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NILE BASIN INITIATIVE
NILE EQUATORIAL LAKES
SUBSIDIARY ACTION PROGRAM

Strategic/Sectoral, Social and Environmental Assessment of Power Development Options in The Nile Equatorial Lakes Region

Final Report

Volume 1

Main Report

February 2007

SNC•LAVALIN
International

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SNC-Lavalin International

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- WL Delft Hydraulics
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Mr. Jakob Granit
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Washington, DC 20433 USA

Subject: **Strategic/Sectoral Social and Environmental Assessment of Power Development Options in the Nile Equatorial Lakes Region Final Report**

Dear Mr. Granit:

We are pleased to submit our final report for this interesting and challenging project. The report consist of:

- The main report, including an executive summary
- A volume of appendices containing all the basic information used in the analyses
- An executive summary in English and
- An executive summary in French

This report provides a solid foundation for planning the development of the power sectors of the region as it contains a proposed development strategy and a NELSAP indicative development plan to the year 2020. It is based on a review of the current environmental and social context, the existing legal and regulatory framework, an assessment of the power needs for the region, an identification of the power development options available in the region and a comparison of these options in terms of environmental, socio-economic and risk considerations.

It has been a pleasure working with you and your team as well as the NELSAP coordinating Unit, other members of the steering committee and the stakeholders who participated in the project.

Sincerely yours,

R Noël

Raymond Noël
Team Leader,
SNC-Lavalin International Inc.

RN/tc

Encl.

A Note to Readers

This SSEA study is a general framework which was used to develop an indicative power development strategy for the NELSAP region. As such, it is based on information gathered from secondary sources initially in 2003 and updated in 2004. Much of the data received was developed by numerous consultants over long periods of time (some dating back 20 years) using a wide range of assumptions. Every reasonable effort has been made to put the information on the consistent basis needed for a strategic level analysis like this SSEA. The SSEA is not a substitute for detailed project specific studies and environmental/social impact assessments needed for the implementation of particular projects. Such studies would invariably incorporate updated and detailed information about various project aspects including alternate configurations, cost estimates, hydrology and plant output, and environmental and socio-economic impact analyses.

Strategic/Sectoral Social and Environmental Assessment
Executive Summary

INTRODUCTION

The Nile Equatorial Lakes (NEL) Region of Africa is experiencing an acute lack of electric power. This absence of electricity makes life more difficult in both rural and urban areas, and places a major burden on economic development. In the context of the Nile Basin Initiative (NBI) and the Nile Equatorial Lakes Subsidiary Action Program (NELSAP), the participating countries have agreed that development of low-cost power generation and regional electricity trade are means to improving productivity and to promoting economic growth. The alternative, an independent development approach, would be more costly, have greater impacts on the environment and achieve less electricity security. The area being studied is shown in Figure 1.

This Strategic/Sectoral Social and Environmental Assessment (SSEA) is intended to produce strategic/ sectoral level guidance to decision making in the power sector at the regional and national levels, and therefore includes an assessment of cumulative environmental and social impacts of different regional power development portfolios. This assessment does not replace detailed project-specific environmental impact assessments or feasibility studies.

About SSEA

The purpose of the Strategic/Sectoral Social and Environmental Assessment (SSEA) is to provide an overview analysis of the social and environmental issues surrounding possible regional power development options in the NEL Region of Africa. The SSEA analyses and ranks identified power options based on a combination of cost, social, environmental and risk considerations.

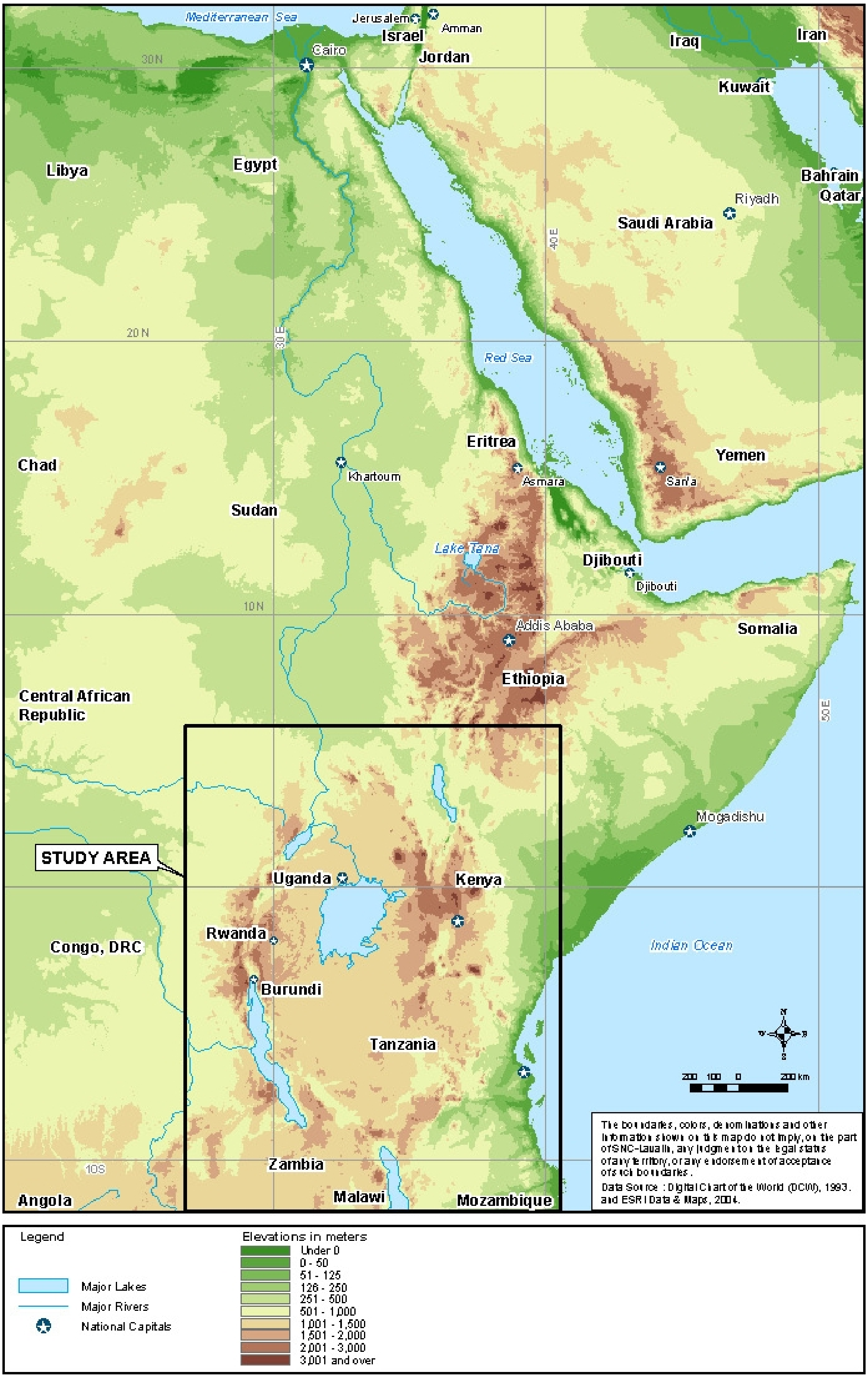
OUTLOOK

The SSEA presents a NELSAP Indicative Power Development Strategy to meet a medium level of growth in the demand for electricity in the region including recommendations for further studies of identified power options as well as advice related to the legal and regulatory framework. The strategy includes a preferred project portfolio of options defined as the NELSAP Indicative Power Development Plan.

OVERVIEW

- Between 2% and 9% of the population has access to electric power supply.
- The total demand for electricity will increase by 2,700 MW, and 16,000 GWH over the period up to 2020.
- By 2020, almost all of the power development options that have low environmental and social impacts will have been used to meet medium demand increases.
- Development strategies that improve geographical or technological diversification will result in the selection of projects with environmental/social risks.

Figure 1 - Map showing the Nile River Countries



- The most significant impacts on the physical and social environment are emissions from thermal plants and potential impacts on wetlands in the Kagera River and the Rufiji River.
- Even the most hydro-intensive portfolio would not have any material effects on the Albert Nile leading to Sudan and the Sudd Marshes.

RECOMMENDATIONS

This SSEA resulted in the following recommendations that were developed from consultations with the Project Steering Committee (PSC) and stakeholders:

<table>
<tr><th colspan="5">Recommendation A:
Many options should be implemented as soon as possible.</th></tr>
<tr><th>Country</th><th>Option</th><th>Generation</th><th>Why?</th><th>When?</th></tr>
<tr><td>Uganda</td><td>Bujagali</td><td>Hydro</td><td rowspan="3">Serious power outages and these options are among the best evaluated</td><td rowspan="3">As soon as possible</td></tr>
<tr><td>Rwanda/ Burundi/ Tanzania</td><td>Rusumo Falls</td><td>Hydro</td></tr>
<tr><td>Rwanda/DRC</td><td>Lake Kivu</td><td>Diesel type using naturally occuring methane gas</td></tr>
<tr><td colspan="5">Comments: The power options could be installed in the short to mid-term, and they are also low cost and with acceptable environmental and social impacts.</td></tr>
</table>

<table>
<tr><th colspan="5">Recommendation B:
Study and implement other power development options.</th></tr>
<tr><th>Country</th><th>Option</th><th>Generation</th><th>Why?</th><th>When?</th></tr>
<tr><td>Burundi</td><td>Kabu 16</td><td rowspan="4">Hydro</td><td rowspan="6">These projects will be required in 2014-2018, based on the medium load growth scenario.</td><td rowspan="6">Soon</td></tr>
<tr><td>Tanzania</td><td>Kakono</td></tr>
<tr><td>Rwanda/DRC</td><td>Ruzizi III</td></tr>
<tr><td>Tanzania</td><td>Ruhudji</td></tr>
<tr><td>Kenya</td><td>Suswa</td><td>Geothermal</td></tr>
<tr><td>Tanzania</td><td>Songo Songo</td><td>Gas-fired plant</td></tr>
<tr><td colspan="5">Comments: Other power development options (hydro, geothermal and natural gas) should also be implemented.</td></tr>
</table>

<table>
<tr><th colspan="4">Recommendation C:
The countries in the region should move immediately towards a high degree of power system interconnection and ultimately integration.</th></tr>
<tr><th>Country</th><th>Generation</th><th>Why?</th><th>When?</th></tr>
<tr><td>All countries in the NEL region.</td><td>Power system interconnection</td><td>To reduce costs in most of the countries involved and create synergies using the mix of technological resources.</td><td>Immediately</td></tr>
<tr><td colspan="4">Comments: Integration would facilitate use of projects with the lowest environmental and social risks.</td></tr>
</table>

Recommendation D: Prepare, develop and finance in the order of 100 MW of existing hydro options and strengthen the associated transmission.			
Country	**Generation**	**Why?**	**When?**
Eastern provinces of the Democratic Republic of Congo (DRC)	Hydro	Some options need to be rehabilitated. Some options appear attractive but need more analysis to confirm interes5t	As soon as possible
Comments: This should also include environmental and socio-economic studies of the Semliki River Basin in which these options are located.			

Recommendations resulting from this assessment, in the form of year-by-year actions required by each country, are presented at the end of this report. These are actions that are urgently required in order to eliminate the current shortages of power and to ensure that sufficient power is available in the future to meet the load with a reasonable and realistic reserve margin.

APPROACH AND ANALYTIC PROCESS

The SSEA was conducted over a three-year period in two stages within the framework of the NBI/NELSAP[1].

The analysis included all of Burundi, Kenya, Rwanda, Tanzania and Uganda, and the eastern part of the DRC, consisting of North Kivu Province, South Kivu Province, the eastern districts of Haut-Uélé and Iluri in Oriental Province, the eastern districts of Tanganyika and Haut Katanga in Katanga Province and the district of Kabambare in Maniema Province.

The key elements of the process included:

- A period of analysis of about 15 years, up to 2020
- The solicitation of stakeholder viewpoints in each step of the SSEA
- The use of existing data as well as information provided by the East African Community Power Master Plan and national power master plans
- Consideration of the legal and regulatory framework of each of the countries as well as relevant international agreements and conventions

[1] This SSEA study is a general framework which was used to develop an indicative power development strategy for the NELSAP region. As such, it is based on information gathered from secondary sources initially in 2003 and updated in 2004. Much of the data received was developed by numerous consultants over long periods of time (some dating back 20 years) using a wide range of assumptions. Every reasonable effort has been made to put the information on the consistent basis needed for a strategic level analysis like this SSEA. The SSEA is not a substitute for detailed project-specific studies and environmental/social impact assessments needed for the implementation of particular projects. Such studies would invariably incorporate updated and detailed information about various project aspects including alternate configurations, cost estimates, hydrology and plant output, and environmental and socio-economic impact analyses.

- Assessment of (calculated/forecasted) climatic changes and runoff due to climate change
- Consideration of power development options limited to those that could have a regional impact
- Ranking of power development options according to cost, environmental, social and risk factors
- Preparation of example portfolios of investments to satisfy alternate development strategies and load growth scenarios
- Preparation of a NELSAP Indicative Power Development Strategy to guide future investment planning.

LEGAL, POLICY AND ADMINISTRATIVE CONTEXT

The legal, policy and administrative frameworks within which a power development option is planned and implemented are a vital consideration at the strategic and sectoral level, as they have a strong bearing on the acceptability of the option as well as on its environmental and social performance. The legal and policy frameworks also influence how suitable a particular jurisdiction is to attracting investment, particularly in a regional or multinational context.

The analysis of the information indicates the following:

All six countries provide a welcoming environment for power development.

- Five of the six countries (the exception being the DRC) have adopted environmental assessment processes that are largely compatible with international requirements governing power generation and transmission projects. However, these processes have been introduced relatively recently (most since 2000) and the countries concerned have limited experience in applying them.
- No resettlement policies and regulations that are compatible with international requirements have been adopted to date. The six countries will need to put in place appropriate compensation and involuntary resettlement policies.
- DRC is the only country that prohibits interventions on rivers within parks and reserves. The other five countries require that Environmental Impact Assessments (EIAs) be carried out in such cases.
- All six countries provide a welcoming environment for the implementation of power projects.

- A country-by-country assessment shows that even though the overall situation appears to be welcoming, a few complementary measures already in progress need to be completely accomplished to promote both private sector involvement and the development of electricity trade between the countries.

- Power trade will need to be favoured through facilitating legislation or regulation.

- Imports need not be regulated or, if they are, as little as possible.

- As for exports, the law on energy should contain a clause authorising the government or the minister responsible for energy to set conditions by decree or to limit exports for the purpose of operational security of the network and quality of supply.

CURRENT ENVIRONMENTAL AND SOCIAL CONTEXT

The region encompasses three major lake watersheds (Lakes Victoria[2], Malawi and Tanganyika) and two river watersheds (Rufiji and Victoria Nile). From a regional perspective, these lakes and rivers are of paramount importance to the subsistence of their populations as they offer a source of water and dietary proteins; provide revenue through fish harvest, exports and tourism; are used as transport avenues; supply water for irrigation, agriculture and electricity; and are home to diverse endemic fish and fauna of ecological and scientific significance.

These lakes and rivers have experienced declines in fish resources, biodiversity and overall deterioration in water quality by means of deforestation, overexploitation and general lack of management. This is due in part to rapid population growth in the areas that border the water (hence increasing pressure on natural resources), human habitat and the economic and social infrastructure.

REGIONAL ENERGY NEEDS ASSESSMENT

An adequate supply of electrical energy provides the basic foundation for development. There are several key issues in the region that need to be taken into account:

- Only a very small proportion of the population of the region, between 2% and 9%, has access to electric power supply.

- The current unit consumption in the region is 95 kWh/capita/year and this includes all industrial and commercial consumption. To put this into perspective, the African countries as a whole consume 930 kWh/capita/year, virtually 10 times the current level in the region.

Electricity consumption in the region is about one tenth of the average for all of Africa.

- The amount of electric energy demanded by the customers currently exceeds the amount that can be provided reliably by the electric power producers.

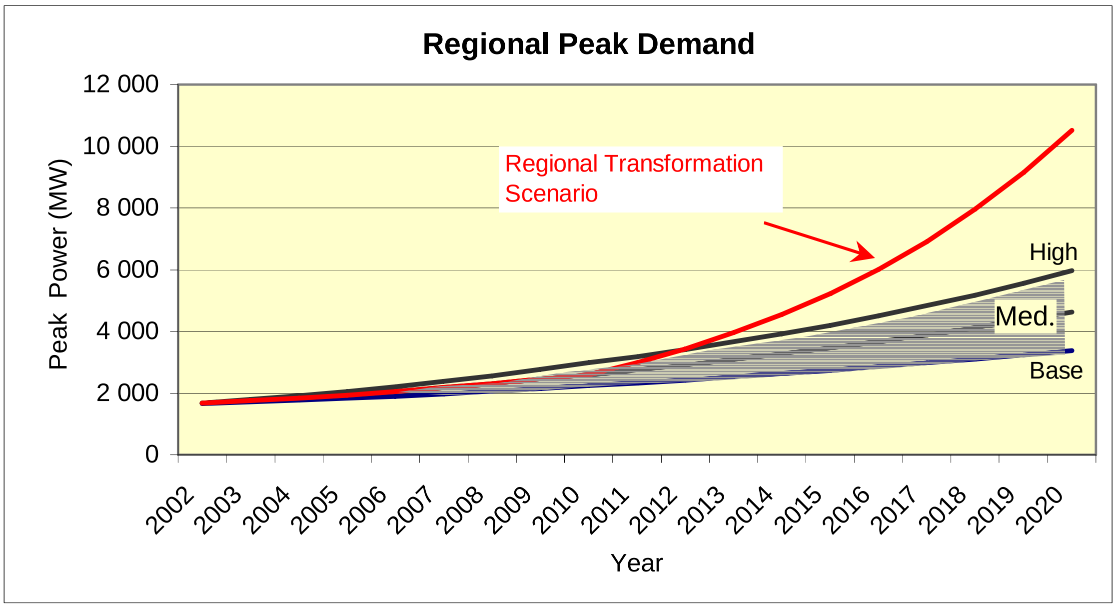
- Electric power demand forecasting methodologies are usually linked to historic trends, which implies a continuation of (or possibly a gradual improvement on) the current socioeconomic condition in the region.

[2] For the purpose of this strategic analysis the Semliki Basin is included in the Lake Victoria basin even if they are two distinct basins. As there are no power development options in that river basin that could be included in the analysis, the environmental and socio-economic situation in the basin has not been reviewed.

Four load growth scenarios were derived. Three are based on a continuation of the status quo (base load growth) with variation in some of the input assumptions regarding the rate of growth of the economies of the countries. A fourth scenario provides an estimate of the needs for the region to improve significantly and transform its economic situation.

The results of the regional load growth forecast are shown below:

Regional Electric Power Needs Assessment in the NEL Region for the Period to 2020



Incremental capacity requirements (MW):

- *Base: 1,500*
- *Medium: 2,700*
- *High: 4,000*
- *Transformation: 8,600*

The Incremental load growth under base scenario is 3.7% to 4.0%, under medium scenario is 5.6% to 6.3%, under high scenario is 6.8% to 6.1% and under transformation scenario is 5.1% to 15%.

IDENTIFICATION AND SCREENING OF NEW POWER DEVELOPMENT OPTIONS

All identified power development options were examined – hydro, geothermal, thermal, wind, solar and demand-side management.

Once the electric power needs for the region have been identified, the resources that could be available to meet those needs must be identified and screened. The first step is to prepare a long list of options without regard for the feasibility of their development. This resulted in the identification of 9100 MW of hydro capacity and 2395 MW of thermal and geothermal capacity. The second step is to screen this list of options to ensure that all are appropriate for the purpose. This screening reduced the amount to 1899 MW of hydro capacity, 2095 MW of thermal and geothermal capacity plus another 30 MW of wind energy conversion systems.

Four screening criteria were suggested by the stakeholders and approved by the Project Steering Committee as follows:

- Availability of data (pre-feasibility level or better)
- Tolerable residual environmental or socio-economic impacts, in compliance with national laws and international conventions
- Unit cost below a specified threshold value of 10 cents US/kWh for firm energy
- Assurance of regional relevance (the size of an option should be greater or equal to 10 MW for Rwanda, Burundi and Eastern DRC, and greater or equal to 30 MW for the East African Community [EAC] countries).

Failure to meet one or many of these criteria would result in an identified project option being eliminated from the overall project candidate list under this screening.

POWER OPTIONS RETAINED FOR COMPARATIVE ANALYSIS

The options retained for the comparative analysis are listed in Table 1.

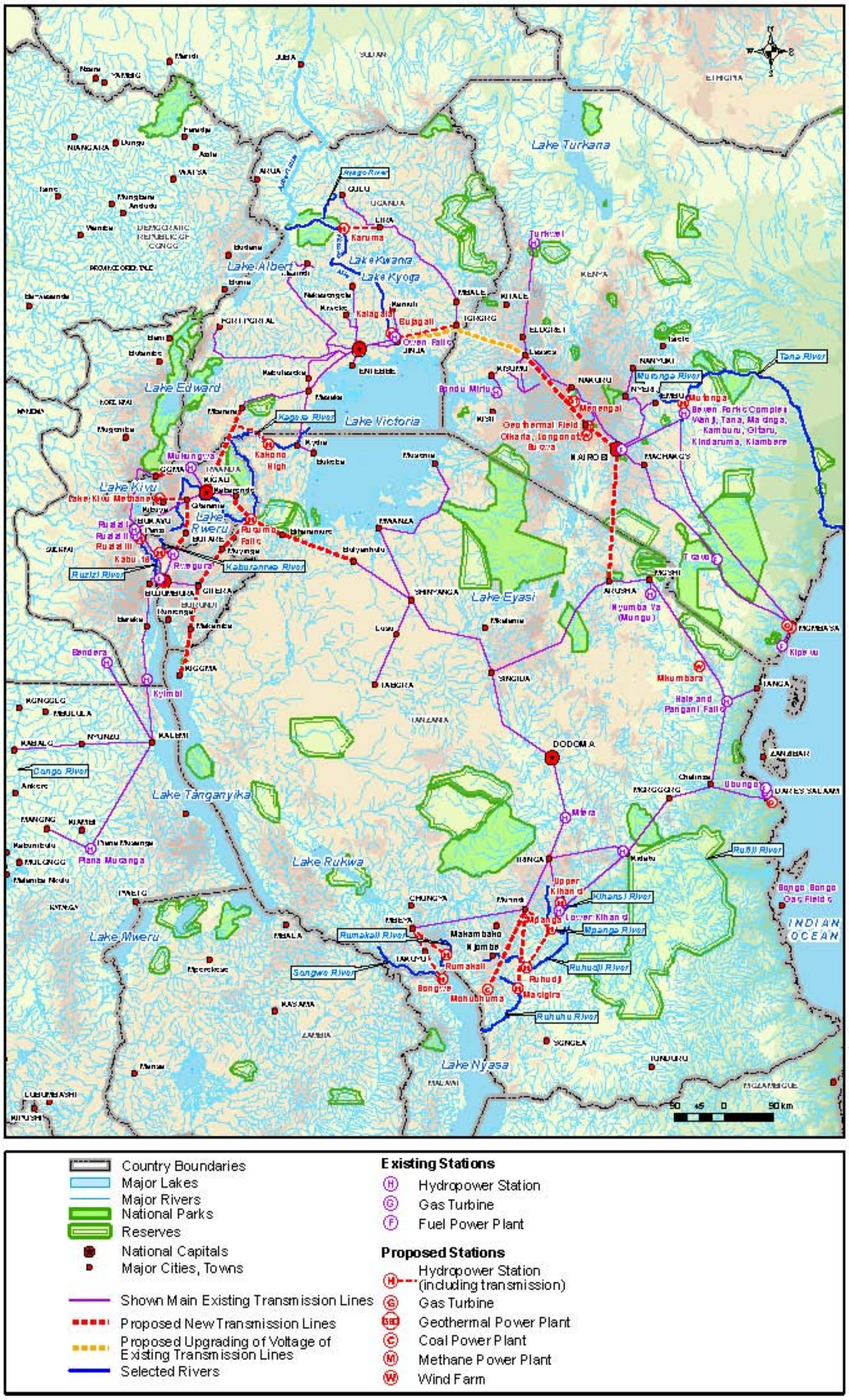
Table 1:
Power Development Options Retained for Comparative Analysis

Options Passing the Screening	
Hydro • Bujagali (250 MW) • Kabu 16 (20 MW) • Kakono (53 MW) • Karuma (200 MW) • Masigira (118 MW) • Mpanga (144 MW) • Mutonga (60 MW) • Ruhudji (358 MW) • Rumakali (222 MW) • Rusumo Falls (61.5 MW) • Ruzizi III (82 MW) • Songwe (330 MW) • Upper Kihansi (no capacity, only energy) **Renewable** • Kivu methane engines 30 MW x 4 units (120 MW)[3] • Generic wind (nominal capacity depends upon sites, 2 X 30 MW assumed)	**Geothermal** • Longonot (70 MW) • Menengai (140 MW) • Olkaria extension (35 MW) • Suswa (70 MW) • Generic (assumed at 140 MW) **Thermal** • Combined cycle gas x 3 units (generic, capacity depends upon amount of gas to be imported) • Gas turbine 60 MW gas – generic x 4 units (generic, capacity depends upon amount of gas to be imported) • Mchuchuma – coal (400 MW) • Mombasa – LNG (generic, capacity depends upon amount of gas to be imported) • Mombasa – coal (generic, capacity depends upon amount of gas to be imported)

The location of these options is shown in Figure 2 and they are described briefly on the following page.

