanga Nickel can be realized in the following:

- one extra 220 kV line from Rusumo Falls
- a T-Off connection from the line to Gitega
- One OHL from a new substation at the border to Burundi.
- a loop in to the line Rusumo Falls to Nyakanazi/Biharamulo.

Overall planning
There is an overall planning for a HV grid in eastern Africa.

The first planning shows an interconnected 220 kV grid from Kenya, Uganda and Tanzania. In 2005 the same grid indicates a voltage of 220 kV or greater.

The actual planning prefers a voltage of 400 kV for the inter African connections in Tanzania and Kenya (see Annex 1.2 of the Executive Summary). The voltage level for the interconnection Kenya - Uganda was foreseen for 220 kV but now a change to 400 kV is in discussion.

The HV grid ring around the Lake Victoria (see Annex 1.2) can be closed via Bukoba in Tanzania or via Rusumo Falls and Birembo (Kigali).

The decision shall be given by the related organizations like SAPP etc. and the financing institutes like AfDB, World Bank and the representatives of Burundi, Rwanda, Tanzania, etc.
Map 6-1 gives an overview of the project area including 220 kV transmission lines as well as the planned 220 kV substations at

- Muyinga and Gitega (Burundi)
- Rusumo, Kigali New Airport and Birembo (Rwanda)
- Nyakanazi, 50 km south of Biharamulo (Tanzania)

There is an ongoing study for EAPP (East African Power Pool) regarding the future HV grid in the region. The results and decisions will be finalized by the end of 2010.

The actual situation and decision is to use 220 kV for the lines related to Rusumo Falls.
Installation and size of line compensation reactors

The installation and the size of the line compensation reactors can be done in different ways:

- design for each line section and connection direct to the line, which means less flexibility for the operation, difficulties in case of grid extensions which are planned for each country
- Design for the whole system and connection to the busbars, which means more flexibility for the operation and in the case of grid extensions.

The size of the line compensation reactors shall be harmonized within all 220 kV projects in the region.

In this planning stage we have chosen a size of 10 MVAR as standard size for the line compensation reactors in the region. This size was assumed in the substations Nykanazi and Kigali as well as in the Rusumo Falls Hydro Power plant, connected to the bus bars.

In other NELSAP projects a standard size of 20 MVar was chosen. In these cases the lines are longer, line compensation reactors are only installed at one side of the line and the line characteristics are different, because the line conductors are different.

A harmonization of the line compensation reactors within all 220 kV projects in the region is recommended.

A general decision shall also be taken about the type of the substation:

- double bus bar system as for the existing substations in all related countries also for 220 kV
- one and a half (1 +1/2) circuit breaker system as used in Kenya

In this planning stage we have used double bus bar systems.