[3] These units use fossil fuel and could therefore be considered as thermal options. However, the fuel is naturally replenished and thus can also be considered as renewable.

Figure 2- Retained Candidate Power Options



Hydroelectric Options

Bujagali Hydroelectric Development

Description:
A 250 MW in one or two stages, run-of-river project with about 12 hours of pondage.

Location:

Located on the Victoria Nile in Uganda, 8 km downstream of the existing Kiira/Owen Falls hydroelectric projects.

Main Impacts:

- the flooding of riverbanks and islands would result in loss of habitats for birds, bats and other animals;
- resettlement in project-affected areas has already been carried out;
- loss of tourism revenues and loss of white-water rafting opportunity;
- the creation of the pondage reservoir would involve a risk of increase of bilharzias.

Kabu 16 Hydroelectric Development

Description:
A 20 MW, run-of-river project with hourly pondage.

Location:

Located in Burundi on the Kaburantwa River, 16 km above its confluence with the Ruzizi River.

Main Impacts:

- some 75 persons (1995 estimate) would be displaced;
- the construction of a 10.5 km road would provide better access to markets and services.

Kakono Hydroelectric Development

Description:
A 53 MW run-of-river project. Part of the benefit of this option would be the provision of irrigation water.

Location:

Located in Tanzania on the Kagera River near the Uganda border.

Main Impacts:

- partial flooding of the Minziro Forest Reserve;
- possible significant resettlement.

Karuma Hydroelectric Development

Description:

A 200 MW, run-of-river project with hourly pondage.

Location:

Located on the Victoria Nile in Uganda, immediately upstream of the limit of Murchison Falls National Park.

Main Impacts:

- about seven hectares of terrestrial habitat would be lost;
- resettlement would be needed for some 35 households;
- the construction of access roads (about 4.5 km) would provide better access to markets and services.

Masigira Hydroelectric Development

Description:

A 118 MW run-of-river project.

Location:

Located in a pristine environment rich in wildlife in Tanzania on the Ruhuhu River, 80 km to the east of Lake Nyasa.

Main Impacts:

- high erosion risk;
- project located in a pristine environment rich in wildlife.

Mpanga Hydroelectric Development

Description:

A 144 MW run-of-river project.

Location:

Located in Tanzania on the Mpanga River, 40 km downstream of the Lower Kihansi project.

Main Impacts:

- the project could affect the hydrology of the Mpanga River, which flows in Kilambero, an important floodplain and designated Ramsar site.

Mutonga Hydroelectric Development

Description:

A 60 MW, run-of-river project with pondage equivalent of six days.

Location:

Located on the Tana River in Kenya, immediately downstream of the Kiambere hydroelectric power plant.

Main Impacts:

- some 11 km^2 of terrestrial habitat would become lacustrine habitats;
- sediment trapping in the reservoir would lead to degradation of bottom life and productivity in the reservoir;
- degradation of the riverbed downstream of the dam would affect river morphology, and the possible reduction of riverine forest area;
- resettlement of some 1,000 people from the reservoir area;
- a risk of increase of malaria and bilharzias.

Ruhudji Hydroelectric Development

Description:

A 358 MW run-of-river project with a separate upstream reservoir.

Location:

Located on the Ruhudji River in Tanzania, approximately 70 km to the east of Njombe.

Main Impacts:

- modification of terrestrial to lacustrine habitats;
- modification of hydrological and nutrient transport conditions in the stretch of river between the storage dam and the intake dam;
- the project could affect the hydrology of the Ruhudji River, which flows into Kilambero, an important floodplain and designated Ramsar site;
- the construction of access roads would provide better access to markets and services.

Rumakali Hydroelectric Development

Description:

A 222 MW run-of-river project.

Location:

Located on the Rumakali River in Tanzania, 85 km west of Njombe.

Main Impacts:

- modification of terrestrial to lacustrine habitat;
- modification of water flows and levels in the wetlands downstream of the dam before Lake Nyasa;
- modification of sedimentation patterns could also impact the exceptional biodiversity of the lake;
- flooding of agricultural land and of a village with 80 buildings;
- reduction of flood risks downstream;
- the construction of access roads would provide better access to markets and services.

Rusumo Falls Hydroelectric Development

Description:

A 61.5 MW project with reservoir.

Location:

Located on the Kagera River at the border between Rwanda and Tanzania.

Main Impacts:

- flooding of 400 km^2, which would include 125 km^2 of existing lake, 250 km^2 of existing wetlands and 15 km^2 of valley slopes;
- the reduction in downstream flood flows and levels could affect wetlands downstream, including in the Akagera National Park;
- approximately 3,000 persons may be affected and some displaced;
- possible increased health risks due to bilharzias and malaria. An optimization study of the site is necessary.

Ruzizi III Hydroelectric Development

Description:

A 82 MW run-of-river project.

Location:

Located on the Ruzizi River, which forms the border between Rwanda and the Democratic Republic of Congo, 25 km downstream (south) of the outlet of Lake Kivu.

Main Impacts:

- sedimentation could impact aquatic habitats and the high biodiversity of Lake Tanganyika in the Congo basin by reducing nutrient input to the ecosystem.

Songwe Hydroelectric Development

Description:

A 330 MW project that would comprise three dams and hydro plants in cascade on the Songwe River.

Location:

The upper dam would be on the border between Tanzania and Malawi. The middle and lower dams would be in Malawi.

Main Impacts:

- the creation of three reservoirs (total area: 5,600 hectares) would involve the loss of wetlands, the modification of terrestrial habitat to lacustrine habitats and a seasonal regulation of water flows that would modify sedimentation patterns in the lake and ultimately impact the lake's very high biodiversity;
- increase in riverbank erosion downstream of the dams; dams would block fish migration; encroachment in protected areas;
- significant population displacement;
- increased health risks (malaria and bilharzia).
- The project could generate significant flood control and irrigation benefits.

Upper Kihansi Hydroelectric Development

Description:
A storage dam to regulate flows to an existing downstream hydro project. The regulation of river flows would allow for an increase in the average annual generation of the existing plant by about 124 GWh but no increase in capacity.

Location:

The dam would be located on the Kihansi River in the Rufiji River basin, 12 km upstream of the existing Lower Kihansi power project.

Main Impacts:

- the reservoir would possibly encroach on primary forest habitat;
- the project could regulate the flow of the Kihansi River, which flows into Kilambero, an important floodplain and designated Ramsar site.

Gas-fired and Coal-fired Thermal Options

Gas-fired Plant in Tanzania

Description:

Gas-fired thermal plants would be sized as required.

Location:

Gas-fired thermal plants would be located as required.

Main Impacts:

- social and environmental impacts of climate change due to greenhouse gas emissions; impacts of acid rain;
- impacts on public health.

Mchuchuma Coal-fired Plant in Tanzania

Description:

A 400 MW project.

Location:

Coal-fired thermal plant would be located as required.

Main Impacts:

- social and environmental impacts of climate change due to greenhouse gas emissions; impacts of acid rain;
- impacts on public health; impacts on land use, habitats and resources due to ash disposal in the case of coal-fired power plants.

Generic Coal-fired Plants in Kenya

Description:

Coal-fired plants would be sized as required.

Location:

Coal-fired thermal plants would be located as required.

Main Impacts:

- social and environmental impacts of climate change due to greenhouse gas emissions; impacts of acid rain;
- impacts on public health; impacts on land use, habitats and resources due to ash disposal in the case of coal-fired power plants.

Lake Kivu Methane Gas Development

Description:

Specially modified diesel engines using methane gas extracted from deep in Lake Kivu have been retained in modules of 30 MW each. There appears to be enough capacity for four such modules.

Location:

Lake Kivu

Main Impacts:

- greenhouse gas and air pollutant emissions will be comparable to a thermal power plant fuelled by natural gas.
- There may be a consequent beneficial increase in nutrients and aquatic productivity in the upper region of the lake.

Geothermal Power Options

Geothermal Plants

Description:
All identified geothermal options have been retained. These are the extension of the Olkaria plant and the Longonot, Suswa and Menengani options, amounting to 455 MW.

Location:

All located in Kenya.

Main Impacts:

- **geothermal power stations, with appropriate site selection and plant design, do not involve significant environmental and social issues.**

Wind Power Options

Generic wind energy conversion systems

Description:
Generic wind energy conversion systems have been retained where wind resources are adequate. For purposes of this study, one or two sites in Tanzania with 30 MW were assumed.

Location:

All in Tanzania: Gomvu (near Kimbiji, southwest of Dar es Salaam), Litember (southwest of Mtwara, near Karatu) and at Mkumbura (near Kmomazi in the Pare/Usambara mountains). The best site is Mkumbura, due to wind conditions.

Main Impacts:

- **most impacts of wind power options can be minimised with appropriate site selection for the wind farm that takes into account land tenure systems and land use conflicts, effects on landscapes and effects on wildlife.**

Options Set Aside

521 MW of power development potential was set aside for lack of information.

Some potential options were screened out because of insufficient information for evaluation (in most cases, conceptual level information) even though these options could meet the other screening criteria (environmental risk, cost and size). These power development options are listed in Table 2, which shows a further potential total of 521 MW that could be included in the project evaluation and planning process if, after further studies are undertaken, they remain as attractive as the preliminary information suggests.

Table 2: Hydropower Options Not Prepared to Pre-feasibility or Better but Meeting Cost Criteria								
Name	**Country**	**Total Cost US $ million**	**Installed Capacity (MW)**	**Energy**		**Generation Cost**		
				Average (GWh)	Firm (GWh)	Average c/kWh	Firm C/kWh	$/kW
Babeba I	DRC	122.40	50	351	*	3.89		2448
Bangamisa	DRC	123.47	48	420	*	3.28		2572
Budana	DRC	12.72	13	70	*	2.08		979
Igamba Falls FSL 865 m	West Tanzania Rwanda	41.74	11	87	*	5.32		3661
Kiliba	DRC	39.06	15	65	*	6.70		2604
Kiymbi/ Bendera II	DRC	52.06	43	377	*	1.57		1211
Mugomba	DRC	87.63	40	160	*	6.13		2191
Muhuma	DRC	71.69	25	100	*	7.98		2868
Panzi	Rwanda - DRC	136.72	36	175	*	8.66		3798
Piana Mwanga	DRC	35.00	38	193	*	2.40		1065
Semliki	DRC	95.59	28	120	*	8.85		3414
Sisi 3	Rwanda - DRC	405.93	174	883	*	5.14		2333
Total			**521**					

COMPARISON OF OPTIONS

The options retained from the screening need to be compared with each other in order to prepare an indicative power development portfolio to meet the load growth scenarios under consideration. This is carried out using a multi-criterion analysis (MCA) and a risk analysis. The characteristic feature of MCA methods is the establishment of formal and, to some extent, quantified procedures for the following three phases of options assessment[4]:

- Identification of criteria
- Ranking of options according to each identified criterion
- Aggregation across criteria to establish an overall preference ranking for the options

There is also a need to identify and assess the risks a power development option could face that would result in its performance being different from that planned (costs higher or lower than estimated, output higher or lower than expected, on-power date earlier or later than expected, etc.). The comparison of the cost ranking with the above results of the MCA within the socio-economic and environmental categories, and when taking into account the assessment of project risks leads to the following:

[4] Nichols, David, and David Von Hippel (Tellus Institute, USA), Theo Stewart (University of Cape Town, South Africa). November 2000. Thematic Review. VI Planning Approaches. Chapter 4: Multi-Criteria Analysis Methods. Report Prepared for the World Commission on Dams.

- All run-of-river hydroelectric options – Mutonga, Ruzizi III, Bujagali, Karuma, Ruhudji, Kabu 16 and Kakono – have a good performance with regards to socio-economic and environmental criteria and, except for Kabu 16 and Kakono, are among the least-cost options. However, results from the project risks assessment raise some issues concerning the following options:

Run-of-river options (Mutonga, Ruzizi III, Bujagali, Karuma, Ruhudji, Kabu 16 and Kakono) ranked well.

  - Bujagali (at 4.24¢/kWh) in Uganda would affect scenery that is considered to be of exceptional beauty.
  - Mutonga in Kenya has a good overall performance against risks as well as socio-economic and environmental criteria. However, it has the highest unit cost among all options at 8.68¢/kWh.
  - Ruzizi III is the second lowest unit cost option (at 2.86¢/kWh). However, it is located in Rwanda and the DRC, and bilateral agreements need to be negotiated before it can be developed.
- Hydroelectric options with seasonal regulation (Songwe and Rusumo Falls) provide more power benefits than run-of-river options, but they also raise the following additional dilemmas:
  - Songwe, at the border of Tanzania and Malawi, also has a relatively low unit cost (3.43¢/kWh) and flood control and irrigation benefits. However, it has significant resettlement and land requirements.
  - Rusumo Falls, at the border of Rwanda and Tanzania near Burundi, with a unit cost of 4.14¢/kWh, is expected to have high land and resettlement requirements. It may also pose problems associated with the proliferation of water hyacinths, increased waterborne diseases and downstream impacts on the Akagera National Park. It may also involve risks related to the need to negotiate power-sharing agreements between Burundi, Rwanda and Tanzania.
- The geothermal options considered in Kenya are ranked second-best against environmental criteria and risks as well as score high against socio-economic criteria. However, this option has a relatively high unit cost of 5.05¢/kWh.
- The generic wind option has a very good performance against socio-economic criteria and risks, and has a fair performance against environmental criteria. However, it also has a relatively high unit cost of 8.33¢/kWh.
- The Kivu methane engines option performs well against socio-economic criteria, but has a higher unit cost of 6.11¢/kWh, and a low energy-payback ratio.
- Coal-fired thermal options: with unit costs of more than 6 ¢/kWh, these options have the highest greenhouse gas and air pollutant emissions among the considered options. Besides, the Mombasa - Coal option in Kenya could have significant impacts in relation to increased risks of pulmonary diseases.

On the basis of the above analysis, two groups of options can be identified for consideration in preparing power development portfolios: (1) best-evaluated options and (2) other options, as presented in Table 3, with the options listed in order of increasing unit cost.

Table 3:
Options to Be Considered in Power Development Portfolios
(Listed in alphabetical order by technology)

<table>
<tr><th colspan="2">Best-evaluated Options</th><th>Other Options</th></tr>
<tr>
<td>Hydro Options
• Bujagali (250 MW)
• Kabu 16 (20 MW)
• Kakono (53 MW)
• Karuma (200 MW)
• Mutonga (60 MW)
• Ruhudji (358 MW)
• Rumakali (222 MW)
• Rusumo Falls (61.5 MW)
• Ruzizi III (82 MW)
Geothermal Options
• Generic geothermal (assumed at 140 MW)
• Longonot geothermal (70 MW)
• Menengai geothermal (140 MW)
• Olkaria extension (35 MW)
• Suswa Geothermal (70 MW)
Renewable Options
• Generic wind (nominal capacity depends upon sites, 2 X 30 MW assumed)</td>
<td>Thermal Options
• Combined cycle gas x 3 units (generic, capacity depends upon amount of gas to be imported)
• Gas turbine 60 MW gas – generic x 4 units (generic, capacity depends upon amount of gas to be imported)
• Mombasa – LNG (generic, capacity depends upon amount of gas to be imported)
• Kivu methane engines 30 MW x 4 units (120 MW)

Total: 1881.5 MW plus generic gas-fired thermal plants.</td>
<td>Hydro Options
• Masigira (118 MW)
• Mpanga (144 MW)
• Songwe (330 MW)
• Upper Kihansi (no capacity, only energy)
Thermal
• Mchuchuma – coal-fired steam (400 MW)
• Mombasa – coal (generic, capacity depends upon amount of gas to be imported)

Total: 992 MW plus generic coal-fired thermal plants .</td>
</tr>
</table>

POTENTIAL IMPACT OF CLIMATE CHANGE

The output from the retained hydroelectric options is a direct function of the amount of water that flows through their turbines for conversion to electricity. Globally, there is strong evidence of climate change that may be significant over time. It is therefore appropriate to assess what these changes are likely to be in the region and to estimate their impact on the output of the options retained for use in this strategic assessment of power development options.

The results of this climate change risk assessment are:

- Overall, for the northern and central-west regions of the study area, there is a high probability of increases in runoff, and thus generation, compared to historic data.
- For the southern region, there is a high likelihood of changes in seasonality of runoff, resulting in lower effectiveness for flow regulation of smaller reservoirs.

In northern and central-west regions of the study area, there is a high probability of increases in runoff, and thus generation.

For the southern region, there is a high likelihood of changes in seasonality of runoff, and lower effectiveness for flow regulation of smaller reservoirs.

As most of the power development options that have been retained are located in the northern part of the region, the impact of climatic change will be positive for the development of the portfolios of generation options. No sensitivity analyses for climate change will be carried out, since they would only present higher energy availability than current conditions indicate.

POWER DEVELOPMENT PORTFOLIOS

A number of illustrative portfolios of power investments are developed to indicate the range of choices available in the region to meet demand. In assembling the portfolios, two major development approaches are considered: **independent development** by each country and a **regional cooperation approach** in which the six countries plan for a joint development of resources.

With **independent development**, mostly in-country options are considered along with the base load growth scenario described above. This is the reference case to which impacts of the other portfolios were compared (Portfolio 1Aa, as shown in Table 4 below).

With **regional cooperation**, three **strategies** to develop power portfolios were considered to meet the demand based on three of the load growth scenarios described above (medium, high and transformation) (see Table 4 below). The **strategies** were:

1. Maximise the use of the **best-evaluated options** available within the region. This strategy leads to heavy reliance on hydroelectric options with the attendant risk of power shortages due to drought conditions.

2. Make use of attractive resources while enhancing **technological diversification**. This strategy reduces reliance on hydroelectric facilities, but increases the cost of power and involves the use of thermal power options that are less attractive from an environmental and social point of view.

3. Make use of attractive resources while enhancing **geographical diversification**. This strategy ensures that each country, in the long term, is not overly dependent upon its neighbours, but at increased financial, environmental and social cost.

Table 4: Nomenclature Used In Portfolio Development				
Power Development Approaches	**1. Independent**	**2. Regional Cooperation**		
Strategies to Develop Power Option Portfolios	**A) Primarily National Options**	**B) Best Evaluated Options**	**C) Technological Diversification**	**D) Geographical Diversification**
Load Growth Scenarios	**a** - Base (growth in demand of 3.7% to 4.0%), one portfolio examined:			
	Portfolio 1Aa			
	b - Medium (growth in demand of 5.6% to 6.3%), three portfolios examined:			
		Portfolio 2Bb	Portfolio 2Cb	Portfolio 2Db
	c - High (growth in demand of 6.8% to 8.1%), two portfolios examined:			
			Portfolio 2Cc	Portfolio 2Dc
	d - Transformation (growth in demand of 5.1% to 15.0%), one portfolio examined:			
		Portfolio 2d*		
Sensitivity Analysis	Limited level of readiness (S1):			
			Portfolio 2Cb (S1)	
	Allowing import options (S2):			
			Portfolio Cb (S2)	
	No comparative analysis; only screening of options (S3):			
			Portfolio 2Cb (S3)	
Note: as the transformation scenario would require all the identified power options in the region it is not appropriate to give the portfolio an identifier for a specific strategy.				

As also shown in Table 4, **six power development portfolios** were prepared to illustrate how applying these different strategies under different load growth scenarios would influence the choice of investments for a NELSAP Indicative Power Development Strategy. Three portfolios (2Bb, 2Cb and 2Db) were based on the medium load growth scenario, and applied all three strategies. Two portfolios (2Cc and 2Dc) were based on the high load growth scenario, and applied only the technological and geographical diversification strategies since, as it turned out, all the best-evaluated options would be used up with the medium load growth scenario. The sixth portfolio (2d) was based on the transformation scenario and required the use of all identified options in the region.

These analyses indicate the following:

- The independent approach to power development leads to lower power availability and the use of smaller, less cost-effective and less environmentally acceptable development options.
- There is very little difference in the early years of the period of analysis between portfolios representing the best-evaluated options, technological diversification and geographical diversification. This applies in terms of option selection, investments, present value of costs and transmission requirements.
- From a power sector planning perspective, security of supply is an important criterion and geographical diversification is preferred. On the other hand, the history of

droughts in the region suggests that technological diversification should be emphasized. As mentioned above, there is little difference between these two strategies. Thus, for purposes of the NELSAP Indicative Power Development Strategy recommended below, the technological diversification strategy is used.

- The medium and highly load growth scenarios can be met with power development options from the region but these growth scenarios will not materially improve the standard of living of the population in the region.
- To significantly improve the standard of living of the people in the region, the transformation scenario would be needed, however, there are insufficient resources in the region to satisfy that demand.

In addition, **three sensitivity tests** were applied to the strategy of enhanced technological diversification in order to assess:

- The impact of including options that have not yet been adequately studied on the portfolio of projects assembled (Portfolio 2Cb [S1])
- The impact of power imports at a defined unit cost of power on the portfolio of projects assembled (Portfolio 2Cb[S2])
- The impact of eliminating the comparative analyses of options and considering only financial cost in determining the order of installation of options on the portfolio of projects assembled (Portfolio 2Cb[S3])

Three sensitivity tests:

- *Include options not sufficiently studied*
- *Include imports*
- *Eliminate comparative analysis*

The sensitivity tests indicate that:

- The replacement of local options by imports is attractive provided such power is available for less than 3¢US/kWh
- It is appropriate to study further some of the options that were set aside initially due to lack of information.
- Portfolios developed without benefit of a comparative analysis do not lead to any cost savings, but increase environmental and social impacts.

Based on the portfolio analysis a NELSAP Indicative Power Development Plan has been prepared outlining a proposed agenda for regional power development in the NELSAP region including transmission interconnection. The plan is further expanded into a broader strategy with recommendation on regional transmission interconnection and legal and regulatory reform.

NELSAP INDICATIVE POWER DEVELOPMENT PLAN

Table 5 presents an indicative power development plan. During the early years of the analysis, there are limited ways in which the load can be met, thus the options in all three strategies are the same. For the period beyond about 2015, there is sufficient time available to carry out the required studies to prepare options for implementation and therefore decisions need to be made as to the strategy that is to be followed. The key issues in the decision are:

- The strategy of using the best evaluated options results in a heavy reliance on hydro options with the attendant risk of drought. It also leads to a heavy reliance by some countries on those countries with abundant hydro resources

Table 5: Mid-Long Term on Power Dates – NELSAP Indicative Power Development Plan			
Year	**Addition**	**Country**	**Capacity Addition (MW)**
2009	Gas Turbines Combined Cycle Diesel	Tanzania Tanzania Tanzania	120 60 10
2010	Geothermal Kivu engine #2 Combined cycle unit	Kenya R/DRC Tanzania	70 30 60
2011	Kivu engine #3 Gas turbine	R/DRC Tanzania	30 60
2012	Bujagali 1 – 4 Rusumo Falls	Uganda B/R/T	200 61.5
2013	Geothermal (Suswa) Kabu 16 Kakono	Kenya Burundi Tanzania	70 20 53
2014	Bujagali 5 Ruzizi III Gas Turbine	Uganda R/DRC* Kenya	50 82 60
2015	Ruhudji	Tanzania	358
2016	Geothermal (Menengai)	Kenya	140
2017	Kivu engine #4 Geothermal (non-specified) Karuma	R/DRC Kenya Uganda	30 140 200
2018	Wind (two plants) Mombasa 1	Kenya Kenya	60 150
2019	Mombasa 2	Kenya	150
2020	Rumakali Mchuchuma (Units 1 and 2) Mombasa 3	Tanzania Tanzania Kenya	222 200 150

Notes:
B/R/T = Burundi, Rwanda and Tanzania
R/DRC = Rwanda and Democratic Republic of Congo
* Ruzizi III could be developed by Burundi, DRC and Rwanda

- The strategy of technological diversification reduces reliance on hydro options but includes more options that are less attractive. There remains, though the issue of perhaps a disproportionate reliance by some countries on others
- The strategy of geographical diversification addresses the issue of perhaps a disproportionate reliance by some countries on others but includes more options that are less attractive.

Another key element is the rate of growth of demand in the region and the resources that are developed to meet this load. As mentioned previously, the base, medium and high load growth scenarios will not change appreciably the standard of living in the region; only the transformation scenario will do so. However, that scenario will use up all the resources identified in the region (all the best evaluated options, others and screened out options).

Flexibility needed when implementing plan.

For the above reasons, it is essential that the NELSAP power development strategy remain as flexible as possible to meet different economic growth and demand scenarios. For the purpose of this analysis, the portfolio of options selected for the NELSAP Indicative Power Development Plan is based on technological diversification, and the medium load forecast of 5.6% to 6.3% per year (2Cb). Options not listed in Table 5 but listed in Table 3 (best evaluated and others) will be needed to implement under the high and transformation growth scenarios. These include the options shown in Table 6.

Table 6: Options Necessary to Implement the High Growth and Transformation Scenarios

Location	Option	Capacity (MW)
Kakono	Hydro	53
Mpanga	Hydro	144
Mutonga	Hydro	60
Songwe	Hydro	330
Upper Kihansi	Energy only	
Generic where required	Additional combined cycle plants	As required
Mombasa	Thermal plants fuelled with LNG, assumed in the number and sizes needed	As required
Mchuchuma	Additional coal-fired units	400
Mombasa	Thermal plants fuelled with coal imported from South Africa or elsewhere, assumed in the number and sizes needed.	As required

These options could be used if the load grows at a rate greater than the medium load growth scenario or of different development strategies are accepted.

CUMULATIVE IMPACTS

The cumulative impacts of the NELSAP Indicative Power Development Portfolio are assessed compared to independent development (in other words, it uses Portfolio 1Aa as a reference point). The cumulative environmental impacts are analysed by river basin. The cumulative social impacts extend beyond the borders of a river basin and are much more related to government administrative units.

Cumulative impacts assessed by comparing impacts for the best evaluated options to the independent development situation.

The approach taken is to compare the portfolio based on comparing the best-evaluated options and the medium load growth scenario (Portfolio 2Bb) with Portfolio 1Aa, and then to indicate the incremental impacts in going from Portfolio 2Bb to the portfolio emphasising technological diversification (Portfolio 2Cb) and then to the portfolio emphasising geographical diversification (Portfolio 2Db).

Environmental Impacts of Portfolio 2Bb

As most of the options in Portfolio 2Bb are hydroelectric, the environmental impacts would be bounded by river basins and not by political or administrative boundaries. For that reason, the environmental impacts are discussed below by river basin.

Lake Tanganyika Basin (includes Kabu 16, Ruzizi III and Lake Kivu methane options):

- As all the hydroelectric options are run-of-river, there would be no change in the flow regime
- Water quality and riparian and vegetative resources would be improved because of the reduction in nutrient flow (with attendant reduction in water hyacinths)
- No impact is expected on fisheries since the options would be built where an obstacle to the migration of fish already exists

Lake Nyasa/Malawi Basin (includes Rumakali and Songwe options):

- The reservoir associated with the Songwe option would reduce flood flows and increase evaporation, but would stabilise the river bed and increase dry season flows
- The reduction in nutrients and change in flow regime could have a negative impact on the wetlands in the delta area
- Migratory fish could be affected; there is insufficient data to assess the degree

Rufiji River Basin (includes Ruhudji option):

- There would be a reduction in flood flows, an increase in dry season flows and an increase in evaporation
- No migratory fish; wetlands are too far away to be affected

Tana River Basin (includes Mutonga option):

- Would eliminate residual flooding
- Possible reduction in riverine forest could increase pressure on two rare primate species
- Potential presence of migratory eels; importance of impact cannot be assessed without EIA

Lake Victoria Basin (includes Rusumo Falls and Kakono options):

- Reduction in flood flows, slight increase in dry season flows, all absorbed by Lake Victoria
- Virtually no change in evaporation/ evapotranspiration rates
- Reduction in wetlands could have an impact on migratory birds; additional studies are required to assess the impact

Reduction in flood flows, reduction in wetlands in Lake Victoria Basin; no change in evaporation and evapotranspiration rates.

- Potential presence of migratory fish; importance of impact cannot be assessed without EIA

Victoria Nile Basin (includes Bujagali and Karuma options):

- As options are run-of-river, there would be no impact on flow regime
- Slight reduction in sediment and nutrient flow would lead to improved water quality
- Some localised loss of habitat

Cumulative impact on downstream Nile (includes only the Lake Victoria Basin and the Victoria Nile Basin - Rusumo Falls, Kakono, Bujagali and Karuma options):

- Virtually no change in flow regime as only Rusumo Falls option would cause small localised changes in flow regime, which would be absorbed by Lake Victoria; all other options are run-of-river
- Possible slight reduction in sediment and nutrient flow would lead to improved water quality
- Virtually no change in evaporation/ evapotranspiration rates

Socio-economic Impacts of Portfolio 2Bb

As most of the options in Portfolio 2Bb are hydroelectric, the socio-economic impacts would be local or regional, but not necessarily bounded by river basins. For that reason, the socio-economic impacts are discussed below in a regional context, although the concept of the impact on river basin is retained to provide similarity for comparison with the environmental impacts discussed above.

Impacts affecting all options:

- Improved employment due to construction and operation of the options
- Risk of increase in communicable diseases due to influx of workers and opening of sites; mitigation programs can minimise these impacts

Overall: Improved employment but risk of increase in communicable diseases due to work force.

- No change in river navigation as options would be located at existing obstacles; river crossings could be facilitated by the construction of new dams with reservoirs if so designed. Most options are run-of- the river options with no major reservoirs.

Northern part of Lake Tanganyika and Kagera watersheds (includes Rusumo Falls, Kakono, Kabu 16, Ruzizi III and the Lake Kivu methane options):

- A potential agricultural boom due to increase in irrigated lands
- A risk of increases in waterborne diseases
- Increases in human pressure due to resettlement and refugee movement in overpopulated areas

Lake Nyasa/Malawi and Rufiji River Basins (includes Rumakali, Songwe and Ruhudji options):

- Possible loss of irrigated land due to Songwe reservoir; potential agricultural boom due to increase in irrigated lands at other options

- A risk of increases in waterborne diseases

Tana River and eastern part of Lake Victoria (includes Mutonga option and geothermal options):

- Loss in irrigated lands and possible out-migration of farmers
- There might be interference with an irrigation project at Bura
- A risk of increases in waterborne diseases
- Higher H_2S emissions

Victoria Nile watershed (includes Bujagali and Karuma options):

- Some negative impact on tourism as a section of rapids will be closed to white-water rafting; mitigation measures being implemented include support to tourism industry to promote other areas

Cumulative impacts on downstream Nile:

- Economic development, river navigation, population density and impacts on health in the areas of the options being considered are clearly not applicable.
- As there are no significant changes in the flow regime there would be no consequent changes in agriculture.

Cumulative Impacts of Other Portfolios

Overall, there are not many differences between the Portfolio based on Best Evaluated Options, Medium Load - Portfolio 2Bb and the Technological and Geographical diversification portfolios, The differences are summarized below:

Portfolio 2Bb vs Portfolio 2Cb	Portfolio 2Bb vs Portfolio 2Db
Best Evaluated vs Technological Diversification	Best Evaluated vs Geographical Diversification
Removal of Songwe (H) Removal of Mutonga (H) Addition of Mombasa (C) Addition of Mchuchuma (C)	Removal of Songwe (H) Removal of Rumakali (H) Addition of Mombasa (C)

Because the portfolios differ so little, the difference in cumulative impacts between the Portfolio of Best Evaluated Options and the two diversification portfolios is small. Moreover, since the two diversification portfolios share some of the same modifications from the portfolio of Best Evaluated Options, i.e. removal Songwe (hydroelectric option) and addition of Mombasa (coal option), the differences are even less determinant.

The main differences between the two diversification portfolios and the Best Evaluated Options portfolio, are that the two diversification portfolios (2Cb and 2Db) increase the air emissions, greenhouse gases and pollutants responsible for acid rains compared to 2Bb. This will translate into a cumulative impact that will be perceptible at the regional level. The other differences due to the removal of Songwe, Mutonga or Rumakali will be much more localized and will translate into less change or no change in the hydrology and aquatic environment of the rivers involved. It will also translate into less positive socio economic impacts because less direct and indirect jobs will be created since dams and power plants will not be built. Some of these jobs will be created where the coal projects will be located, but the construction activities are less important than for hydropower plants and dams, and overall economic benefits would be smaller.

Apart from the advantages derived from the diversification, whether technological or regional, the two portfolio do not offer environmental or social benefits compared to the Best Evaluated Options portfolio (2Bb).

Comparison of the Independent and the Regional Integration Approaches

The most significant differences between all portfolios lie between the Independent portfolio (1Aa) and any of the Regional Cooperation portfolios (2Bb, 2Cb, 2Db). Over the Independent portfolio, any of the regional portfolios will have the following advantages:

- Decrease pressure on deforestation
- Less greenhouse gases and other air pollutants
- Better regional integration more reliable electricity supply
- Less water related conflicts
- Better environmental planning and management with positives consequences on management of aquatic resources: fisheries and biodiversity
- Improvement of socio-economic conditions, including alleviation of daily chores such as wood gathering.

INSTITUTIONAL ISSUES

There does not seem to be any major legal or regulatory impediment to regional cooperation. Indeed, there is cross-border trade in electric power. There are, however, some key issues that would need to be resolved before some of the options identified above can be implemented. These include:

- Certain hydropower options span international boundaries in trans-boundary rivers. Before they can be financed, lenders will insist that agreements be concluded between the countries on the joint use of the water.
- Some of the options may be installed in one country for the immediate benefit of another country. This will require power purchase agreements as well as transmission access agreements with other parties.

Significant cross-border trade may require strengthening of transmission systems as well as close cooperation between the load dispatch centres of each affected country. In this context, for the efficient functioning of a regional electricity market (at some point in the future), the member countries need to articulate a minimum platform for cross-border power trade that embraces the following:

Significant cross-border trade in electricity will require strengthening of transmission systems as well as close cooperation between the load dispatch centres.

- Each member country should decide on the degree of security of power that is appropriate to it, given the availability and cost of resources and the level of reliance it is willing to place on the power systems of neighbouring countries.
- Imports/exports need not be regulated per se or, if they are, as little as possible, to ensure only that (a) such trading is not more costly than native generation when such

supply is available; and (b) operational security of the network and quality of supply are not compromised.

If a country opts for a multi-buyer system to facilitate and foster regional trade, then it is important to have open access to the transmission network and transparent procedures and non-discriminatory rules for pricing and volume of trade.

OVERALL STRATEGIC CONCLUSIONS FOR THE NILE EQUATORIAL LAKES REGION

This strategic/sectoral and environmental and social assessment of regional power development options in the NEL Region leads to the following conclusions:

<u>Load Growth:</u>

- Under the base forecast scenario, electricity use would increase by less than 10% over current levels of about 95 kWh/capita/per year. Under the medium load growth scenario, consumption would increase to 141 kWh/capita, an increase of 53% over current levels, but not even half of the current average for all of Africa (even excluding the wealthier countries) of 320 kWh/capita. For the high growth scenario, consumption would reach 181 kWh/capita, an increase to almost double the current level in the region, but still well under the current average for all of Africa (even excluding the wealthier countries).
- It is only under the transformation scenario that consumption would reach 318 kWh/capita, which is about the current average for all of Africa excluding the wealthier countries. This is still only about one-third of the level reached by the developing countries of the world, even when the wealthier of them are excluded from the comparison. It is also well under the value of 500 KWh/capita/year, which is regarded as a minimum quality of life.

<u>Resources:</u>

- By the end of the period of analysis (2020), three-quarters of the power development options that passed the screening will have been required to meet the medium load growth scenario.
- In order for the countries to be able to cooperate regionally in the development of their power sectors, a backbone of transmission facilities needs to be built as soon as practicable.

<u>Cumulative Impacts of Power Development:</u>

- The cumulative impacts were considered using the development of the region with no regional integration as a reference case. This would include continued suppressed electricity demand and the installation of smaller and less attractive power development options than regional integration would foster.
- The cumulative impacts on the environment from multiple hydro projects in a river basin or several thermal plants compared at the global level are relatively minor; the most significant would be emissions from thermal plants and potential impacts on wetlands in the Kagera River and the Rufiji River.
- Only two of the five river basins studied flow into the Nile beyond the Victoria Nile. These contain only four hydro power development options (Bujagali, Kakono, Karuma, Rusumo Falls). Appropriate operation of these options will allow the flows out of the Lake Albert towards the Sudan and the Sudd marshes to simulate the natural flow patterns.

Climate Change:

- The runoff in the northern part of the region is expected to increase due to climate changes. On the other hand, the runoff in Southern Tanzania is expected to remain at current levels or to decrease slightly.
- The overall impact of climate change on the power output of the NELSAP Indicative Power Development Portfolio is expected to be positive over the period of the assessment.

Investments Required:

- To meet the medium load growth scenario for all three regional cooperation strategies, the total capital investment required over the period 2005 to 2020 is very similar at just under US$6 billion (includes US$0.7 billion up to 2009 inclusive).
- The high load growth scenario would require over 50% more investment – US$8.25 billion to meet an additional demand of 1300 MW.
- The transformation scenario would require over three times more investment – US$16 billion.

Over US$6 billion required to meet medium load growth scenario, regardless of strategy selected.

Imports:

- Imports from Inga in the DRC, or from other sources, would be attractive if power can be delivered into the region for under approximately US 3¢/kWh.

RECOMMENDATIONS AND NELSAP INDICATIVE POWER DEVELOPMENT STRATEGY

The following are specific recommendations (based on the medium load growth scenario):

- Each of the following options should be designed and built as soon as possible:

Power Development Options

Country	Option	Capacity
Uganda	Bujagali	250 MW
Burundi	Kabu 16	20 MW
Tanzania	Kakono	53 MW
Kenya	Geothermal plants in Kenya	2 by 70 MW
Rwanda/DRC	The second & third phases of the Lake Kivu gas engines	30 MW each
Tanzania	Ruhudji	358 MW
Burundi, Rwanda & Tanzania	Rusumo falls	62 MW
Rwanda & DRC	Ruzizi III	82 MW

There is an urgent need for additional electricity installations. 1025 MW of the best evaluated options should be implemented as quickly as possible.

All of these options are required during the period 2009 to 2015. The order of installation of these options would depend upon the speed with which the additional studies required for each can be completed.

- During the period 2009 to 2015, provide additional gas turbines, diesels and some combined cycle plants to fill an expected shortfall that cannot be met by the implementation of the above power development options.
- Planning should begin now for the installations required after 2015. Such planning should take account of the strategy for development that the governments of the region opt for (best evaluated options, technological diversification or geographic diversification). Planning should be based on the medium load growth scenario but should be flexible enough to advance new power development options if the growth is higher than the medium load growth scenario.
- Replace local plants with imports from outside the region if such imports cost less than US 3¢/kWh (levelised unit cost over the life of the purchases).

Additional Studies:

- Carry out studies on several of the power development options that have only been identified and studied to the reconnaissance level. These include:

Country	Option	Capacity (MW)
DRC	Kiymbi	43 (rehabilitation)
	Budana	13 (rehabilitation)
	Piana Mwanga	38 (rehabilitation)
	Bangamisa	48
	Babeda 1	50
	Sisi 3/5	174-205

- Carry out further studies of the Malagarasi Cascade (including Igamba Falls) from the point of view of development for the region (current information is for options that use only a small fraction of the potential of the cascade).

Transmission Requirements:

- The East African Community Master Plan[5] has proposed a substantial investment in transmission lines and substations within each of the EAC countries. In addition, the plan proposes two interconnections:
  - a 330 kV transmission line, Arusha, Tanzania-Embakasi (Nairobi), Kenya
  - a double circuit 220 kV transmission line, Tororo-Lessos (note the countries)

To take advantage of the synergies of integrated development, transmission needs to be reinforced in each country AND interconnections need to be expanded and reinforced.

[5] BKS Acres, East African Power Master Plan Study, Final Phase II Report, March 2005

During the assessment of the needs of Burundi, Rwanda and Western Tanzania, the following transmission lines were proposed:

- 110 kV line from Kigoma, Rwanda to Rwegura, Burundi
- 132 kV line from Kabarondo, Rwanda passing near Ngara to Biharamuro in the Kagera Province of Tanzania
- 132 kV line from near Ngara, Rwanda to Gitega, Burundi
- 110 kV line from Gitega, Burundi through Bururi to Kigoma, Tanzania

- The routing of the first three of these lines is based on the assumption that the Rusumo Falls project would be built so that these lines would evacuate power from that plant to Burundi, Rwanda and Western Tanzania.
- In addition to the above transmission requirements, additional lines are required to connect more strongly the East Africa Community (Kenya, Tanzania and Uganda) with Burundi, Eastern DRC and Rwanda:
  - A 132 kV line from Mbarara to Kigali
  - A 132 kV line from Bulyanhulo to Biharamulo, Tanzania

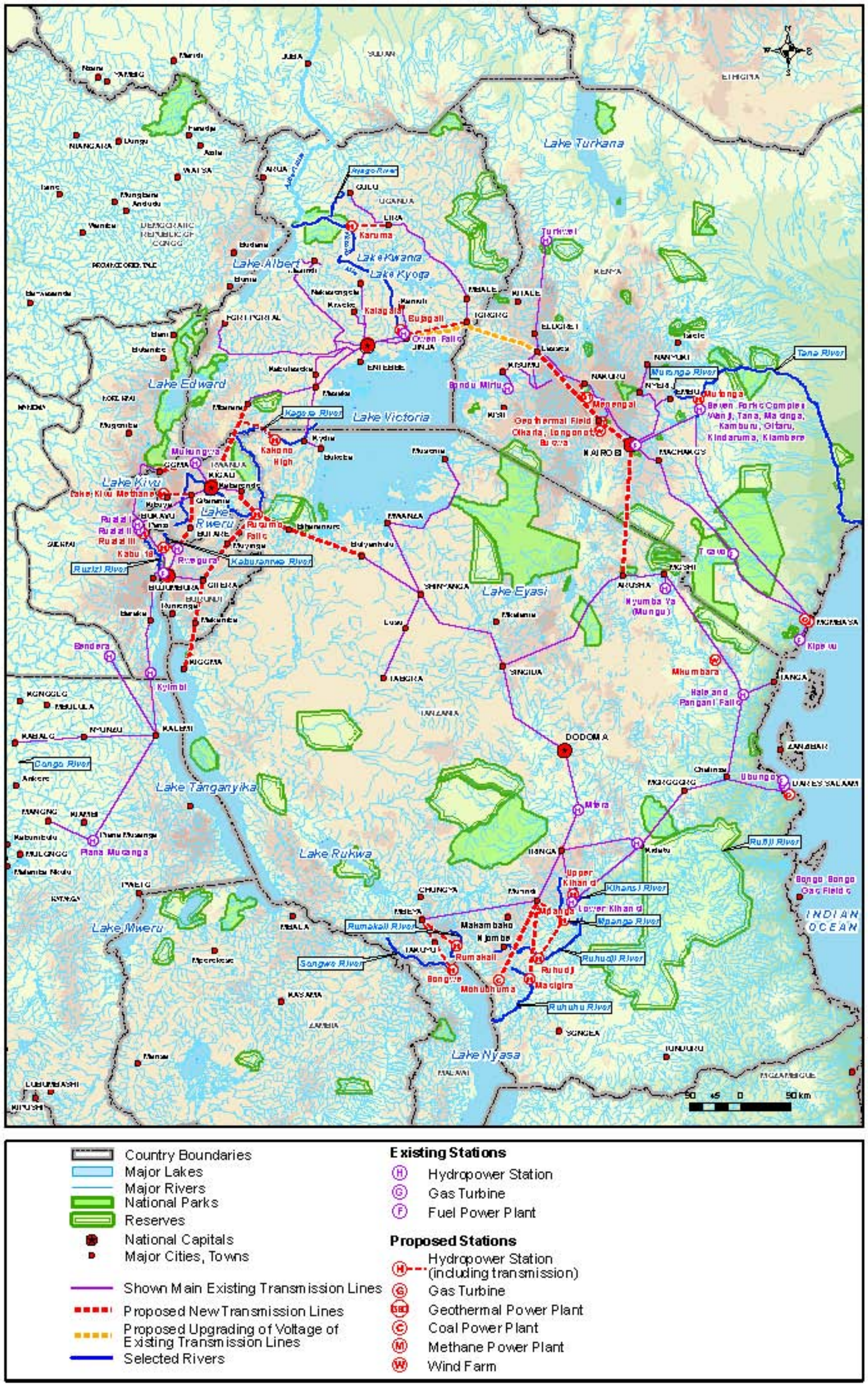
Coordination and Integration:

- The governments of the six countries should decide on the level of coordination and integration of their power sectors and then carry out the appropriate actions on changes to the legal and regulatory framework to facilitate, to the desired level, power trading between the countries of the region.
- There does not seem to be any legal or regulatory impediment to regional cooperation. There are however, some issues that would need to be resolved before some of the options identified above can be implemented. This includes agreements between the countries on the joint use of the water will need to be concluded for the Ruzizi III and Rusumo Falls options as they are located on international boundaries;
- Significant cross-border trade may require strengthening of transmission systems as well as close cooperation between the load dispatch centres of each affected country.
- For the efficient functioning of a regional electricity market (at some point in the future) the member countries need to articulate a minimum platform for cross-border power trade that embraces the following security of supply and policies on imports and exports:
- If a multi-buyer system is promoted in the region to facilitate and foster regional trade, then it is important to have:
  - Access to transmission networks are open, transparent and non-discriminatory;
  - Functional unbundling, at least in the initial stages, be limited to transmission and generation coupled with the creation of an independent transmission system operator at the national level that would provide transmission services and open access same-time information;

- Transparent pricing arrangements for transmission services (also called wheeling charges or transit fees) and ancillary services.

- Countries where options are located must have institutional capacities to ensure full implementation of national laws, standards and regulations with regard to environmental impact assessments, community impacts, mitigation and monitoring.

Figure 3- Map Showing Regional Development of Power and Transmission Requirements to 2015 (Regional Approach, Technological Diversification, Strategy and Medium Load Growth Scenario)



List of Abbreviations

AEC	African Economic Community
AU	African Union
bcf	Billion cubic feet
BReTIN	Backbone Regional Interconnection Network
CEQ	Council on Environmental Quality
Cf	Cubic feet
CIA	Cumulative Impact Assessment
CITES	Convention on International Trade in Endangered Species
COMESA	Common Market for Eastern and Southern Africa
DRC	Democratic Republic of Congo
DSM	Demand side management
DWT	Dead-weight tonnes
EAC	East African Community
EAPMP	East African Power Master Plan
EIA	Environmental Impact Assessment
FOB	Free on Board
GHG	Greenhouse Gases
GJ	Gigajoule
GRDC	Global Runoff Data Centre
GNI	Gross National Income
GtC	Gigatonnes of carbon emissions per year
GWh	Gigawatt-hour
HEPP	Hydroelectric Power Plant
HIPC	Highly Indebted Poor Countries
kWh	Kilowatt-hour
IDA	International Development Association
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IUCN	World Conservation Union (formerly International Union for Conservation of Nature and Natural Resources)

LNG	Liquefied Natural Gas
MCA	Multi-Criteria Analysis
Mt	Million tonnes
MW	Megawatt
NBI	Nile Basin Initiative
NCAR	National Center for Atmospheric Research
NEL	Nile Equatorial Lakes
NEL-CU	Coordinating Unit for NELSAP
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
NePAD	New Partnership for African Development
NGO	Non Governmental Organization
PET	Potential Evapotranspiration
PPP	Purchasing Power Parity
PSC	Project Steering Committee
PF	Plant Factor
PV	Photovoltaic
RDC	République Démocratique du Congo (note English acronym used : DRC)
SADC	Southern African Development Council
SAPP	Southern Africa Power Pool
SENOKI	Société d'électrification du Nord Kivu
SNEL	Société national d'Électricité (the electric utility in DRC)
SSEA	Strategic/Sectoral Social and Environmental Assessment
SSEA I	SSEA applied to Burundi, Rwanda and western Tanzania
SSEA II	SSEA extended to include Kenya, Uganda, all of Tanzania and eastern DRC
STC	Standard Testing Conditions
Tcf	Trillion cubic feet
TWf	Terawatthour
UNEP	United Nations Environment Programme
Wp	peak-watt
WWF	Worldwide Fund for Nature (World Wildlife Fund)

List of Definitions

Term	Definition
Captive Power	Electricity produced for consumption by the producer of that energy (i.e. the energy produced by a power plant run by a hotel (or industry, agency or individual) for the exclusive use of that hotel
Demand	The maximum amount of electricity required by a system during any one-hour period over a year, measured in megawatts (MW)
Electric Energy	The amount of electricity consumed over a period of time, measured in kilowatt-hours (kWh). The summation of the demand by the system during each hour of the period
Energy Payback Ratio	The ratio of the energy produced by a power development option over its expected useful life divided by the amount of energy required to build and operate the facility
Firm Capacity	The maximum output of a power development option that can be guaranteed 19 years out of 20 based on historical records
Group A	In the transmission analysis, the countries of Burundi, eastern DRC and Rwanda
Group B	In the transmission analysis, the countries of Kenya, Tanzania and Uganda
Option	A specific proposed means of developing and producing electricity. It applies to the technology used (hydro, thermal wind, solar, etc.) and to the specific plant as identified by its location (i.e. the Bujagali hydroelectric development or the Mchuchuma Coal-fired thermal plant
PF or Plant Factor	The output of a power development option in GWh on average over a year divided by the installed capacity in MW divided by the number of hours in a year, all multiplied by 1000.
Portfolio	A grouping of options that are developed over time during the period of analysis in order to meet the selected load forecast scenario
Project	A specific and existing means of producing electricity.
Scenario	A hypothesis of how a country or a region will develop over the period considered in the assessment. This applies in this work to the regional electricity needs assessment
Strategy	A deliberate pattern for the development of options (i.e. all hydro, all thermal, geographic diversification, etc.)
Suppressed Demand	Electricity that is demanded by customers that the utility cannot supply

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1 INTRODUCTION

The Nile Equatorial Lakes Region of Africa is experiencing an acute lack of electric power. This absence of electricity for the vast majority of the population makes life more difficult in both rural and urban areas, and places a major burden on economic development. Paradoxically, the region has one of the world's highest potential for hydroelectric development, generally on a "run-of-the-river" basis with limited environmental consequences or social disruption.

This assessment, which does not replace detailed project-specific environmental impact assessments or feasibility studies, examines a number of power generation options and ranks them in terms of environmental, social, cost and risk criteria.

The assessment suggests that several of the options merit further consideration and, if properly designed, implemented and operated, would have restricted adverse environmental and social consequences.

1.1 Purpose of the Strategic/Sectoral Social and Environmental Assessment

The purpose of the Strategic/Sectoral Social and Environmental Assessment (SSEA) is to provide an analysis of the social and environmental issues surrounding possible power development options in the Nile Equatorial Lakes Region of Africa and to rank the various options based on a combination of cost, social, environmental and risk considerations.

The SSEA is intended to produce strategic/sectoral level guidance to decision-making in the power sector at the regional and national levels. Specifically:

- To assist the Nile Equatorial Lakes (NEL) riparian countries in their selection of supply options (including interconnections) by contributing to making informed and transparent decision-making before major funds to investigate individual projects are committed.
- To promote the inclusion of environmental and social criteria; assist in screening out inappropriate or unacceptable projects at an early stage. This will reduce upfront planning and preparation costs for public and private investors and minimizing the risk that projects encounter serious problems due to environmental and social considerations.
- To provide an opportunity to look at the option of improving the performance of existing generating assets from economic, technical, social and environmental perspectives.
- To examine the potential cumulative environmental and social impacts of different regional power development portfolios.
- To serve as an instrument to provide information to facilitate consideration by the World Bank Group and other potential financing organizations, both public and private, of possible requests to support the NEL power development program.

The SSEA is intended to complement detailed, project-specific environmental and social impact assessments and does not in any way act as a replacement or substitute for such detailed assessments.

1.2 Scope of the SSEA

The SSEA was carried out over a period of three years from 2003 to 2006. The initial terms of reference included Burundi, Rwanda and Western Tanzania. These terms were enlarged in 2004 to allow for an expansion of the area covered by the SSEA to include all of Tanzania as well as Kenya, Uganda and the eastern part of the Democratic Republic of Congo. They were then expanded again in 2006 to include an assessment of the situation with independent development, the effect of climate change and a deepening of the analysis of the cumulative impacts of power development in the region.

The scope of work of the SSEA of Power Development Options, as defined in the terms of reference includes the following key tasks:

(1) Assessment of the energy policy, legal and administrative framework in the six countries (Burundi, eastern DRC, Kenya, Rwanda, Tanzania and Uganda);

(2) Assessment of the current environmental and social condition in the region;

(3) Power needs assessment for the six countries of the Nile Equatorial Lakes Region;

(4) Identification and screening of power options;

(5) Comparative analysis of power options;

(6) Risk analysis of the options;

(7) Assessment of the potential impact of climate change;

(8) The development of power development portfolios including interconnections;

(9) Assessment of the cumulative impacts of development on the region; and

(10) Mitigation plan for selected power option alternatives.

The assessment focuses on macro-economic issues at the regional level as opposed to the national level. The terms of reference are included as Appendix A.

1.3 Decision-making Context: Energy, Environment and Development

The SSEA recognizes that, although the reliable availability of electric power at reasonable cost improves the quality of life and is essential for economic development, power generation, transmission and distribution facilities may cause environmental degradation, adverse social impacts and provide few economic or social benefits to the populations near or displaced by those facilities. This is particularly the case when power options are planned and implemented without incorporating such considerations as early as possible into the decision-making and design process.

The SSEA process ensures that environmental and social considerations are brought to the attention of the decision-makers within the NEL Riparian countries and at the World Bank Group and other potential financing organizations, both public and private, before irrevocable decisions on power options have been made and/or funds have been committed.

1.4 Context

1.4.1 Energy

Only a very small proportion of the population of the region has access to electric power. The lack of a reliable supply of electricity adversely affects the quality of life and severely constrains economic development throughout the region. In urban centres, power supply is unreliable and, in some areas available for fewer than six hours per day. While larger facilities such as hospitals, hotels and government buildings have access to back-up diesel generating units, the general population has to go without refrigeration, effective lighting and ventilation for long periods of the day. In rural areas, the absence of electric power supply has resulted in reliance on expensive fossil fuels for generators and wood or charcoal for most domestic purposes, thus contributing to deforestation and adding to the workload of women and children.

1.4.2 Water Resources

The water resources of the Nile Equatorial Lakes Region (NEL) are composed of one of the world's greatest complexes of lakes, wetlands, and rivers. The NEL sub-basin includes the headwaters of the White Nile, which are located in the upland plateau and from which water flows northwards via lakes and rivers to landforms at lower altitude. There are strong hydrological and environmental interactions between the individual hydrological units comprising the NEL Region. The water resources of the NEL sub-basin are central to the survival and livelihood of local populations and the sustenance of the region's unique natural ecosystems. There is great potential for these resources to underpin strong economic growth in the region.

The region has traditionally been characterized by economies dependent on rain-fed agriculture and subsistence farming; low industrialization; poor development of infrastructures; and, high population growth and poverty. The population of the six countries that are the focus of the SSEA was estimated in mid 2005 to be in the order of 117 million[1]. Two of these countries (Burundi and DRC) are among the five poorest countries in the world. The population's average access rate to electricity in the NEL region is about five to 10 percent.

1.4.3 The Nile Basin Initiative and the Strategic Action Plan

The Nile Basin Initiative (NBI) provides for an agreed basin-wide framework to fight poverty and promote socio-economic development in the ten Nile countries (Burundi, the Democratic Republic of Congo (DRC), Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda). It directly and indirectly contributes to the achievement of the Millennium Development Goals (MDG)[2]. The NBI is led by a Council of Ministers in charge of Water Affairs from the member states (Nile-COM) with the support of a Technical Advisory Committee (Nile-TAC), and a Secretariat (Nile-SEC). A Strategic Action Program has been established that includes basin-wide projects (Shared Vision Program) designed to lay the foundation for cooperative action, and two subsidiary action programs (SAPs) whose objectives are to promote poverty alleviation, growth and improved environmental management.

The two SAPs established under the NBI are the Nile Equatorial Lakes Subsidiary Action Program (NELSAP) and the Eastern Nile Subsidiary Action Program (ENSAP). ENSAP includes three countries – Egypt, Ethiopia, and Sudan – and focuses on integrated water resources management, flood management, power generation and interconnection, irrigation and drainage and watershed management. NELSAP includes eight countries – Burundi, DRC, Egypt, Kenya, Rwanda, Sudan, Tanzania, and Uganda – and targets investments in power development, transmission interconnection and trade, water resources management, management of lakes and fisheries, agricultural development, and water hyacinth control. A NELSAP-Coordination Unit (NELSAP-CU) coordinates and facilitates the activities of the program.

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1 April 2005 estimate: Burundi = 6.2 million; SNC-Lavalin estimate of the population of Eastern DRC is about 12.9 million; Kenya = 30.8 million; Rwanda = 7.3 million; Tanzania = 36.2 million; and Uganda = 24.0 million for a total of 117.4 million. World Development Indicators Database, World Bank, April 2005

2 Millennium Project Commissioned by the UN Secretary General, September 2004. The MDGs constitute specific, measurable targets that are summarized by the following eight goals: eradicate extreme poverty; achieve universal primary education; promote gender equality and empower women; reduce child mortality; improve mental health; combat HIV/AIDS, malaria and other diseases; ensure environmental sustainability; and develop a global partnership for development.

1.4.4 The Power Development Program of NELSAP

Under the NELSAP program, the NEL riparian countries have specified the need for more power and a more efficient means of sharing power among the NEL region countries. This need is reflected in the short term and long-term objectives of the NELSAP Power Development and Trade Sub-program. The *long-term objectives* of this sub-program are:

- To promote regional economic development and improved quality of life through provision of ample power supply at reasonable prices;
- To increase regional power supply in the NEL region by improving export and import capabilities between NEL member countries; and
- To improve reliability of power supply and the quality of power delivered through interconnecting the currently isolated networks in each country.

The *immediate objectives* are to augment the supply of power to the grids of the region and to provide decision makers with guidance on the development process required to achieve the long-term objectives in the most efficient, economical and socially and environmentally sustainable way.

1.4.5 NBI Shared Vision and NELSAP Scaling-up Strategy

The Shared Vision and Objectives defined in the policy guidelines of the Nile River Basin Strategic Action Program are[3]: "to achieve sustainable socio-economic development through the equitable utilization of, and benefit from, the common Nile Basin water resources." To be more specific, they include:

- To develop the water resources of the Nile Basin in a sustainable and equitable way to ensure prosperity, security, and peace for all its people;
- To ensure efficient water management and the optimal use of the resources;
- To ensure cooperation and joint action between riparian countries, seeking win-win gains;
- To target poverty eradication and promote economic integration; and
- To ensure that the program results in a move from planning to action.

The *NELSAP Five-Year Scaling-up Strategy* includes promoting economic growth, peace and stability. Recent progress in the region has increased the flow of goods, services, ideas, and capital between the NELSAP countries. The strategy is designed to promote cooperative and in-country investment projects in the Nile Equatorial Lakes region within the Nile Basin Initiative framework and boost domestic, regional and foreign investments. The strategy targets water resources related development in two key sectors:

- Natural Resources Management and Development; and
- Power Development and Trade.

The *NELSAP Five-Year Scaling-up Strategy* supports action along three tracks:

Track 1 – Current cooperative inter-country NELSAP projects: Build on early results in the first set of cooperative and inter-country pre-investment NELSAP projects. This entails moving forward with significant power generation projects defined and the core backbone

[3] The Council of Ministers of Water Affairs of the Nile Basin States. February 1999. *Policy Guidelines for the Nile River Basin Strategic Action Program*.

transmission interconnection network for the NELSAP region. Track 1 will provide a fast track to major cooperative development in areas such as power generation, transmission interconnection, multi-purpose river basin development, and fisheries development.

Track 2 – New cooperative inter-country NELSAP projects: Identify and prepare new cooperative and inter-country Nile projects in the NELSAP region. These projects will be in new geographic areas and/or in new sectors not addressed in the first set of NELSAP investment projects.

Track 3 – New consultative or cooperative in-country Nile projects: Identify and prepare new consultative or cooperative in-country Nile projects. Consultation during preparation and implementation of NELSAP project activities, and action at the lowest appropriate level are part of the NBI process, thus supporting in-country actions within the sub-basins of the Nile Basin.

1.4.6 Specific NEL-COM Objectives for NELSAP

The specific objectives that Nile Equatorial Lakes Council of Ministers (NEL-COM) has defined for NELSAP are the following:

- The eradication of poverty;
- The promotion of economic growth; and
- The reversal of environmental degradation.

1.4.7 Lake Victoria Basin Vision and Strategy Framework

The Vision and Strategy Framework for Management and Development of Lake Victoria Basin[4] includes as a principle focus the development of a broad consensus on realistic, achievable objectives and indicators for sustainable management of the Lake basin in a time frame of 15 years, and to develop mechanisms that will enable stakeholders to advocate their interest, provide feedback to government, and monitor progress towards achieving the goals set in the vision process. The national visions for Lake Victoria Basin, as formulated in the national reports, encapsulate some common, shared principles and values:

- Kenya**:** “A Lake basin community enjoying a sustained natural resource base within a well conserved environment providing foundation for economic vibrancy that improves their livelihoods and increases opportunity for full realization of their potential.”
- Tanzania: “A Basin with the resources sustainably managed and communities having high standards of living”.
- Uganda: “A Lake Victoria Basin which is well planned and managed providing sustainable benefits, with a prosperous population meeting their development needs without depleting the natural resources and degrading the environment”.

The three national visions all express that future development in the Victoria Lake Basin will have to take into consideration the closely inter-linked dimensions of:

- Economic development as a basis for prosperous populations and improved livelihoods;
- Sustainable use of the natural resource base; and

4 A report by Statkraft Grøner in association with Norwegian Institute for Urban and Regional Research, Cornell University, Makerere Institute of Social Research, Dar-Es-Salaam University College of Land and Architectural Studies, Agrechs Development Consultants in collaboration with The Regional Task Force, September 2003.

- Protection of the environment.

These dimensions are all fundamental to capture the core values of sustainable development: poverty alleviation, quality of life and environmental protection.

The framework produced prioritized strategies in five sectors:

- Ecosystems, Natural Resources and Environment;
- Production and Income Generation;
- Living Conditions and Quality of Life;
- Population and Demography; and
- Governance, Institutions and Policies.

1.5 Organization of the Report

The Final Report of the Strategic/Sectoral, Social and Environmental Assessment (SSEA) of Power Development Options in Nile Equatorial Lakes Region consists of this Report in two volumes. It contains fifteen chapters followed by thirteen appendices.

This **Chapter 1** provides an introduction to the strategic/sectoral social and environmental assessment of power development options.

Chapter 2 presents the approach and analytical process followed.

Chapter 3 presents a review and analysis of the legal, policy and administrative context of the SSEA study.

Chapter 4 presents a description of the current socio-economic and environmental issues as well as the status of the power sector.

Chapter 5 illustrates the electricity needs assessment for the region on the basis of various growth scenarios taking into account the input received during the Seventh PSC Meeting and the Third Stakeholders Consultation Workshop held in Nairobi in April 2005. It also presents a scenario of the electricity needs to transform the region into one with economic and social prosperity.

Chapter 6 identifies available power options in the NEL-Region. This includes new hydro options, thermal power options, renewable energy and off-grid options.

Chapter 7 presents a screening of the identified power options and **Chapter 8** presents the options that were retained from this screening process.

Chapter 9 presents a comparative analysis of the options taking account of cost, environmental and social criteria. This is continued in **Chapter 10** where the various risks are identified and assessed.

The power development options retained in Chapter 8 are ranked in **Chapter 11** taking account of the results presented in Chapters 9 and 10.

Chapter 12 examines the potential for climate change and assesses the impacts of such changes.

Chapter 13 groups options retained into several different power development portfolios**,** taking account of the ranking of individual options, the possibility of interconnections and several strategies for development.

Chapter 14 provides an assessment of the cumulative impacts of a portfolio of generation additions that responds to the countries in the region developing on an independent basis and then presents the incremental impacts if the region develops in an integrated manner. This includes the demarcation of spatial boundaries, the identification of the main regional trends and issues, the description of resources and resource-uses vulnerable to cumulative impacts, the identification of cause-effect relationships for the main issues, an analysis of the "no-projects" alternative, an analysis of the cumulative impacts for the baseline portfolio and an environmental management plan.

Chapter 15 presents the conclusions, an Indicative NELSAP Power Development Strategy and recommendations of the report.

The appendices cover the following areas:

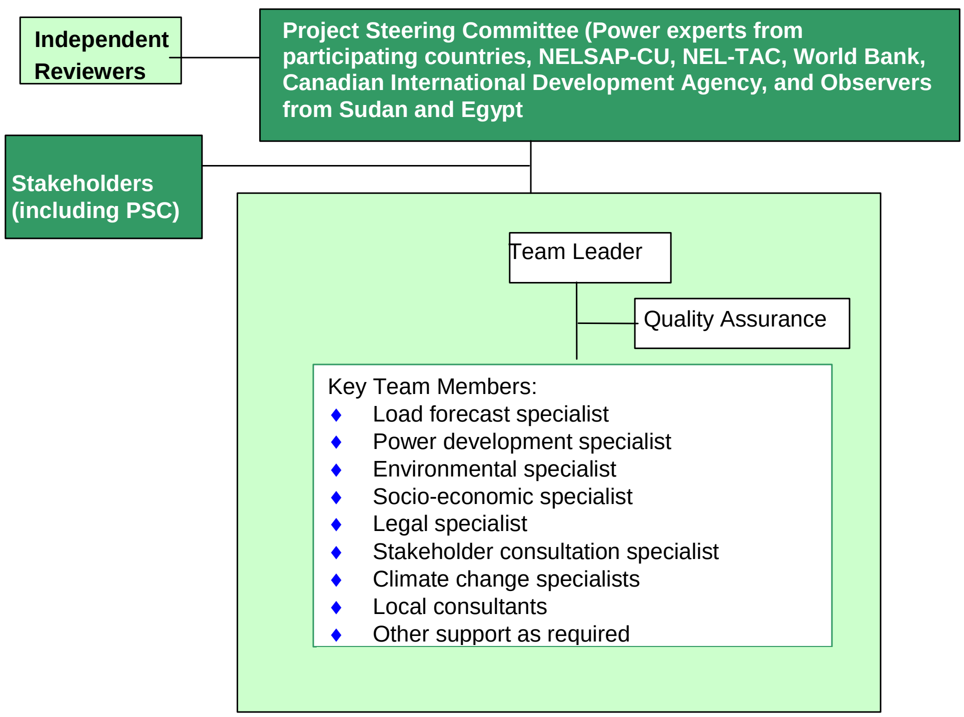
- Terms of Reference
- Synopsis of Stakeholder Consultations
- Synopsis of Environmental and Social Policies as well as their Legal and Administrative Frameworks
- Synopses of Energy Policies and related Legal and Administrative Frameworks
- Supporting information for the regional power needs assessment
- Identification of New Power Options
- Planning Parameters and Costing of Options
- Mitigation Measures
- Data Sheets for Retained Power Development Options
- Comparative Analysis of Options
- Assessment of Climate Change and Impact on Runoff
- Development of Portfolios
- References and Sources of Documents

2 APPROACH AND ANALYTIC PROCESS

2.1 Organization and Conduct of the Assessment

The assessment has been carried out by SNC-Lavalin International Inc., of Canada, in collaboration with Hydro-Quebec International, of Canada (the Consultant)[1]. Also included on the study team were Vincent Roquet et Associés Inc. (consultant for stakeholder consultations); Stratus Consulting Inc.), Michael A. Stevens, Consultant, WL Delft Hydraulics (consultants for climate change); Experco International (local consultants for Burundi, Eastern DRC and Rwanda); GIBB Africa Limited (local consultant for Tanzania and Kenya); and Sustainable Resources Network (local consultant for Uganda). This organization is shown schematically in Figure 2-1.

Figure 2-1 - Organisational Structure for SSEA



The Consultant was guided by a Project Steering Committee (PSC), which is composed of representatives from the World Bank, power experts and NELSAP-TAC members from Burundi, DRC, Kenya, Rwanda, Tanzania and Uganda, observers from Sudan and Egypt, NELSAP-CU, and a representative from the Canadian International Development Agency (CIDA), the role of which was to guide the implementation of the SSEA. The Consultant was contracted by the World Bank.

Two independent reviewers provided advice, expertise and strategic guidance throughout the process. The Review Panel reported to the Steering Committee.

The SSEA was conducted over a three-year period from 2003 to 2006 and consisted of the following stages:

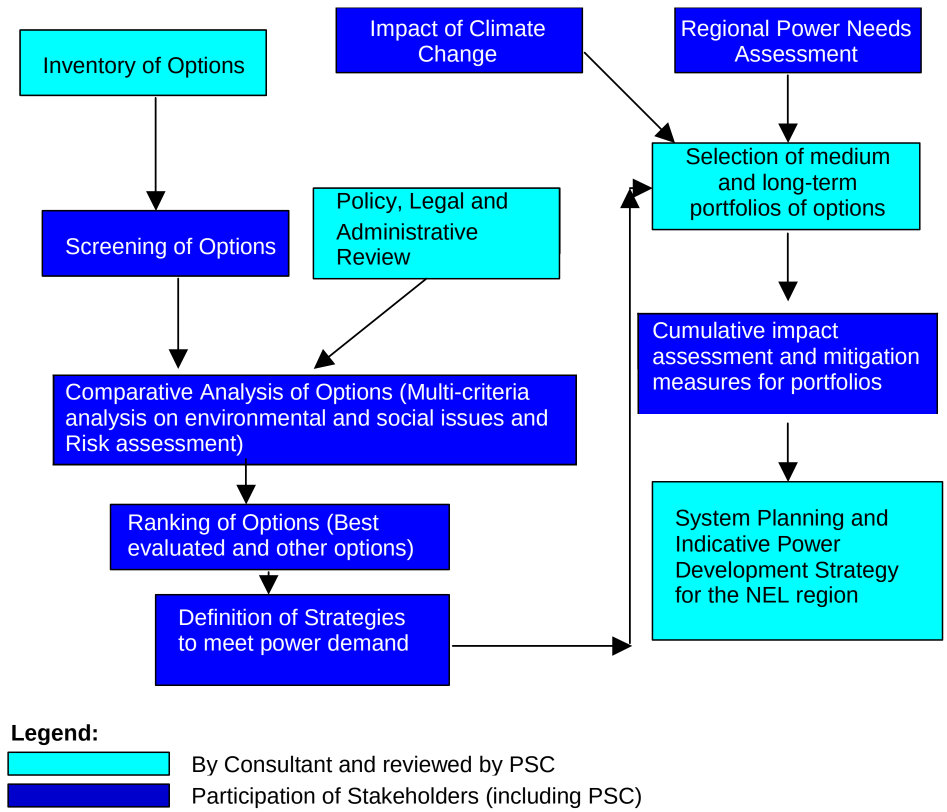
[1] Services of local consultants were retained for gathering environmental and socio-economic information on power development options and potential stakeholder representation.

- Stage I which included the countries of Burundi and Rwanda and the western part of Tanzania;
- Stage II which added the remainder of Tanzania, all of Kenya and Uganda and the eastern part of the Democratic Republic of Congo (DRC);
- Extension of Stage II which added new elements not contained in the earlier work (specifically climate change analyses and a definition of a situation without regional integration), deepened the cumulative impact assessment and applied a stricter screening of options with the effect of eliminating options in national parks or forest preserves as required by the Algiers convention.

2.2 Overall Approach

The overall approach followed for the assessment is presented in Figure 2-2.

Figure 2-2 - Process Followed for SSEA of Power Development Options



Each of the steps in the process is described briefly below[2].

[2] This SSEA study is a general framework which was used to develop an indicative power development strategy for the NELSAP region . As such, it is based on information gathered from many secondary sources, initially in 2003 and then updated in 2004. Thus, the information has been developed by numerous different consultants over a long period of time (some dating back 20 years) using a wide range of assumptions. Every reasonable effort has been made to put the information on the consistent basis needed for a strategic level analysis like this SSEA. The SSEA is not a substitute for detailed project-specific studies and environmental/social impact assessments needed for the implementation of particular projects. Such studies would invariably incorporate updated and detailed information about various project aspects including alternate configurations, cost estimates, hydrology and plant output, and environmental and socio-economic impact analyses."

- Policy, legal and administrative review – one of the basic requirements of the assessment is to ensure that the legal and administrative framework will support the objectives of this assessment, which includes all six countries working in concert for the benefit of the region;
- Regional power needs assessment – before any options are developed, it is essential that an assessment of the regions needs for electric power be carried out;
- Inventory of options – one of the first steps in the assessment is to identify the power development options that might be developed in the region;
- Screening of options – from the entire list of power development options that have been identified, inappropriate or unacceptable options need to be screened out. This is done primarily on technical grounds;
- Comparative analysis of options – the power development options need to be compared on the basis of cost, environmental and social considerations before they can be selected for implementation;
- Risk assessment of options – this assessment recognizes that some options are riskier to develop than others and these risks need to be identified and, to the extent possible, quantified;
- Ranking of options – using the preceding analyses, the power development options can be ranked on the bases of cost, environmental and social considerations and risks;
- Definition of strategies – there is a very large number of ways each of the power development options can be combined to meet the power needs of the region. The development of a set of strategies allows for the development of these options in a manner that suits the objectives of the countries involved;
- Selection of portfolios – a grouping of power development options needs to be identified that meets the needs of the region and follows the strategies accepted;
- Assessment of impact of climate change – one of the major risks that has been identified is that of climate change and its possible impact on runoff which, in turn affects the output of the hydropower development options that are being considered;
- Cumulative impact assessment of portfolios – the implementation of power development options will have an impact on the social and physical environment and this need to be taken into account. It is also necessary to assess the impact of more than one option being developed in a particular area and also to consider the combined impacts of the power development options and other developments in the area;
- Development of an indicative power development strategy for the NEL Region - this is a plan to install power development options in a specific order and timing to meet the needs of the region using resources that are acceptable from a social and environmental point of view. The strategy also includes other recommendations on the legal and institutional framework and updates of studies on other identified projects particularly in eastern DRC.

Following this process, the participating countries would then take the results of the indicative power development strategy and use if to inform decision-makers concerning development of power development options.

2.3 Key Elements in the Approach

2.3.1 Role of the Project Steering Committee

The consultant was guided in the work be a Project Steering Committee (PSC) that met regularly throughout the process. The committee consisted of two power experts from each country involved (usually one from the electric utility and one from the ministry responsible for power). In addition, there were observer members from the Sudan and Egypt.

During these meetings, the PSC:

- Provided basic data relevant to the work;
- Reviewed progress by the Consultant; and
- Provided assistance in overcoming obstacles.

2.3.2 Stakeholder Consultation Process and Communication Strategy

Stakeholder consultation was an integral part of the SSEA of power development options in the Nile Equatorial Lakes region. The overall objective of the stakeholder consultation program was to incorporate stakeholder viewpoints into each step of the SSEA, especially as regards:

- The identification and screening of power options;
- The selection of comparison criteria and their weighting according to their importance;
- The comparative analysis of power options;
- The selection of strategies for development of power options;
- The cumulative impact assessment and identification of mitigation actions for selected power investment portfolios.

The stakeholder consultation program constituted a regional “pulse-taking” of the different issues at hand. Because of the regional scope of the SSEA, such a pulse-taking exercise was more appropriate than an in-depth public consultation seeking to take into account the input of all of the stakeholders concerned by each power option.

The strategy of a regional pulse-taking required that national and regional stakeholder representatives from Burundi, eastern DRC, Kenya, Rwanda, Tanzania and Uganda be:

- Relatively limited in numbers;
- Required to speak for large numbers of people at national or regional levels;
- Selected in order to cover to the widest extent possible the spectrum of issues involved in the study (e.g.: rural and urban development, environment and water resources management, poverty alleviation and public health, agriculture, industry, tourism, consumer interests, gender issues, etc.); and
- Selected in order to reflect the concerns of national and local governments, civil society organizations (including the private sector), and academia.

Four stakeholder consultation workshops were held at strategic times in the work schedule. Stakeholder representatives from each country included five members drawn from national and local governments (such as Environment Ministry representatives), civil society organizations (including the private sector), and academia plus two power experts drawn from the members of the steering committee.

The communication strategy adopted for the SSEA was based on the preparation of seven public information bulletins in English and in French. Although it was recognised that access to the Internet in the Upper Nile Basin countries is limited, it was decided that information on the project as well as all documents produced in the course of the project be posted on a dedicated section of the consultant's Web site (www.ssea@snclavalin.com). Alternative means of communication adopted in the course of the SSEA included national media events with press releases held at the end of stakeholder consultation workshops.

Appendix B presents an overview of the contribution of stakeholder representatives to the SSEA of power development options in the Nile Equatorial Lakes region.

2.3.3 Use of Existing Data

The analyses were to be based on existing data. This meant limited site visits to selected hydropower sites by the consultant. Local consultants were retained to gather available data (project reports, socio-economic data, environmental data, etc.).

This data collection was supplemented by canvassing all members of the PSC and the stakeholder representatives at the workshops for the identification and provision of data on projects that they were aware of.

Because the level of data varied from report to report, it was necessary to adjust data, based generally upon the consultant's experience and judgment in order to put all reports on a relatively similar basis.

2.3.4 Variable Project Level Information

For some power development options, the data available were at the detailed feasibility level information, which included environmental and social impact assessments and detailed cost estimates. At the other end of the spectrum, there were projects that had barely been identified and for which no firm information was available, not even a precise location of facilities.

In order to carry out a comparison on a fair basis, a minimum level of detail was selected (and approved by the PSC) below which a project would be rejected from consideration. The level selected was that of pre-feasibility.

2.3.5 Climate Change Impacts

Climate change analyses are carried out based on expected (calculated/forecasted) changes in temperature and runoff comparing a block of time in the recent past with a block of time some distance in the future (50 and 100 years). The level of detail is insufficient to permit detailed forecasts of changes in river flows on a year-by-year basis over the period of the analyses.

General directions and magnitudes of expected variations were estimated and the expected impacts on power outputs of various power development options were considered from the point of view of assessing the risk that power outputs would be less than estimated using conventional analyses.

2.3.6 Selection of Options

As the SSEA is a regional study, only power development options that could be of regional benefit were considered. This implied:

- Power development options needed to be above a minimum size in order to be considered (≥ 10 MW in the smaller countries and ≥ 30 MW in the larger countries);
- Only options studied that could be connected to the electric power grids of the were included;
- The import of electric power from countries outside the region was also included in the analysis;
- Off-grid options were identified and discussed but not included in the analysis of power development options as they were not regional in character.

2.3.7 Spatial and Temporal Boundaries

This analysis is carried out under the auspices of the Nile Basin initiative. Figure 2-3 below provides a map covering the whole region from the southern part of Tanzania to the mouth of the Nile. The area covered by the study is also highlighted in this map. Figure 2-4 indicates the boundaries of the Nile Basin within the six upstream riparian countries. Figure 2-5 provides some detail of the part of the Democratic Republic of Congo that is included in the study.

In order to ensure that the full area of the drainage basin was included, the geographic boundaries for the analyses were set as follows:

- All of the countries of Burundi, Kenya, Rwanda, Tanzania and Uganda; and
- The eastern provinces of the Democratic Republic of Congo, which covered eastern districts of the Oriental Province (the Haut-Uélé and the Ituri), the eastern districts of the Katanga province (the Taganika and the Haut Katanga) and the totality of the North and South Kivu provinces.

There are several strong reasons for carrying out the study on a regional basis, including:

- The resources in the Nile River Basin are crucial to the livelihood and well-being of countries and their population from the headwaters of the River to its outlet into the Mediterranean Sea. Any use by upstream riparian countries may have an impact on downstream users; it is therefore essential to plan on the development of such resources in a concerted manner.
- Several of the identified power development projects have potential social and environmental impacts in other countries.
- There are synergies in developing hydroelectric projects on both sides of the equator (the wet period for projects north of the equator occur in different months from the wet period in river basins south of the equator).
- There are synergies in the development of a mix of types of projects (Uganda is endowed with most of the hydro resources in the region, Tanzania with most of the coal and natural gas and Kenya with most of the geothermal resources).
- There are economies of scale in working on a regional basis instead of country by country (each country working separately would need to install smaller, less economic plants than the bigger countries or the smaller ones working together).

Figure 2-3 – Overview of Nile River Basin Countries

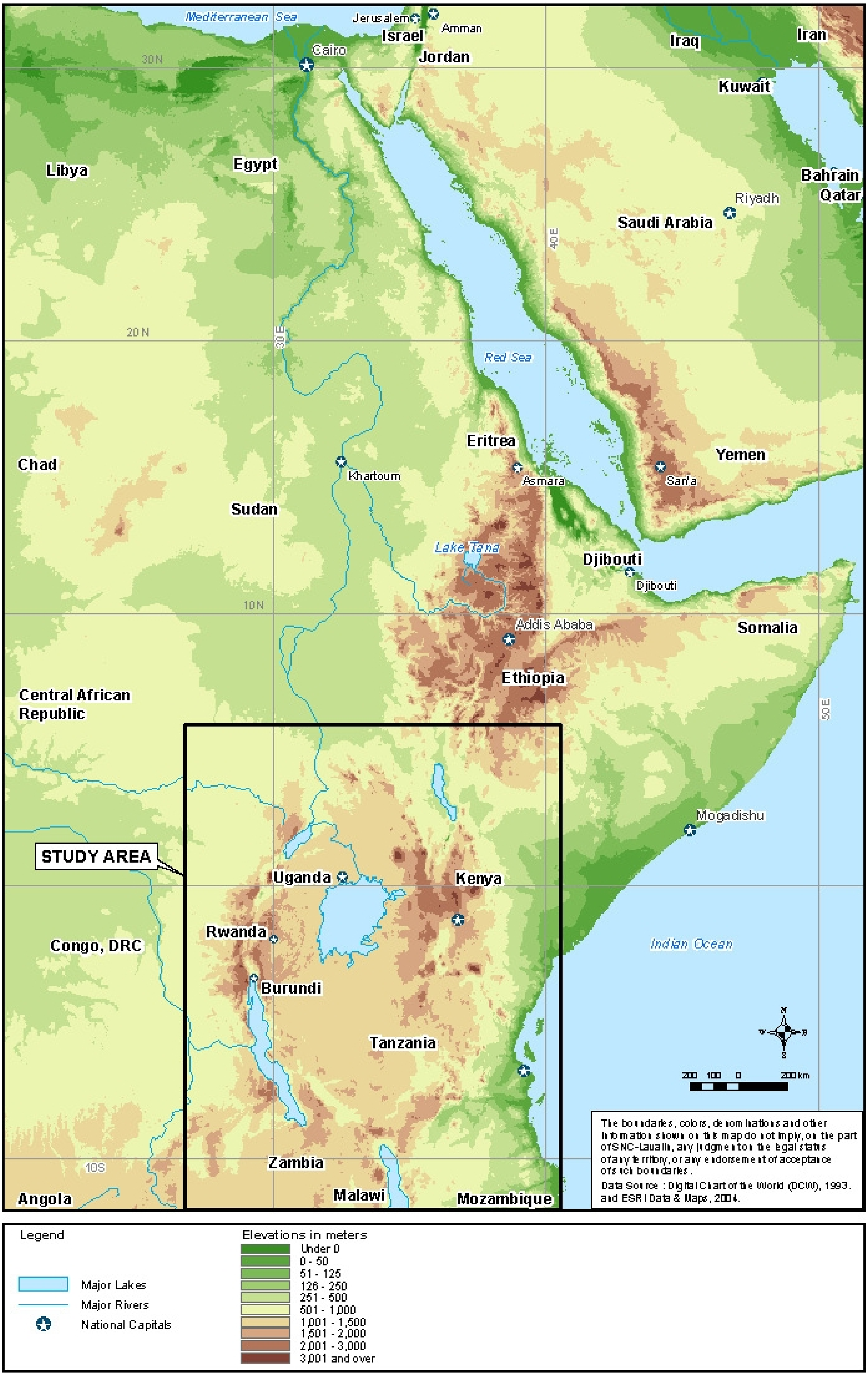


Figure 2-4 - Nile River Basin at Lake Victoria

Figure 2-5 - The Democratic Republic of Congo – Provincial Map Showing the Region under Analysis

- There is significant political tension in the area and cooperation in the power sector is a pragmatic start to improvement of such international relations.

In order to allow for the strategic planning of the implementation of power plants including hydroelectric power, a long horizon is required. In this case a period of about 15 years was selected: up to 2020.

2.3.8 Selection of Strategies to secure supply under different development approaches

The analyses consider two main approaches: an "independent development" approach in which each country provides its own power development strategy and a "regional cooperation" approach in which all six countries cooperate in the development of power resources for the joint benefit of the six countries. In the latter approach, several strategies for satisfying the demand in the region are examined, each of which has implications on security of supply of power to each country as well as the technological and other risks associated with the power development options considered.

2.3.9 Distribution of Benefits

The ranking of power options raises a number of issues related to the distribution of benefits, damages and risks among stakeholders. For instance, the following complex issues are encountered:

- Thermal plants have little impacts on land use but emit air pollutants and greenhouse gases that have local, regional and global effects. Hydropower options may have significant local impacts depending on the reservoir area and the alteration of the hydraulic regimes. But global effects in terms of air emissions are much less important for hydropower plants than for thermal plants. Which type of technology is preferable?
- Is it acceptable to pay a potentially higher price for renewable energy options such as wind power or photovoltaic with limited environmental impacts? Who will pay for the added cost and at the expense of what other priorities?

The following principles described in a report of the International Energy Agency on Hydropower and the Environment[3] have been followed in order to:

a) Resolve these types of complex issues;

b) Guide the selection of relevant evaluation criteria and the ranking of options; and

c) Comply with the NELSAP and NEL-COM objectives as well as with World Bank safeguard policies and procedures[4].

These principles are generally recognized as being applicable to the planning and implementation of infrastructure projects. When applied to power options, they can be expressed as follows:

[3] International Energy Agency. Implementing Agreement for Hydropower Technologies and Programmes. May 2000. *Annex III Hydropower and the Environment: Present Context and Guidelines for Future Action. Volume II: Main Report*.

[4] World Bank Safeguard Policies and Procedures include: Operational Policy/Bank Procedure 4.01 - Environmental Assessment; 4.04 - Natural Habitats; 4.09 - Pest Management; 4.10 - Indigenous Peoples; 4.11 – Physical Cultural Resources; 4.12 - Involuntary Resettlement; 4.36 - Forests; 4.37 - Safety of Dams; 7.50 - Projects in International Waterways; 7.60 - Projects in Disputed Areas.

- Sustainable development: preference should be given to options that meet today's generation's needs without compromising those of future generations;
- Precaution: preference should be given to options that can minimize damage to the environment;
- Fairness and justice: if impacts cannot be avoided, preference should be given to options that allow for a fair compensation of the affected population, including benefit sharing of project-related revenues and restoration of their livelihoods;
- Optimality: promote consistency and transparency for comparing all costs and all benefits as well as their distribution among all concerned stakeholders, while acknowledging the limitations with respect to measuring and placing values on many natural resources.

3 LEGAL, POLICY AND ADMINISTRATIVE CONTEXT

The legal, policy and administrative frameworks within which a power development option is planned and implemented is a vital consideration at the strategic and sectoral level as it has a strong bearing acceptability of the option as well as on its environmental and social performance. It is well known that the levels of impacts and the distribution of benefits of any major infrastructure are strongly influenced by the regulatory environment and by the capacity of the relevant institutions and agencies to monitor and enforce their application. The legal and policy frameworks also influence how suitable a particular jurisdiction is to attracting investment, particularly in a regional or multi-national context.

The first section of the chapter provides an overview of national legal and institutional frameworks related to environment and power development, including environmental assessment processes, land tenure, resettlement issues, constraints to development in parks and protected areas, water management, forestry and international environmental commitments. The second section summarizes the World Bank's Safeguard Policies. The third section provides an overview of energy sector policies. The fourth section provides a short description of the regional institutional framework. The analysis, conclusions and recommendations are provided in the final section of the chapter. Appendices C and D contain background information and reference standards.

3.1 National Legal and Institutional Frameworks Related to Environment and Power Development

3.1.1 Environmental Impact Assessment Procedures and Legal Requirements

Each of the Nile Equatorial Lakes countries, with the exception of the DRC, has adopted recent environmental legislation including environmental impact assessment (EIA) procedures. In the DRC, all projects theoretically require an Energy-Environment study to be carried out by the Ministry of Energy concurrently with the Ministry of Environment. Because of their recent adoption, regional experience in applying EIA processes is limited to only a few power projects.

3.1.2 Land Ownership and Land Use Rights

Land tenure refers to the way land is owned, occupied, used and disposed of within a community. Across the Upper Nile Basin countries, land tenure is mixed and can be based on customary rules[1], colonial regulations and post-colonial legislation. The governing rules on property in each country generally allow the respective States to expropriate private land for public use, with appropriate compensation. This privilege is usually granted to electric utilities through enabling legislation, although they generally need to be authorized by the Government when exerting the privilege.

3.1.3 Resettlement Policy and Regulations

Involuntary resettlement is not addressed in the legal frameworks of Burundi, DRC, Rwanda, Tanzania or Uganda. In Kenya, government policy requires that the World Bank's Operational Procedure OP 4.12 be applied for power generation and transmission projects (see 3.2). Regional experience in applying international resettlement standards is limited to only a few power projects.

[1] Specific rules of customary tenure vary according to ethnic groups and regions. Customary tenure often recognises the individual right to possess and use land subject superintendence by his family, clan or community.

3.1.4 National Parks and Protected Areas

All countries, except Burundi, are Parties to the African Convention on the Conservation of Nature and Natural Resources (Algiers Convention), of 15 September 1968. Under this Convention, “any work tending to alter the configuration of the soil or the character of the vegetation, any water pollution, etc.” is forbidden in strict nature reserves and in national parks. Only the competent legislative authority, i.e. the Government, can alter or alienate any portion of these “strict nature reserves” and national parks (Cf. s. 3 (d)). While the Government retains ultimate power to allow the implementation of power projects in “strict nature reserves” and national parks, by legislatively altering their boundaries or alienating some of their area, such areas should be considered as very unlikely sites for power projects, particularly in view of the World Bank’s stated support for maintaining the integrity of national parks and protected areas.

Notwithstanding the above general conditions, it should be noted that there is no specific prohibition of power projects in National Parks in Burundi, Kenya, Rwanda, Tanzania and Uganda. Each of those countries has specific legislation that is relevant to development in parks and protected areas. In the DRC, a law related to nature conservation and protected areas provides that lands situated in integral nature reserves cannot be allocated to uses that are incompatible with the protection of nature. In particular, the law forbid works to be carried out in rivers, and prohibit pollution of waters either directly or indirectly. It should also be noted that the World Bank does not support project development within parks and other protected areas.

3.1.5 Water Management (including irrigation)

Burundi, Tanzania and Uganda have a paragraph relating to protection of water resources within their Environmental laws or policies. In addition, Tanzania has a Water Statute.

Kenya has adopted specific water legislation. Rwanda and Tanzania have adopted a Water Policy. A draft Water Code has been prepared and is under discussion in the DRC.

3.1.6 Forestry

In many Nile Equatorial countries, wood supplies the basis of most of household energy needs. This fact, combined with other environmental factors linked to rapid population growth such as the need for more grazing lands, contributed to the rapid reduction of forest areas. In North Kivu (DRC) and Rwanda, deforestation has been accelerated by the presence of refugees after the mid-1990s events. The reduction of forested areas contributes to the deterioration of soil fertility, to erosion and to desertification. Each of the six countries has adopted frameworks governing forestry activities but few of those encompass the sustainable development principle. Uganda has a Forest Policy providing for the sustainable use of forests. Tanzania has a specific policy dealing with Forest preservation. The rehabilitation and preservation of forested areas are part of the Environmental policy adopted by each country except the DRC.

3.1.7 International Environmental Commitments

States signal their intention to bind themselves to the terms of a treaty (also known as a convention) by **signing** the treaty. The final indication that a state is prepared to implement the terms of the treaty is **ratification**. Occasionally, ratification may be achieved by signing a treaty. However, in the majority of states, ratification of a treaty requires a separate process, and the executive or legislature must consider the agreement closely and give its final approval before it has domestic effect.

Most treaties do not enter into force until a certain number of states ratify the treaty. Once this number is achieved, a treaty will thereafter be '**in force**'. The number of ratifications required to bring a treaty into force is a matter of political negotiation and is usually set at a diplomatic conference where the agreement is signed. Once a treaty is in force, the terms of the treaty become binding legal obligations. States that are signatories to a treaty but have not ratified it will still be bound in international law not to take measures that defeat the purposes of the treaty, but the terms of the unratified treaty are unlikely to have any domestic effect in practice. This is because in most states, national (domestic) law is considered to be implemented separately from international law. **Accession** is one means by which a state can accept the offer or the opportunity to become a party to a treaty already negotiated and signed by other states. In general, it has the same legal effect as ratification.

The main International Conventions dealing with environment and their status in the different Upper Nile Basin countries are listed in Table 3-1. The description of each convention is available in Appendix C World Heritage Sites in the six countries concerned are listed in Table 3-2 while Ramsar Sites in the six countries are listed in Table 3-3. Additional information on these conventions is also provided in Appendix C.

Table 3-1 - Status of Principal International Conventions

Convention/Protocol	Burundi	DRC	Kenya	Rwanda	United Republic of Tanzania	Uganda
African Convention on the Conservation of Nature and Natural Resources (Algiers Convention) (Open for accession by any independent African State)	Signed	In force	In force	In force	In force	In force
Basel Convention on Hazardous Wastes	Accessed	Accessed	Accessed	Accessed	Accessed	Accessed
Convention on Biological Diversity (SCBD)	Ratified	Ratified	Ratified	Ratified	Ratified	Ratified
Convention on International Trade in Endangered Species (CITES)	In force	In force	In force	In force	In force	In force
Convention on Wetlands of International Importance especially as Waterfowl Habitat (RAMSAR)	In force	In force	In force	Ratified	In force	In force
Kyoto Protocol to the United Nations Framework Convention on Climate Change	Accessed	Accessed	Accessed	Accessed	Accessed	Accessed

Convention/Protocol	Burundi	DRC	Kenya	Rwanda	United Republic of Tanzania	Uganda
United Nations Convention to Combat Desertification (UNCDD)	In force	In force	In force	In force	In force	In force
Vienna Convention for the Protection of the Ozone Layer and Subsequent Protocols and Amendments	Accessed + Accepted Subsequent Amendments and Protocols	Signed + Accepted Subsequent Amendments and Protocols	Signed + Accepted Subsequent Amendments and Protocols[2]	Signed + Accepted Subsequent Amendments and Protocols	Accessed Initial Protocol and Subsequent Amendments and Protocols	Signed Montreal Protocol and Accessed or Ratified Subsequent Amendments and Protocols

[2] Except for Beijing Amendment (2004)

Table 3-2 - World Heritage Sites in the Nile Equatorial Lakes Countries

States/Parties	World Heritage Sites (year of designation)
Eastern DRC	Virunga National Park (1979) Garamba National Park (1980) Kahuzi-Biega National Park (1980) Salonga National Park (1984) Okapi Wildlife Reserve (1996)
Burundi	None
Kenya	Lake Turkana National Park (1997, 2001) Mount Kenya National Park/Natural Forest (1997) Lamu Old Town (2001)
Rwanda	None
Tanzania	Ngorongoro Conservation Area (1979) Ruins of Kilwa Kisiwani and Ruins of Songo Mnara (1981) Serengeti National Park (1981) Selous Game Reserve (1982) Kilimanjaro National Park (1987) Stone Town of Zanzibar (2000) Kondoa Rock Art Sites (2006)
Uganda	Bwindi Impenetrable National Park (1994) Rwenzori Mountains National Parks (1994) Tombs of Buganda Kings at Kasubi (2001)

SOURCE : UNESCO Web site (www.unesco.org)

Table 3-3 – List of Ramsar Wetlands in Nile Equatorial Lakes Basin Countries

States	Ramsar Wetlands
Burundi	- Rusizi Delta of the Réserve Naturelle de la Rusizi and the northern part of the Lake Tanganyika littoral area
Eastern DRC	- Parc national des Virunga - Parc national des Mangroves
Kenya	- Malagarasi-Muyovozi Wetlands - Lake Natron - Kilombero Valley Floodplain - Rufiji-Mafia-Kilwa Marine Ramsar Site
Rwanda	- Rugezi-Bulera-Ruhondo (from 1 April 2006)
Tanzania	- Malagarasi-Muyovozi Wetlands - Lake Natron - Kilombero Valley Floodplain - Rufiji-Mafia-Kilwa Marine Ramsar Site
Uganda	- Lake George - Lake Nabugabo wetland system

SOURCE : Convention on Wetlands of International Importance

3.2 The World Bank's 'Safeguard Policies'

Among the overall set of Operational Policies guiding the operations of the World Bank, Bank management has identified ten key policies, known as the 'Safeguard Policies', that are critical to ensuring that potentially adverse environmental and social consequences of projects are identified, minimized, and mitigated. These ten policies are:

- OP/BP 4.01 Environmental Assessment;
- OP 4.04 Natural Habitats;
- OP 4.36 Forests;
- OP 4.09 Pest Management;
- OP/BP/GP 4.12 Involuntary Resettlement;
- OP/BP 4.10 Indigenous Peoples;
- OP/BP 4.11 Physical Cultural Resources[3];
- OP 4.37 Safety on Dams;
- OP/BP 7.50 Projects on International Waterways; and
- OP/BP 7.60 Projects in Disputed Areas.

OP/BP 4.01 Environmental Assessment is considered to be the umbrella policy for the Bank's environmental 'Safeguard Policies'. This policy requires that Environmental Assessment be carried out for projects proposed for Bank financing to ensure that such projects are environmentally sound and sustainable. All projects proposed must be screened by the Bank and put into one of four categories for Environmental Assessment purposes. If a project falls into categories A or B, an Environmental Assessment must be conducted to respond to Bank requirements. A Category A or B project would normally include a comprehensive environmental management plan.

OP/BP/GP 4.12 Involuntary Resettlement aims at avoiding or minimizing and mitigating adverse social and economic impacts arising out of involuntary land acquisition and resettlement. This policy promotes participation of displaced people in resettlement planning and implementation. The policy's key economic objective is to assist displaced persons in their efforts to improve or at least restore their incomes and standards of living. This policy also prescribes compensation and other resettlement measures and requires that the project include adequate resettlement planning instruments.

3.3 Energy Policy

This section begins with an assessment of power trading with neighboring countries. It then discusses issues around attracting investments and facilitating financing, including encouragement of foreign investments, the rights of foreign investors to own real property, the right to transfer profits from the country, government protection offered to foreign investors.

[3] Physical cultural resources are defined as "movable or immovable objects, sites, structures, groups of structures, and natural features and landscapes that have archaeological, palaeontological, historical, architectural, religious, aesthetic, or other cultural significance" (Source : World Bank Web site: www.worldbank.org).

The main sources and references underpinning the review, analysis, recommendations and conclusions regarding the national energy policies and the legal and administrative frameworks of the six countries can be found in Appendix D.

3.3.1 Power Trading with Neighboring Countries

There are strong incentives for trading with neighboring countries, including:

- Sharing of reserve requirements which increases system reliability and reduces investments and operating costs;
- Economies of scale which permit the joint construction of larger facilities with (usually) lower unit costs;
- Reduced operating costs due to a wider selection of units available under merit order dispatch;
- Greater security of supply (particularly if one of the systems is predominantly hydro-based and the other is more thermal-based).

Trading in electricity can also lead to cooperation in more areas of economic and political activity. Trading is already taking place throughout the region:

- Burundi - Rwanda – DRC through the Ruzizi II plant operated by SINELAC
- Burundi - Rwanda – through SINELAC
- DRC - Rwanda
- Uganda to Kenya
- Uganda - Rwanda
- Uganda to Tanzania

There are also plans in place to interconnect Uganda and Eastern DRC.

On the other hand, while electricity can be characterized as a product, or good, or moveable property, that is “manufactured” from natural resources, (i.e., water, gas, oil, etc.), it also constitutes a strategic good which renders essential services. These considerations warrant its institutional control in order to ensure its economic availability and physical quality.

When it comes to power trading with other countries, this institutional control is even more important since prices that can be obtained in other markets can make it tempting for a network operator or for power producers to “neglect” local load and trade electricity with a view to increasing their profits. Each country should make security of power supply a fundamental goal in its energy policy. Indeed, both Kenya’s and Uganda’s energy policies set as a goal the improvement of the security of supply.

3.3.1.1 The SINELAC Experience

Under a Convention signed in 1984, Burundi, (then) Zaire and Rwanda agreed to jointly build and operate a hydroelectric station, Ruzizi II. Ruzizi II is the common property of the three countries. It supplies electricity to REGIDESO (Burundi), ELECTROGAZ (Rwanda) and SNEL (DRC).

SINELAC[4] operates three 12 MW units, installed in 1989 (Units 1 & 2) and 2001 (Unit 3). The construction of the power plant was financed mainly by the International Development

4 SINELAC: Société Internationale des Grands Lacs.

Association (53%), the European Development Fund (17%), and the *Banque de Développement des Pays des Grands Lacs* (2%). The remainder of the financing came from various credits (Italy, *Agence Française pour la Maîtrise de l'Énergie*) and contributions from the shareholder States.

It is difficult to adequately assess SINELAC since it has been operationally handicapped for most of its existence. This is due to the chronic insecurity in the region, the lack of adequate resources, and the lack of respect for their commitments by the shareholder countries[5]. Indeed, according to a recent World Bank report, "*the three national utilities were never allowed by their governments to set their own tariffs to recover their Sinelac costs, with the result that right from the start, Sinelac has faced delays and difficulties in getting its bills paid*."

Further on, the Report notes that "*The onlending terms of the IDA credits for Sinelac are at the heart of the interlocking debts between the three states, their power utilities and Sinelac. While these onlending conditions may have seemed reasonable at the time, they appear very onerous today. A solution to the outstanding arrears to Sinelac needs to be agreed in the context of a broader financial restructuring of the entity.*" [6]

In addition, Ruzizi II presently suffers from a period of low runoff affecting the sub-region. However, SINELAC is an interesting example of cooperation and common exploitation of resources among the three countries. Recent decisions taken by the three governments[7] as regards its financial restructuring to ensure viable operation could put SINELAC back on track.

3.3.1.2 Independent Power Production

One question that should be addressed is that of access of Independent Power Producers (IPPs) to transmission networks, notably for regional trade. However, this would involve modifications to the status of the existing utilities, from single buyer to supplier of transmission services, require putting in place transmission system operators, the creation of open access same-time information systems with grid codes, ancillary services, etc. It is not evident that the networks of Tanzania, Rwanda and Burundi are ready for such reforms at this time.

However, it should be noted that there are currently IPPs in Uganda, Kenya and DRC that provide power to either the state utilities or act as captive generation.

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[5] Cf. L'Avenir Quotidien, 08/09/04 - « *…la SINELAC, société internationale communautaire longtemps asphyxiée par les conséquences néfastes de l'insécurité dont la sous région est victime. … remédier à la paralysie et au disfonctionnement organisationnel, structurel et technique dus au manque des ressources suffisantes, aux engagements conséquents et concrets des pays actionnaires*. »

[6] Project Appraisal Document on a Proposed Credit in the Amount of SDR 16.7 Million (USD 25 Million Equivalent) to the Republic of Rwanda for an Urgent Electricity rehabilitation Project – December 27, 2004 (Report No. 30253-RW)

[7] 23-25/08/04 Meeting in Johannesburg – as reported on Umuco.com "…*les ministres de l'Énergie des trois pays se sont réunis du 23 au 25 août derniers à Johannesburg (Afrique du Sud) pour dégager des pistes en vue de la relance des activités de la SINELAC. Les trois gouvernements ont décidé de la restructuration financière de cette société en vue de son exploitation viable. Il s'agit, selon l'ACP, de réhabiliter les groupes deux et trois du barrage hydroélectrique de Ruzizi II, dans l'est de la RDC. La centrale de Ruzizi II, avec une capacité installée de 36 mégawatts, alimente en électricité le Rwanda et le Burundi.* »

3.3.1.3 Lessons Learned

International experience from regional electricity power trading arrangements such as those in Southern Africa Power Pool highlight that the core elements of a minimum policy platform to facilitate and support the development of a regional electricity market include:

- At least a functional separation of transmission from generation with appropriate ring-fencing between the two functions;
- Non-discriminatory open access to national transmission networks operated by a transmission system operator (TSO);
- Transparent and harmonized pricing principles for transmission access, wheeling (energy transit), and ancillary services;
- Transparent and harmonized standards for transmission interconnection, metering, reliability, types of ancillary services, and system safety;
- De-monopolization of import and export of electrical energy by a single national entity.

The West African Power Pool (WAPP)[8] was created as a result of an ECOWAS meeting of ministers of energy in Ghana in November 1999 and serves the countries of Benin, Burkina Faso, Ivory Coast, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo.

In January 2003 an Energy Protocol was signed. It is based on the European Energy Charter designed to promote investment and trade in energy across Europe and the former Soviet Union, but adapted to West African circumstances. It covers a wide range of legal and commercial aspects promoting security for investors. For example, the Energy Protocol provides for free repatriation of capital, protection against nationalization, free selection of key staff without nationality requirements, and legal recourse in the event of meddling by government or industry regulators. The energy Protocol enshrines the principles of open access to national transmission grids and free trade across West Africa in all kinds of energy.

Operating a region-wide electricity market, open to free trade and unfettered investment requires the creation of an information center to monitor developments and, eventually, to provide dispatching services. To serve these purposes, the ECOWAS Energy Information Observatory was launched in 2003. Its main tasks are to collect monthly energy supply and demand balances, provide forecasts of potential energy surpluses available for trading, coordinate maintenance schedules, and engage in long-term generation and transmission expansion planning.

The sustainability of the WAPP depends upon its independence. The fast start in developing the WAPP has been reliant on donor funding for both conceptual and practical help. To ensure the sustainability of the organization, it should have its own resources, perhaps via a small fee on all electricity served within any of the WAPP countries.

3.3.1.4 Specific Provisions by Country

Kenya and Rwanda do not have legislation covering the import or export of electricity. In Burundi import and export of electricity are authorized. In DRC and Uganda import and

[8] Source: West African Electricity Sector Integration, State of Progress and Future Challenges for the West African Power Pool, by Daniel J. Plunkett, April 29, 2004

export need a license or authorization. In Tanzania, while the import of electricity is authorized, its export is forbidden by law. Only a governmental decree can bypass this rule.

3.3.2 Attracting Investments and Facilitating Financing

Generally, governments need to be concerned with how to attract investors, facilitate the financing of energy projects, and foster regional cooperation in meeting the demand for electricity. This section looks at these issues and, where warranted, offers the Consultant's recommendations on how to address them effectively.

A transparent and favorable legal and regulatory framework for both foreign investment and local private investment is central to attracting investments and facilitating the financing of energy projects. Favorable terms and conditions may mean acceptable interest rates, sufficient duration of loan terms, repayment schedule, etc. Transparency of relevant legislation and regulations will help to make foreign investors feel more secure. The development of a legal and regulatory framework that attracts foreign investment will need to take into account the following issues:

- How to encourage foreign investments;
- The right of foreign investors to own assets, including properties (land, buildings) in the country;
- The right to transfer profits out of the country;
- Protective measures that governments can offer to foreign investors.

Each of these issues is discussed by country in Appendix D.

3.3.2.1 Encouraging foreign investments

Rwanda, Tanzania and Uganda have adopted in the 1990s legal frameworks that are favorable to foreign investments. In Kenya, foreign investors whose activities contribute to the Kenyan economy are given certificates which offer them some protection and advantages. The climate for foreign investment has improved in the DRC following the adoption of policies and measures aimed at attracting foreign investments. In Burundi, no references were found on this issue with regard to the electricity sector.

3.3.2.2 The right of foreign investors to own real property

Some countries restrict foreign ownership of real properties and some forbid it. The right for foreigners to own real properties is an important factor in attracting foreign investment. Therefore, it is an issue that should be taken into account in the development of the appropriate legal and regulatory framework to attract foreign investment.

The legal frameworks of Kenya, Rwanda, Tanzania and Uganda provide that foreign investors can own real property. In Burundi, no references were found on this issue. Consequently, it would need to be established whether foreign investors would face restrictions as regards ownership of real property. In the DRC there is no substantial difference in treatment between foreign and domestic enterprises.

3.3.2.3 The right to transfer profits out of the country

The right to repatriate profits is an important consideration for foreign investors. After paying reasonable fiscal levies, foreign investors expect to be allowed to transfer all or a portion of their profits out of the country. Clear and detailed legislation and regulation provides security and protection to investments on energy projects.

The legal frameworks of DRC, Kenya, Tanzania, Uganda and Rwanda allow the repatriation of profits with different levels of restriction. Some countries such as Tanzania have less restriction towards the repatriation of profits. In Burundi, no references were found on this issue. Consequently, it would need to be established whether foreign investors would face restrictions as regards repatriation of profits or sale proceeds.

3.3.2.4 Government Protection Offered to Foreign Investors

Investments in Tanzania are guaranteed against nationalization and expropriation. The DRC, Kenya, Rwanda and Uganda offer protections against compulsory acquisitions. Rwanda and Uganda have laws providing for fair compensation in case of compulsory acquisition. In Burundi, no references were found on this issue. Consequently, it would need to be verified whether foreign investors are offered adequate government protection against undue appropriation or expropriation without just compensation.

3.4 Regional Institutions

Emerging regional development structures that cooperate actively with the Nile Basin Initiative (NBI) and NELSAP include the new African Union (AU), the New Partnership for Africa's Development (NePAD), the East African Community (EAC – three member states), the Southern Africa Development Community (SADC – 14 member states), the Common Market of Eastern and Southern Africa (COMESA – 20 member states), the Economic Community of the Great Lakes Countries (CEPGL) – three member states, and the Inter-Governmental Authority for Development (IGAD – seven member states).

These institutions are summarily described in Appendix C. In 2006, the East African Community states adopted the Protocol on Environment and Natural Resources Management.

3.5 Analysis, Conclusions and Recommendations

3.5.1 Analysis and Conclusions

3.5.1.1 Environmental and Social Framework

The review and analysis of the overall legislation and the national environmental and social policies for the six countries indicate that five of the six countries (with the exception of the DRC) have adopted environmental assessment processes that are largely compatible with international requirements governing power generation and transmission projects. However, these processes have been introduced relatively recently (most since 2000) and the countries concerned have limited experience in applying them.

With respect to land ownership and use rights and to resettlement policy and regulations, the review and analysis of the overall legislation and national policies for the six countries indicate that no resettlement policies and regulations that are compatible with international requirements have been adopted to date. However, in Kenya, government policy for power generation and transmission projects is to apply the World Bank's O.P. 4.12 on Involuntary Resettlement.

With respect to parks and protected areas, DRC is the only country that prohibits interventions on rivers within parks and reserves. The other five countries require that EIAs be carried out in such cases. With respect to water management and forestry resources, most countries have Policies or Acts, which require that EIAs be carried out for projects that can affect watercourses or forests.

Table 3-4 at the end of this chapter provides a summary overview of environmental and social policy frameworks for each country, including the following topics:

- Environmental assessment process;
- Land ownership and land use rights;
- Resettlement policy and regulations;
- Constraints on development in parks and protected areas;
- Water management;
- Forestry.

The analysis in this table is based upon information summarized in Appendix C.

3.5.1.2 Energy Policy Framework

The review and analysis of the overall legislation and the national energy policies for the six countries indicate a welcoming environment for the implementation of power projects. Moreover their legal, regulatory and institutional frameworks address most of the important issues and concerns identified in the course of the project and, in particular, the issues and concerns of economically sustainable power sector development.

As regards specifically the investments in power projects as well as the cross border trade, a country by country assessment shows that even though the overall situation appears to be welcoming, a few complementary measures already in progress need to be completely accomplished to secure both the private sector involvement and the development of electricity trade between the countries.

Table 3-5 at the end of this chapter provides a summary overview of energy policy frameworks for each country, including the following topics:

- Main legislation covering the electricity sector;
- Authority supervising the operations of the sector and responsible for policy formulation;
- Regulatory board or authority;
- Electricity industry structure;
- Licensing for generation, transmission and distribution;
- Private sector participation;
- Restrictions on import or export of electricity;
- How to encourage foreign investments;
- The right of foreign investors to own assets, including property;
- The right to export profits out of the country.

The analysis in this table is based upon information summarized in Appendix D.

3.5.2 Recommendations

Notwithstanding the presence of appropriate legal and institutional frameworks related to environmental protection of natural resources, property rights and livelihoods, the experience with the application and enforcement of these frameworks is limited. Accordingly, it is important that measures be taken at the national level to strengthen the technical, scientific and administrative capabilities of the agencies and individuals assigned with responsibilities in this regard.

Some additional recommendations on legal and regulatory issues apply to all countries in the region and some are country-specific. These are presented below:

Recommendations applicable to all countries:

- The six countries will need to put in place appropriate compensation and involuntary resettlement policies or at least, as Kenya does, commit to abide by rules similar to the ones contained in the World Bank's Operational Policy OP 4.12.
- Power trade will need to be favored through facilitating legislation or regulation. Presently, only Burundi appears to offer the required flexibility in its legal framework.
- Imports need not be regulated or, if they are, as little as possible. All that would need to be checked is that they are not more costly than national generation when such is available[9]. What is of primary importance is for the Government to give itself the utmost flexibility in order to be able to react rapidly to fast evolving conditions.
- As for exports, the law on energy should contain a clause authorizing the Government or the Minister responsible for Energy to set conditions by decree or to limit exports for the purpose of operational security of the network and quality of supply as is the case in Burundi. In addition, acting through decree rather than legislative amendment would allow the Government to adjust faster to changing conditions.

Recommendations for Burundi

- In order to be able to successfully attract investments and facilitate financing of energy projects on favorable terms and conditions, Burundi will have to address clearly the incentives for the foreign investors including the right of foreign investors to own real property, the right to transfer profits out of the country, government protection offered to foreign investors.

Recommendations for the Democratic Republic of Congo

- As regards the development of imports and exports, the "Décret du 31 juillet 1953" needs to be updated to allow the expansion of commercial arrangements with neighboring countries on the basis of a maximum of flexibility.
- No framework law for environmental assessment has been put into place to date. This issue should be addressed in order to qualify for financing and facilitating the smooth realization of hydropower generation projects.

Recommendations for Kenya

- None required.

Recommendations for Rwanda

- For a better development of the power sector, it would be advantageous for the country to update the main legislation related to electricity sector management and development and to include within this legislation a few articles which specifically address imports and exports of electricity. These works are going to be complementary to the role of the Rwanda Investment and Export Promotion Agency (RIEPA), which guarantee the gainful involvement of the private investors.
- Rwanda should make the security of power supply a fundamental goal in its energy policy, as is the case with Burundi and Tanzania.

9 At first glance, this would appear improbable, but it could happen between parent companies that would want to keep the profits "in-house".

Recommendations for Tanzania

- The new legal framework of Tanzania will need to offer more transparency as well as minimal institutional safeguards, in order to better be able to attract investments and facilitate financing of energy projects on favorable terms and conditions. More specifically, this has to address clearly the right of foreign investors to own assets in the country as well as the incentives for encouraging the involvement of foreign investors.

Recommendations for Uganda

- It would be beneficial for the Government to somewhat relax the existing regulatory control on the import and export of electricity. For instance, in Canada, since 1994, the National Energy Board (NEB) has been issuing so called “umbrella permits” under which utilities in Canada can export up to a given amount of power and energy without having to obtain further authorization, thus eliminating the need to petition the NEB for each and every export contract. There is no regulation of imports. These “umbrella permits” greatly facilitate power trade, especially in the context of spot market activities.

Table 3 - 4 : SUMMARY OVERVIEW OF ENVIRONMENTAL AND SOCIAL FRAMEWORKS

BURUNDI	DRC	KENYA	RWANDA	TANZANIA	UGANDA
ENVIRONMENTAL ASSESSMENT PROCESS					
The **Environment Code (2000)** institutes an EAP for works that are susceptible to impact the environment.	No framework law has been enacted to date.	Section 569 of the **Environmental Management and Coordination Act (1999)** defines the projects to undergo EIA.	Rwanda environmental law **'Loi organique No 4/2005'** requires an EIA prior to works in wetlands and watersheds	The **Environmental Management Act (2004)** provides for mandatory EIA for projects listed in the Third Schedule of the Act	Section 20 of the **National Environment Statute (1995)** establishes the projects to be considered for EIA
LAND OWNERSHIP AND LAND USE RIGHTS					
Expropriation is governed by the **Loi 1/008 portant code foncier**' and the **Décret/Loi 1/41 portant instauration du domaine public**'. Indemnity rates have been actualised in 2003 by the '**Ordonnance ministérielle No 720/CAB/667/2003'.**	The State is the sole owner of ground but must obtain the agreement of the Chief of clan before the attribution of land. A Decree of 1931 provides for expropriation and compensation for the installation of transmission lines.	**Registered Land Act of 1969 (Cap 300)** has not yet been enforced on all the territory where communal ownership is widespread. Compulsory acquisition for electric generation purposes must follow procedures set up in the **Electric Power Act (1997)**.	**Land Act (2004)** recognised State ownership, private ownership and communal ownership. Electrogaz must compensate the owners of lands used for the installation of power lines either under agreed settleement or court decision.	Land Acquisition procedures are outlined in the **Land Acquisition Ordinance, CAP. 118.** Tanesco can expropriate under the terms of the **Electricity Ordinance, CAP 131.**	**Land Act (1998)** provides for customary tenure, mailo tenure and freehold tenure. This act provides for procedures in case of compulsory acquisition for public purposes. **Land Regulations (2004)** specifies what should be considered in calculating compensation.
RESETTLEMENT POLICY AND REGULATIONS					
Not adressed.	Not adressed.	Government policy is to apply the **World Bank O.P 4.12 on involuntary resettlement.**	Not adressed.	Not adressed.	Not adressed. A resettlement policy was drafted in 1995 but was not adopted.
CONSTRAINTS ON DEVELOPMENT IN PARKS AND PROTECTED AREAS					
Following the **Environment Code (2000)**, National Parks and Reserves must be protected from activities that can alter or spoil them.	Laws related to the creation of Reserves and Parks forbid works to be carried out in rivers within the limits of Parks and Reserves.	No specific prohibition of power projects in National Parks. The Government retains the ultimate power to alter parks boundaries or alienate some of their portions.	Little information is available on this issue although '**Loi organique No 4/2005**' requires an EIA prior to works in wetlands and watersheds	The **National Environmental Policy (1997)** states that adverse impacts of development projects in conservation areas will be minimize by environmental impact studies.	Uganda **Wildlife Statute (1995)** provides for an EIA for projects that could potentially affect wildlife. The **Environment Statute (1995)** requires that EIAs for projects in parks or reserves follows NEMA guidelines.
WATER MANAGEMENT					
According to the **Environment Code (2000)** works and construction affecting water ecosystems must be subject to EIA procedures.	The '**Loi du 20 juillet 1973 portant régime des biens, régime foncier et immobilier'** provides for the protection of downstream ecosystems. A draft Water Code is in discussion since 2000.	The **Water Act (2002)** specifies how rights to water usage may be acquired.	The **'Loi organique No 4/2005'** set up measures to protect watershed and prevent wetlands deterioration. MINITERE Sectoral Policy on water aims, among other thing, to improve the use of water for energy purposes. A Water Act is actually in preparation.	The **Environmental Management Act (2004)** sets principles for the protection and management of river beds and shores. The **National Water Policy (2002)** states that water related activities should cause least detrimental effect to the environment.	The **Water Statute (1995)** provides for the protection and management of water resources. The **Environment Statute (1995)** requires an EIA for hydropower projects. Such EIA regulations would be issued by NEMA in consultation with the Department of Water Development.
FORESTRY					
Forestry activities are governed by the **Forestry Code (1985).** The **National Strategy on Environment and Environmental Action Plan (1997)** promotes the sustainable use of forest resources.	Forestry activities are governed by the **Forestry Code (2000)** which provides for the consultation of affected populations.	The **Forestry Act (2005)** calls for sustainable management of resources through community consulation.	Forestry activities are governed by the **Forest Regime (1988).** The **National Environmental Policy** outlined deforestation as the third priority issue of the government and calls for the rehabilitation of degraded forest.	The **National Forest Policy (1998)** adresses the issue of forest degradation and calls for participatory community-based management of forests.	Forest conservation and management are under the National Forest Authority.

Table 3 - 5 : SUMMARY OVERVIEW OF ENERGY POLICY FRAMEWORKS

BURUNDI	DRC	KENYA	RWANDA	TANZANIA	UGANDA
MAIN LEGISLATION COVERING THE ELECTRICITY SECTOR					
2000 Loi n° 1/014 du 11 Août In process of being updated	**1978** Ordonnance n° 78/196 du 5 mai portant statuts de la S.N.E.L. [1] [1] together with various decrees or orders	**1997** Electricity Power Act	**Colonial Era (before 1962)** Series of Decrees, Ordinances etc. In process of being updated	**1957** Electricity Ordinance CAP 131	**1999** Electricity Act
AUTHORITY SUPERVISING THE OPERATIONS OF THE SECTOR AND RESPONSIBLE FOR POLICY FORMULATION					
Ministère de l'Énergie et des Mines	Min. Portefeuille (Financial aspects) Min. Énergie (Technical aspects)	Ministry of Energy	Ministry of Infrastructure, Secretariat of State for Energy and Communications	Ministry of Energy and Minerals (MEMD)	Ministry of Energy and Mineral Development (MEMD)
REGULATORY BOARD / AUTHORITY					
		Electricity Regulatory Board (**ERB**) established by Parliament in 1997 under the Electricity Power Act	Agence de Regulation des services d'utilité publique (**RURA**) Loi n° 39/2001 du 13/09/2001	An Energy and Water utilities Regulatory Authority Act N. 11 was adopted in June 2001 but is not yet in force.	The Electricity Regulatory Authority regulates the power sector under the mandate assigned by the Electricity Act
STRUCTURE OF THE INDUSTRY & UTILITIES / FIRMS OWNERSHIP					
VERTICAL INTEGRATION HORIZONTAL INTEGRATION 100% STATE OWNED UTILITY (SOU) The *SOU* **REGIDESO** is also responsible for supplying water.	**VERTICAL INTEGRATION** HORIZONTAL INTEGRATION 100% STATE OWNED UTILITY (SOU) The *SOU* SNEL has a de facto monopoly for generation, transmission and distribution of electricity	**PARTIAL UNBUNDLING** Open Gen. + Single Buyer downstream **Generation** : KenGen (SOU) + IPPs **Transmission + Distribution** : Single Buyer : KPLC 51% Public and 49% private	**VERTICAL INTEGRATION** HORIZONTAL INTEGRATION 100% STATE OWNED UTILITY (SOU) The *SOU* **ELECTROGAZ** is also responsible for supplying water. ➔ Progress towards Kenya's structure	**VERTICAL INTEGRATION** HORIZONTAL INTEGRATION 100% STATE OWNED UTILITY (SOU) Tanzania Electricity Supply Company (TANESCO)	**UNBUNDLING** **Generation** : UEGCL (SOU) *run by ESKOM Uganda Ltd (concession)* **Transmission** : UETCL *100% public company* **Distribution** : run by UMEME Ltd. as a concession *Generation and Distribution businesses are to be leased out to private operatorson LT concession while transmission will remain a public function in the MT*
LICENSING FOR GENERATION, TRANSMISSION AND DISTRIBUTION					
NO	Authorization required for Private Generation Agrrement required for commercialization	Licencing required for Generation, Transmission, Distribution and Sales according to Electricity Power Act	**NO**	Licencing for Generation, Transmission and Distribution. All operators are licenced according to Electricity Ordinance (1957)	Licencing required for Generation (≥ 50 MW), Transmission, System Operator, Bulk Supply, Distribution, Sales, Exports & Imports according to Electricity Act (1999)
PRIVATE SECTOR PARTICIPATION					
None presently, but the Loi n° 1/014 sets the lawful framework for a successful Public-Private Partnership (PPP)	7 private power Generation and commercialization projects are presently being studied. 1 pilot project SENOKI (5 MW) initiated by the inhabitants is being built	4 IPPs presently generate power and sell it to KPLC under PPAs : OrPower4 Inc, Iberafrica Power, Westmount Power Co., Tsavo Power Co.	None presently, but under Loi 39/2001, RURA is mandated to facilitate the involvment of the private sector	Several private operators in the country and especially a number of IPPs, the biggest be ITPL (100 MW) and SONGAS (180 MW)	Significative private involvment ESKOM Uganda Ltd, UETCL, UEDCL
RESTRICTIONS ON IMPORT or EXPORT of ELECTRICITY					
Loi No. 1/014 sets no restrictions on imports and expports of electricity	"*Décret du 31 juillet 1953 relatif à l'importation et à l'exportation de l'énergie électrique*" regulates imports and exports of Electricity and specifies that they must be authorized by the King.	No specific rule governing imports and exports of electricity	SINELAC Tripartite agreement with DRC and Burundi. Bilateral contracts with DRC and Uganda	Imports covered by specific contacts with Uganda and Zambia. Exports covered by Electricity Ordinance CAP 131	Under Art. 61 of the Electricity Act (1999), the imports or exports of electricity require a licence from Electricity Regulatory Authority UETCL Exports to Kenya, Tanzania & Rwanda
HOW TO ENCOURAGE FOREIGN INVESTMENTS					
	Expropriation is not a factor in DRC's investment clir climate and furthermore DRC is a member of the WB's MIGA	Under the Kenyan Companies Act of 1962, a deduction is allowed in computing taxable income which is designed to encourage industrial growth and attract foreign investments	The Investment Code promises foreign investors incentives and facilities no less favourable than those enjoyed by local investors	Investors are encouraged according to the Energy Policy and the Tanzania Investment Act	Through the investment Code, the Gvt of Uganda prvides the necessary legal policy and physical infrastructure for private investments to flourish
THE RIGHT OF FOREIGN INVESTORS TO OWN ASSETS, INC. PROPERTIES (Land, buildings) IN THE COUNTRY					
Not addressed	DRC's laws covering investment do not différentiate between foreign and domestic enterprises	No restrictions appear to exist	Addressed in Investment Code	Addressed in National Energy policy	Art. 26 of the Constitution expounds that every person has the right to own property either individually or in association with others
THE RIGHT TO EXPORT PROFITS OUT OF THE COUNTRY					
Conditions similar to Rwanda should be formulated	DRC Gvt regulations allow for the transfer of dividends and other funds associated with investments	Under the Kenyan Companies Act of 1962, foreign investors holding a Certificate of Approved Enterprise are protected from compulsory entitled to repatriation of both capital & profits	The Rwanda Investment Code stipulates the situation where funds can be "externalized" : Salaries and other benefits to foreign staff in connection with the business can be repatriate	Protection explicitely stated Clear rules for dispute resolution	The legal and regulatory environment has been conducive to foreign direct investment and Uganda has received high scores in investor surveys on favourable policy towards repatriation of profits

4 CURRENT SITUATION IN THE REGION

This chapter presents a description of the environmental and socio-economic conditions prevailing in the region. The description is presented by watershed rather than by national or administrative boundaries since the environmental conditions and human activities that affect each other are interlinked within a shared watershed. The study area encompasses three major lake watersheds (Lakes Victoria, Malawi and Tanganyika) and three river watersheds (Victoria Nile, Tana and Rufiji). Of these watersheds, only the Victoria Lake and the Victoria Nile are directly linked to the Nile River watershed (Figure 4-1). The four other watersheds identified in the study area discharge either in the Indian Ocean (Tana, Rufiji, and Lake Nyasa/Malawi) or in the Atlantic Ocean (Lake Tanganyika).

From a regional perspective, these lakes and rivers are of paramount importance to the subsistence of their populations, as they offer a source of water and dietary proteins, provide revenue through fish harvest, exports and tourism, are used as transport avenues, provide water for irrigation, agriculture and electricity and their diverse endemic fish and fauna are ecologically and scientifically significant.

The descriptions focus on issues or parameters that are most relevant to power development. They are not intended to be exhaustive, instead emphasis is placed on capturing those aspects that should be taken into account by decision-makers at the strategic and sectoral levels.

4.1 Environmental conditions and issues

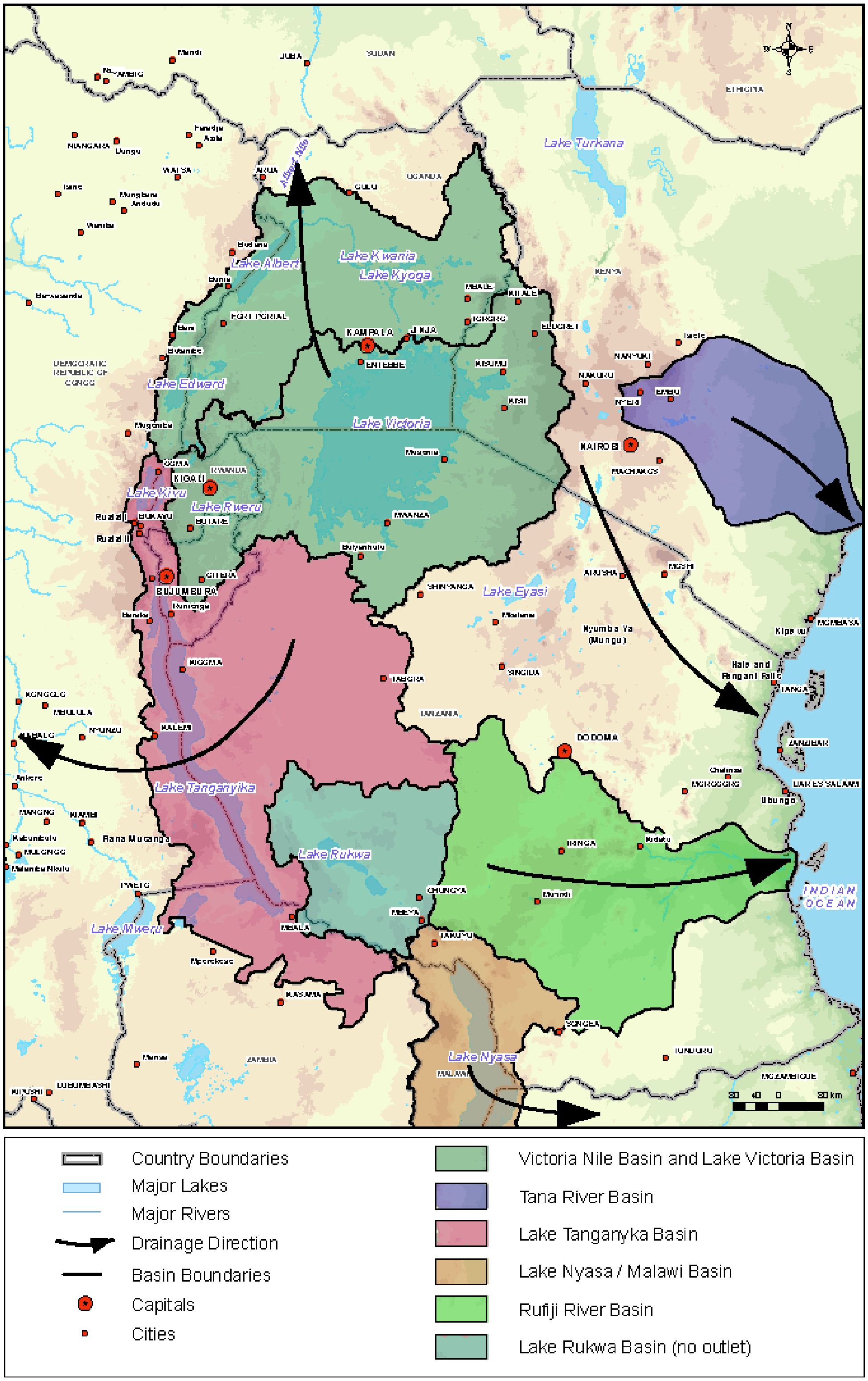
4.1.1 Lake Victoria Basin

Lake Victoria has a total surface area of 67,850 km^2 and a catchment area of 193,000 km^2. With a volume of 2,760 km^3 (average and maximum depth of 40 m and 80 m respectively) Lake Victoria is the world's second largest freshwater lake in surface area and is the largest lake in Africa.

About 86% of total water input falls as rain, with evaporation accounting for 80% of the losses[1]. The Kagera River, draining Burundi, Rwanda and part of Uganda, is the single largest river flowing into the lake while the Victoria Nile River is the only surface outlet from the lake. Since 2003, the water level has dropped over 1.1 m from its 10 year average[2]. Recent (2004-2005) level declines are 50% due to drought and 50% due to over-abstraction with respect to the "Agreed Curve"[3]; over 2004-2006 total decline due to over-abstraction was 65 cm, with a slight recovery of lake levels at the end of 2006. Rain remained at least average till 2003. Declines in levels became visible towards late 2003. Because of these low water levels, hydro generation at Owen Falls is now less than 50% of installed capacity and power outages in Uganda are common.

[1] S. Kayombo and S. Jorgensen
[2] CRDI, 2006
[3] This "Agreed Curve" is an operating rule agreed by Uganda and Egypt intended to ensure that the releases through the Owen Falls dams correspond to the natural flow of the river before damming.

Figure 4-1 - Definition of Watersheds



Lake Victoria is known for its endemic species of cichlid fishes. Approximately 200 indigenous species, including the cichlid fish species, are under threat since the introduction of the Nile Perch during the 1950s (the Nile Perch is of critical importance to the economies of the three riparian countries). These species and the overall biodiversity of the lake are threatened for the reasons discussed below.

- Industrial (breweries, tanning, fish process, agro-processing and abattoirs), and domestic waste are polluting the Lake. With a long retention time (residence time is 23 years, while flushing time is 123 years) all the pollutants entering the lake remain for a long time. Pollution from heavy metals and organics seems to be localised and there is no evidence of serious mercury bioaccumulation in fish. Small scale gold mining could, however, lead to mercury contamination as 78% of water samples analysed in the Victoria goldfields contained mercury concentrations significantly above WHO's drinking water standards of 1 g/L.
- The following sources are contributing to the increase of nutrient concentrations in the lake: domestic, industrial and agricultural wastes and wastewater, sediments from soil erosion due to deforestation (in part due to demand for firewood), poor land management practices and atmospheric deposition. These nutrients are contributing to the lake eutrophication and parts of the deepest areas are considered dead zones as they are unable to sustain life due to oxygen deficiency.
- Wetlands are being degraded and are disappearing rapidly. About 75% of the wetlands are significantly affected by human activity and 13% are severely degraded[4].
- The lake is undergoing significant changes due to the proliferation of water hyacinth, which was absent from the lake prior to 1989 and has, since the late 1990s been choking important waterways and landings[5]. The invasion of water hyacinth is altering the food web and affecting biological diversity, impacting the health and livelihood of local fisherman and farming communities, and interfering with hydropower schemes. In recent years, the situation has improved somewhat as a result of biological controls and efforts to decrease nutrient loading.
- Over-fishing and the introduction of foreign fish species are another threat to the lake's fisheries and biodiversity. In particular, the introduction of Nile Perch has reduced fish biodiversity, while over-fishing has begun to reverse the impact of Nile Perch on the lake, both trends emphasizing the benefits of proper fish management.

4.1.2 Victoria Nile Basin

Lake Victoria's only outflow is located at the northern end of the Lake and is the starting point of the Victoria Nile, which then makes its way to Lake Kyoga and further to Lake Albert. Hence, the Victoria Nile is closely interlinked with Lake Victoria.

The hydroelectric plant at Owen Falls already uses the Victoria Nile. The options Bujagali and Karuma downstream of Owen Falls would make more effective use of the water in the Victoria Nile. Thus it would tend to reduce the pressure on the power production facilities in Uganda, with the impact of reducing the flows out of Lake Victoria.

This whole Victoria Nile basin may be characterized by exceptional landscapes, with a succession of falls, rapids and small lakes. Although not much is known about fisheries in the basin, it is known for a certainty that many species of yet undescribed fish inhabit the area, and some species thought to be extinct have been found in the area. Many of these

[4] S. Kayombo and S. Jorgensen
[5] Ibid

species would also be endemic as there are many falls along the river too high to allow fish migration from one stretch to the other, therefore resulting in local speciation with time. In addition, the construction of Owens dam complex, isolated for all intent and purpose any fish migration between Lake Victoria and the Victoria Nile.

Important water hyacinth and papyrus mats have been reported in Lake Kyoga, the largest lake in the Victoria Nile basin. This is a very shallow lake, and accumulated papyrus and water hyacinth mats have blocked the outlet, resulting in a rapid increase of water levels in the lake. The presence of this weed is also indicative of eutrophication and of the presence of nutrients from man made sources.

4.1.3 Lake Nyasa/Malawi Basin

Lake Malawi is the third largest lake in Africa[6] and is about 560 km long and 75 km wide at its widest point with a surface area of 33,000 km^2 and a drainage area of 132,000 km^2. Lake Malawi is part of the Zambezi watershed, which discharges into the Indian Ocean.

Lake Malawi basin has a humid to sub-humid climate with a mean annual rainfall that varies between 1000 and 2600 mm depending upon location in the basin, most of which falls during the rainy season from November to May with the north receiving more rainfall than the south[7].

Lake Malawi is home to 15% of the world's freshwater fish species, with more than 600 and perhaps up to 1000 endemic species in total[8], the majority of which belong to the monophyletic species of cichlids.

Consequently, Lake Malawi, with Lake Tanganyika, is by far one of the most species-rich areas in Eastern Africa and is believed to have the highest density of freshwater-dependent species in the world. It has been quoted as being biologically the most important lake in the world[9]. In addition, the Eastern Afromontane mountainous range, located partly in the Albertine Rift, harbours more endemic mammals, birds and amphibians species than any other region in Africa.

Lake Malawi is the most important source of animal protein in Malawi, with up to 70% of dietary animal protein derived from the Lake's fish. It may be assumed that the situation would be similar for the Tanzanian part of the watershed. The fishery sector in the watershed is thought to constitute a major source of income and livelihood for more than 300,000 people. In addition to serving as a fish resource, the lake serves for domestic use, livestock, agriculture, hydropower generation and for transport and tourism development.

Hydroelectric plants on the Shire River generate most of Malawi's energy. This power source is precarious as the river drains from Lake Malawi and is thus dependent on the Lake's water level, which fluctuates with climatic changes and deforestation levels. Between 1915 and 1935 the Lake was completely closed with no outflow and in 1997 electric power was rationed in November and October due to low lake levels[10]. Forest cover in the lake catchment decreased from 64% to 51% from 1967 to 1990 contributing considerably to runoff and erosion levels and consequently to fluctuations in the Lake level and stream flow. This could have a direct impact on the proposed hydroelectric developments in the northern section of the Lake.

[6] Gov. Tanzania, 2005
[7] Ibid
[8] J. Chafota et al., 2005
[9] WWF, 2005
[10] H. Bootsma and S. Jorgensen

Erosion rates, in part caused by deforestation for firewood needs, are high for all catchment sub-basins draining into the lake. This in turn alters the composition and quality of the lake's water, decreasing fish biodiversity and fisheries productivity.

Sedimentation, in combination with over-fishing, has caused fish stocks to decline by 10,000 tons per year and per capita fish consumption is 50% lower than it was 20 years ago[11]. Poor agricultural practices and biomass burning have increased sediment deposits in the Lake, which have resulted in higher blue-green algae densities; a potential toxin to humans, domestic animals and other aquatic life.

4.1.4 Lake Tanganyika Basin

Lake Tanganyika is fed by numerous small rivers and two major influent rivers; the Ruzizi that drains Lake Kivu to the north and the Malagarasi that drains western Tanzania south of the Lake Victoria Basin. The only outflow is the Lukuga River close to Kalemi. It eventually reaches the Congo River Basin, which discharges into the Atlantic Ocean .

Lake Tanganyika has a unimodal rainfall regime with a wet season from November to May and a dry season from June to October[12]. The main part of the basin has an annual rainfall of between 800 - 1000 mm[13],. The Lake has a surface area of 32,000 km^2 and a total catchment area of 239,000 km^2. Most of Lake Tanganyika's water loss occurs through evaporation from strong winds.

Lake Tanganyika with Lake Nyasa/Malawi, is by far one of the most species rich areas in Eastern Africa and is believed to have the highest density of freshwater-dependent species in the world. It is also renowned for its endemic species of cichlid fishes, a group of fish that is by far the most diverse in the world. Unlike other African great lakes, it also hosts species of non-cichlid fish and invertebrate organisms and is among the richest freshwater ecosystems in the world. Lake Tanganyika has about 500 endemic species, 200 cichlid fish and a total of 2,156 different species[14].

The basin faces threats of pollution, sedimentation and over-fishing. Bujumbura, in Burundi, is a key concern as it has the watershed's highest population density and is hosts to most of the area's industries, several within a few kilometres of the lakeshore. Potential pollution sources in Bujumbura include: textile dying plants, breweries, paint factories, soap factories, battery factories, fuel transport and storage depots, a harbour and a slaughterhouse. Wastes from the industries are generally not treated and ultimately make their way to the lake. The same is true for domestic waste, mercury and other chemicals used in small-scale uncontrolled gold and diamond mining. Potential petroleum exploitation in the area could add to this situation. Pesticide and metal levels are not yet an issue but they should be closely monitored due to the lake's very long residence time of 440 years.

Erosion caused by extensive deforestation in the area is increasing sedimentation levels. In addition, the lake is subject to over-fishing and destructive fishing methods.

Because of great human pressure, the Ruzizi Nature Reserve has been downgraded from a national park. It has been suggested that the boundaries be discussed to protect riverine and littoral species.

[11] J. Chafota et al., 2005
[12] Gov. Tanzania, 2005
[13] Ibid.
[14] K. West, 2001

Monitoring stations around the lake have demonstrated a mean increase in air temperature of about 0.7˚C in the north and 0.9˚C in the south since the 1960s. These climatic changes have already caused an increase of surface water temperature near Bujumbura of 0.4˚C during the dry season and 0.3˚C during the wet season[15].

4.1.5 Rufiji River Basin

Parts of the Rufiji Basin have a dry to sub-humid climate. The basin is the largest catchment basin in Tanzania covering 177,420 km^2. It covers 20% of Tanzania, is home to 20% of Tanzania's population and represents 30% of Tanzania's total surface water[16].

The Rufiji River is formed by the convergence of the Kilombero and Luwegu Rivers and it's main tributary is the Great Ruaha River. A characteristic of the Rufiji River is that it drains into the Indian Ocean creating a state of dynamic equilibrium between the Rufiji River and its estuary. Tides of the Rufiji Delta travel up deltaic branches of the Rufiji River over considerable distances, particularly when the Rufiji River is low. During floods, silt laden Rufiji waters penetrate far into the delta and deposit river sediments. These tidal branches change continuously under the influence of fluctuating discharges, varying intrusion of salinity and changes in sediment transport creating unique biologically diverse ecosystems such as mangrove forests, extensive intertidal flats, sea grass beds and sand bars. The Rufiji River's delta contains East Africa's largest contiguous mangrove with 64% of Tanzania's mangroves in the Rufiji Delta. However, since the implementation of the world's largest prawn farm in the Rufiji Delta, mangrove forests have been destroyed to open ponds in which the prawns are raised.

Water abstraction from irrigation in various areas is creating problems of water availability, causing serious water use conflicts including human-wildlife conflict due to displaced animals and competition for water by upstream irrigators and downstream dams. Furthermore, smallholder irrigators are not controlled and have no incentive for efficient water use. Dry season flows have been on the decrease in the Great Ruaha River since the early 1990s with sections of the River completely drying up in 1993. Dry periods are longer, with a recorded period of 111 days without any flow in 1999.

The Selous Game Reserve covers 21,000 km^2 and is one of the largest game reserves in Africa with approximately 750,000 large mammals, a third of Tanzania's wildlife.

Wetlands including freshwater swamps, the Kilombero (Ramsar site) and Rufiji River floodplains, coastal swamps and mangroves of the Rufiji delta provide habitats for a wide range of animals.

The Lower Kihansi hydropower project on the Kihansi River has dried out the river's wetlands by reducing water flow and is seriously threatening the Kihansi spray toad and two rare plant species endemic to the Kihansi Gorge[17].

4.1.6 Tana River Basin

Located in Kenya, the Tana River basin covers an area of 1,300 km^2 and contains more than four million people. It is the only permanent river in this extremely dry region and constitutes a vital water resource for all sectors of the human population. It is also heavily used for hydropower. To date five major reservoirs have been built and these have had a major influence on the river's downstream flow and physical characteristics.

[15] S. Jorgensen et al.
[16] EJ. Manongi
[17] E. Olsen, 2001

The Tana River region contains species and habitats that are not found elsewhere in East Africa. Six protected areas are located in the river and delta area, including some of the few remaining riverine forests which support at least four endemic plant species, three of the four primates that are endemic to Kenya and two endemic bird species, and savannahs and grasslands that contain populations of large mammals. As well as supporting tourism activities, forests and wildlife are also used by local communities. Approximately a third of local populations in the Tana River and Delta region regularly hunt, and rely on fuelwood, construction materials, medicines, boat building materials and wild foods sourced from natural forest. Forest and grassland areas, in particular, have been heavily impacted by dam construction, leading to changes in wildlife and plant species composition and numbers[18].

4.2 Socio-Economic Conditions and Issues

4.2.1 Regional Issues

4.2.1.1 Socio-economic Activities and Urbanization

Major economic uses related to the rivers and lakes in the region include provision of fresh water, lake and river transportation, water use for agricultural and industrial purposes, waste water disposal and hydroelectric power.

These activities are mainly concentrated in urban areas, which are growing at a rapid pace (over 5-10% per year in most of the larger towns). The increase in socio-economic activities and the rapid urbanization in this region are the source of environmental impacts through the discharge of untreated toxic substances into lakes and rivers and increased water consumption for industrial and municipal uses. Furthermore, the anarchy of urban growth near the lakes and rivers, associated with the spread of slums, the lack of amenities and increased pressure on the natural resource base, contributes to increasingly unsustainable living conditions for incoming migrants from rural areas.

4.2.1.2 Political Situation

The ability of national governments to intervene in the management of natural resources is weak due to budget restrictions and low institutional capacity to implement programs. For instance, the governments' inability to enforce rigorous legislation in terms of forest conservation has led to overexploitation of the forest for timber. This has led to extensive deforestation over the drainage basins and has impoverished the region. As explained by Ribbink[19] : "*Although fuel wood production provides a major source of livelihood to some rural household, communities that have sold all their forest resources experience new depths of poverty as both their source of income and their supply of forest products for domestic use disappear*. "

The region has had a history of civil strife and ethnic conflicts, which have led to widespread refugee displacement and political instability. However, the political situation in all of the countries of the Nile Equatorial Lakes region has markedly improved since the end of the 1990s. All of these countries have elected governments and are close to being at peace, including Rwanda that has moved a long way since the 1994 genocide. For example, since August 2006, the Lord's Resistance Army (LRA) which has sowed terror since 1986 in the northern part of Uganda has signed a cessation of hostilities with the government, promising peace in this area[20]. Recent elections in the Democratic Republic of Congo have been successfully concluded for the first time since the country's independence. As part of a trend

[18] IUCN, 2003
[19] Ribbink,2001
[20] International Crisis Group, 2006

towards regional integration, Rwanda and Burundi have recently joined Kenya, Tanzania and Uganda in the East African Community (EAC).

4.2.1.3 Tourism, Culture and Protected Areas

The displacement of refugees, poor conservation practices and weak economies have generated an enormous pressure on natural resources and constitute a threat fornatural parks and protected areas in the region: people looking for water, food, firewood and rich natural soil come closer and closer to protected areas. For example, in 1997, population estimates for those living adjacent to protected areas in the region were 93,000 in Uganda and 134,000 in Rwanda.

There is a great potential for ecological tourism related to wildlife and exceptional white rivers for water related activities such as rafting. In Uganda, for instance, tourism is the second largest source of foreign exchange. Over 6,000 people raft the Victoria Nile each year, providing indirect economic gains of nearly $4 million US a year. On the other hand, the lack of adequate services (such as transport, roads, hotels, and electricity) constitute real barriers to tourism.

Resource extractive activiries and environmental degradation are threatening the preservation of cultural sites around which local indigenous knowledge is built. Not taking into account this indigenous knowledge and cultural beliefs can lead to impoverishing already vulnerable populations.

4.2.1.4 Gender Issues

Although society is still highly patriarchal in the region, civil strife and ethnic conflicts have been catalysts for the emergence of women as active participants at all levels of society. For example, in Rwanda, women's groups were invited by the government to play an active role in the reconstruction of the country after the genocide in 1994. While some political actions have helped to change women status, many gender issues still persist in the region. Sexual violence and abuse, insecurity, lack of access to productive land and weak participation in politics and public life are daily concerns for women in the region.

4.2.1.5 Health Issues

The most common health issues in the Nile Equatorial Lakes region are related to a poor diet and to diseases due to contaminated water[21]. Water polluted by the dumping of untreated sewage and of agricultural and mining wastes in drainage basins exposes people to water-borne diseases, water-related vector borne diseases, and faecal/orally transmitted diseases[22]. These health problems include malaria, cholera, schistosomiasis, typhoid and dysentery.

A number of epidemics of cholera, dysentery and other water-borne diseases have occurred in the region and researchers have confirmed that the endemic character of these illnesses among the drainage basins' population was due to the poor quality of the water.

It is estimated that almost 5 million people live with HIV/AIDS in the countries of the Nile Equatorial Lakes region[23]. This statistic does not take into account millions of children who have been orphaned or made vulnerable by HIV/AIDS in the region. Massive population movements resulting from civil strife, ethnic conflicts and extreme poverty in the region have

[21] UNEP, 2004
[22] Ibid.
[23] CIA, 2006

worsened the situation. Prevalence rates for HIV/AIDS in 2003 (% of persons aged 15 to 49) were estimated at 6.0% in Burundi, 4.2% in DRC, 6.7% in Kenya, 5.1% in Rwanda, 8.8% in Tanzania and 4.1% in Uganda[24]. The fact that HIV/AIDS is still the major cause of death among 15-49 years old and is responsible for 12% of all annual deaths in Uganda illustrates the ravage of HIV/AIDS. In addition, the high HIV/AIDS prevalence speeds up the Tuberculosis (TB) epidemic: up to 75 percent of TB patients in some of the region's countries are co-infected with HIV/AIDS.

4.2.1.6 Chronic Poverty

As a result of these socio-economic issues, the people living in the Nile Equatorial Lakes region are among the poorest and most food insecure in eastern Africa. Indeed, the population of Kenya, Tanzania and Uganda living , around Lake Victoria are more likely (up to 5 to 10%) to live below the poverty threshold than elsewhere in their respective countries[25].

4.2.2 Lake Victoria and Victoria Nile Basins

Lake Victoria contributes significantly to the alleviation of poverty in acting as sources of dietary proteins and water, as providers of income (fish harvest, export and tourism) as well as avenues for transport of goods and persons.

The Lake Victoria Basin faces the most complex social, economic and political issues encountered in the study area[26]. The region, which is dependent on a fragile and diminishing natural resource base, suffers deep chronic poverty, political instability and reduced human development potential.

The Lake Victoria Basin is by far the area where over population constitutes the largest threat to the sustainability of the environment; it supports one of the densest and poorest rural populations in the world (estimated at 35 millions in 2004) and it comprises 83 large towns. The human population density is well over 100 persons per km^2 and can reach up to 1,200 persons per km^2 in some areas. Moreover, because of a high population growth rate (2-4% in most parts of the Lake Basin), the population is expected to double within 20 years[27].

Forty percent of the population of the region is concentrated along the Kagera River (mainly in Rwanda, Burundi, Tanzania and Uganda). One third of the population is settled in Kenya (in the Nyanza and Western provinces) and in Uganda, particularly in the northern shore of the Lake, an urbanized area of high agricultural fertility.

The population depends mainly on the lake basin's natural resources for its livelihood. Over 70% of the population lives from subsistence agriculture, pastoralism and agropastoralism. As a result, 80% of the lake catchment is mainly used for agriculture and subsistence farming associated with unsustainable agronomic practices, causing soil erosion and land degradation[28] .

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[24] CIA, 2006
[25] According to the CIA World Fact Book, the population below the poverty line represented 68% of Burundi's population (2002), 50% of Kenya's population (2000), 36% of Tanzania's population (2002), 60% of Rwanda's population (2001) and 35% Uganda's population (2001).
[26] UNEP, 2004
[27] World Bank, 1999
[28] UNEP, 2004

Within the Lake Victoria Basin, there are large-scale farms of coffee, tea, cotton, rice, maize, sugar and tobacco[29]. The underdeveloped manufacturing sector consists mainly of breweries, sugar refineries, soft drink and food processing factories, oil and soap mills, leather tanning factories, mining companies and textiles[30]. For example, the indistrial sector in Tanzania contributes to only 7% of national GDP compared to 48% for agriculture. On a more local scale, some industries, such as Yala Swamp in Kenya, harvest the extensive papyrus fringe that borders the Lake for thatching houses and making carpets/mats.

Fisheries constitute a major economic sector in terms of contribution to total GDP and employment creation for the Lake Victoria Basin, along with agriculture and manufacturing. Along the lakeshore, the fishing trade involves, directly or indirectly, most of the population. This industry provides employment for between 0.5 and 1 million Ugandans, more than 0.8 million Tanzanians and 0.8-1.5 million Kenyans, and most of the fish landed in these countries come from Lake Victoria[31].

The Lake Victoria fishery, which was a multi-species fishery before 1980, is now a three species fishery dominated by the Nile Perch, introduced in 1950 (*Lates niloticus*). In Lake Victoria, Nile Perch production represents about 300,000 tonnes of fish per year[32]. However, as expressed in a UNEP report[33] : "*there are concerns that this income generation is not benefiting the local people; they have lost their favourite species and the perch is now mostly harvested for foreign markets*." And there are good reasons to express these concerns: the population in the Lake Victoria basin are faced with fish consumption declines and malnutrition[34]. As well, unsustainable fishing practices and over-fishing are threatening the subsistance fisheries and the biodiversity of the basin.

Several studies conducted since 1960 have shown that the high incidence of cholera in the Lake Victoria area was closely linked with the proliferation of plankton (blue-green algae) and of water hyacinth[35]. Moreover, these studies have shown that one of the major risks to contract an illness in the whole region was to use the lake water as drinking water. The Lake Victoria region in Kenya has been recognized as a stable endemic area of malaria, which is still a leading cause of mortality in the Lake region.

Table 4-1presents some socio-economic indicators for the economies of the countries contained in the Lake Victoria and Victoria Nile basins.

4.2.3 Lake Nyasa/Malawi Basin

With a population estimated at 1.6 million people, Lake Malawi Basin is shared by the countries of Malawi, Mozambique and Tanzania[36]. Eighty percent of the riparian population lives in the southern part of the Lake in Malawi, where the population density can reach over 116 persons per km^2 [37] . Due to its remoteness and isolation from the rest of the Basin, the shore in Tanzania and Mozambique is sparsely populated[38]and most of the human pressure on the basin comes from Malawi.

[29] UNEP, 2004
[30] Ibid.
[31] Ibid.
[32] Ibid.
[33] Ibid.
[34] Ibid.
[35] IDRC, 2000
[36] WWF 2003
[37] UNEP, 2004
[38] Ribbink, 2001

The countries' GNP per capita is as follows: Malawi 220 USD, Mozambique 90 USD and Tanzania 210 USD[39]. The economies of the three countries are heavily dependent on international aid[40]. Livelihoods are natural resource based: agriculture and fisheries are the principal economic activities within the catchment's area. For instance, in Tanzania, the sale of food and cash crops account for about 70% of rural incomes and this sector accounts for more than 48% of the Tanzanian GDP[41]. More than 90% of the population living in the rural areas in Tanzania practice agriculture.

Lake Malawi also supports an ornamental fish trade for the international market. Even if underdeveloped, the manufacturing sector is concentrated on the northern shores of the lake, in Malawi, where 14% of the basin population live in urbanized areas where most of the anthropogenic activities having a major impact on the basin are located. In the northern and eastern parts of the lake, low population density helps to maintain vegetation and to keep the land lightly exploited.

Levels of education and technology are low and literacy levels are 56% in Malawi, 40% in Mozambique and 68% in Tanzania. A majority of the population lives below the poverty line (54% in Malawi, 70% in Mozambique and 58% in Tanzania). In Tanzania, approximately 80% of the poor live in rural areas[42]. According to Riibink (2001), an overarching problem is that "*poverty of the population within the Lake Basin and its dependence upon natural resources are making it increasingly difficult to maintain sustainable use of resources*"[43]. The most undeveloped regions within each country in terms of infrastructures, social development and economy are in this basin[44].

The only prominent water-engineering project is the Shire Valley hydroelectric power plant on the Shire River. There are many irrigation schemes within the catchment particularly on the Malawi side. There is increased demand for water for crop irrigation as more and more irrigation schemes are being established[45].

In the Lake Nyasa/Malawi Basin, health problems, mainly water-borne and vector borne diseases (bacterial diarrhea, hepatitis A, typhoid fever, malaria, plague, schistosomiasis) are related more to poor sanitary conditions then to agricultural or industrial effluent[46]. An indicator of low health status is the lack of amenities, associated with poor access to electricity, unsafe water sources and lack of decent latrines[47]. The prevalence of HIV/AIDS is 14.2% in Malawi, 12.2% in Mozambique and 8.8% in Tanzania.

The region is quite politically stable. However, the boundary of the Lake and of the meandering Songwe River remains the subject of discussions between Malawi and Tanzania.: Malawi claims that the border runs along the eastern shore of Lake Malawi while the Tanzanian government claims that it runs through the lake.

[39] UNEP, 2004
[40] WWF, 2003
[41] CIA World Fact Book, 2006
[42] URT, 2001
[43] Ribbink 2001
[44] UNEP, 2004
[45] Ibid.
[46] Ibid.
[47] Ibid.

Table 4-1 - Some Socio-Economic Indicators of the Economies of the Lake Victoria and Victoria Nile Basins

	Burundi	Rwanda	DRC	Kenya	Tanzania	Uganda
Population in the Country (million) (2004)	7.3	8.9	55.9	33.5	37.6	27.8
Population density (km^2)	281	356	25	59	43	141
Life expectancy (years)	44	44	44	48	46	49
GDP (million USD) (2004)	783	2,218	4,925	14,276	11,822	7,300
GDP real growth rate (%) (2000 – 2004)	2.3	5.2	3.7	2.7	6.9	5.4
GDP per capita PPP* (USD) (2004)	107	250	88	427	314	262
GDP by sector (%) (2004)						
Agriculture Industry Services	32 13 50	41 21 39	42 24 30	28 15 46	39 16 35	32 20 41
Population below PPP USD $1/day	54.6	51.7	-	22.8	57.8	-

*PPP=Purchasing Power Parity
(Source : World Bank – Africa Development Indicators, 2006

Table 4-2 presents some socio-economic indicators for the economies of the countries containing this basin. Some of this information has already been presented in Table 4-1 as some countries may contain more than one basin, but it has been repeated for easy comparison.

Table 4-2 - Some Socio-Economic Indicators of the Economies of the Lake Nyasa/Malawi Basin (2004)

	Malawi	Mozambique	Tanzania
Population in the Basin (million)	12.6	19.4	37.6
Population density (km^2)	134	25	43
Life expectancy (years)	40	42	46
GDP (million USD)	1,936	5,360	11,822
GDP real growth rate (%) (2000-2004)	3.0	8.9	6.9
GDP per capita PPP* (USD)	154	276	314
GDP by sector (%)			
Agriculture Industry Services	34 15 38	24 26 41	39 16 35
Population below PPP USD $1/day	41.7	37.8	57.8

*PPP=Purchasing Power Parity
(Source : World Bank, Africa Development Indicators, 2006

4.2.4 Lake Tanganyika Basin

The catchment of Lake Tanganyika is submitted to less human pressure than Lake Victoria. However, the population living in the drainage basin (estimated at 10 million in 2000) is growing very rapidly (about 2.5% per annum), resulting in a rapid doubling time of 25–30 years[48]. Human activities in this zone will therefore increase, compromising the equilibrium of the natural ecosystem. For instance, population pressure has led to the removal of a large surface of tropical forests to establish small agricultural plots.

However, population densities vary considerably within the Lake Tanganyika Basin. Burundi is by far the densest area of the basin with 250 persons per km^2 [49]; this high density rate is due to the presence of the Burundian capital, Bujumbura, at the north side of the lake. The density in DRC is about 21 persons per $km^{2;}$ in Tanzania, 35 persons per km^2; and in Zambia, 13 persons per km^2 [50].

In major urban areas, people are often involved in administration and aspects of international trade between the four countries. The capital of Burundi, Bujumbura (population 400,000) has an international airport and more than eighty industries (paint, brewery, textiles, soap, batteries, etc.). In eastern DRC, Goma, Uvira and Kalemie have some industries and are

[48] World Bank 1999
[49] Ibid
[50] Ibid

linked to others centres of the country. In Tanzania, the transit point for goods and people in Tanzania is Kigoma (population 135,000) with a rail connected to others centres. Even if some urban areas are located along the Lake shore, the Tanganyika Basin shared by DRC, Tanzania and Zambia is quite remote, marginalized from economic and industrial centres as well as disadvantaged in terms of public services and basic infrastructures (electricity, running water and communications).

Table 4-3 illustrates some of the socio-economic indicators for the countries riparian to Lake Tanganyika. Some of this information has already been presented in Table 4-1 as some countries may contain more than one basin, but it has been repeated for easy comparison.

Table 4-3 - Some Socio-Economic Indicators of the Lake Tanganyika Basin (2004)

	Burundi	DRC	Tanzania	Zambia
Population in the Basin (in millions)	7.3	55.9	37.6	11.5
Population per km^2	281	25	43	15.4
Life expectancy at birth (years)	44	44	46	38
GDP (million USD) 2004	783	4,925	11,822	3,887
GDP real growth rate (%) (2000-2004)	2.3	3.7	6.9	4.6
GDP per capita PPP* (USD)	107	88	314	339
GDP by sector (%)				
Agriculture Industry Services	32 13 50	42 24 30	39 16 35	17 27 45
Population below PPP USD $1/day	54.6	-	57.8	75.8

*PPP=Purchasing Power Parity
(Source : World Bank, Africa Development Indicators, 2006

Outside of these urban settlements, people's livelihoods depend on subsistence agriculture and small-scale commercial fishing[51]. Fisheries provides jobs and livelihoods for more than 1 million people[52]. Because of the scarcity of fertile land, most farming occurs on steep slopes or narrow strips of land between the Rift escarpment and the Lake. The principal subsistence crop is cassava and commercial crops are oil palm and limited rice, beans, corn and banana production[53]. Deforestation to practice agriculture and increased fuel wood demands have led to fuel wood shortages in many lakeshore villages[54].

Due to the presence of tsetse flies, cattle herders have not settled down in the region; however, regional political instability has forced some cattle owners to move their cattle to nearby lakeside areas.

[51] UNEP, 2004
[52] Ibid.
[53] Ibid.
[54] Ibid

Though urban pollution and over-exploitation of the biological resources are not yet a major issue in this region, some scientists have warned that over fishing and use of inappropriate methods will reduce in the long term the fishery and agricultural potential.

Much of the Burundi and Congolese shorelines of the northern Lake Tanganyika Basin have experienced violence, driven by conflict over natural resources and access to land. Chronic poverty and endemic unemployment have exacerbated the problem and have led to large population migrations. These population movements have had significant repercussions on economic and social development in the basin. Furthermore, political instability has undermined the tourism sector, which has considerable potential in this region even if local infrastructure is not yet on a level that would allow for mass tourism.

There are several designated protected areas (refer to appendix B) in the riparian zones surrounding the lake. Burundi has two designated protected areas: the Rusizi Natural Reserve (recently downgraded from National Park) and Kigwena Forest; Tanzania has two: Gombe Stream National Park and Mahale Mountains National Park; and Zambia has the Nsumbu National Park. DRC currently has no protected areas in the lake region. The Rusizi Natural Reserve is recognized as an international site of ornithological interest due to the presence of resident and migrant bird fauna. Chimpanzees and other primates are found in Gombo Stream and Mahale Mountains National Parks, sites of the longest-running primate studies. Nsumbu National Park hosts , in low density, elephants, lions, leopards, gazelles and other game. It should be taken into account that Mahale Mountains and Nsumbu National Parks provide a natural protection to the Lake as their borders extend 1.6 km into the Lake.

Tsetse flies, AIDS/HIV, malaria, poor sanitation and waterborne diseases (cholera and diarrhoea) are the major health issues. The prevalence of AIDS/HIV is 4.2% in DRC, 8,8% in Tanzania, 16.6% in Zambia and 6% in Burundi.

Life expectancy in Lake Tanganyika's riparian nations averages 42- 51 years. Literacy rates range from 45 to76 percent. Per capita income ranges from 110- 320 US$ per year with significant proportions of the population living below the national poverty lines and with less than $1 US per day. Another good indicator of living conditions in this region is the Human Development Index (HDI). Compared with 177 states, DRC is ranked 167th, Zambia 166th, Tanzania 164th and Burundi 169th [55]. Those results reflect the poor socio-economic situation faced by many residents of the Lake Tanganyika Basin.

4.2.5 Rufiji River Basin

The population increase (more than 5.5 million people in 2005) in the Rufiji River Basin has raised the demand for land resources. This demographic trend is being exacerbated by the migration of many pastoral migrants from the northern part of Tanzania. As a result, resource utilisation has intensified and has led to increased environmental degradation.

Water resources in the basin are mainly used for irrigation, generation of electricity, and domestic use. The Rufiji Basin is very rich in resources and significant potential exists for both irrigated and rainfed agriculture on the fertile land: 75% of the Rufiji basin land is considered to be suitable for irrigation. Iringa and Mbeya, both within the Rufiji Basin, are two of the four major grain producing regions in Tanzania. Increased grain production in these areas is mainly brought about by expansion and intensification of smallholder farming. It has to be noted that non-sustainable agricultural development in the catchment may have a significant impact on the delta's ecology.

[55] UNDP, 2005

During the last thirty years, public infrastructure such as highway and hydropower development on the Great Ruaha River have set the stage for rapid exploitation of the basin's resources (fish and petroleum). Local and foreign fishing companies have been attracted to the delta by the great potential for fisheries.

These activities, unless properly planned and coordinated, may lead to resource degradation in the delta. In the Great Ruaha sub-basin, water shortages and water use conflicts are already being experienced. Competition is mainly between downstream hydropower generation and upstream irrigation.

The situation is further aggravated by poor water management: smallholder irrigators use water without controls and no incentives exist to use water efficiently. In theory, a water right must be given to a person or a community to take water from a pump or irrigation equipment. However, in reality, smallholder irrigators do not hold water rights. Tanzania has a very long history of indigenous irrigation, and conflicts have arisen over the need to pay for a permit for something their ancestors have always seen as an asset.

The basin has abundant, undeveloped wildlife resources, with potential tourist attractions in the Selous and Rungwa Game Reserves, and Mikumi and Ruaha National Parks. The Kilombero is a potential Ramsar Site because it contains 70% of the world's Puku population, an atypical antelope. The Selous Game Reserve, the second biggest conservation area and the largest game reserve in Africa, has an enormous tourist potential.

4.2.6 Tana River Basin

In 1991, almost 200,000 crop farmers, livestock keepers and fishermen lived permanently in areas that are directly adjacent to the Tana River and the Tana Delta. In total, it is estimated that over a million people depend on the river's flooding regime for their livelihoods, including an additional 800,000 nomadic and semi-nomadic pastoralists as well as seasonal fishermen and fish traders. Almost 2.5 million livestock, including over a million cattle, rely on the Tana's floodplain grasslands and water bodies for dry season pasture and water. With no other permanent water sources in the region, the Tana provides the only source of emergency and drought pasture.

About 115,000 people practice flood recession and riverbank farming around the Tana, which provides the only source of land in the region that is suitable for arable agriculture. These farmers depend both on floodwater to irrigate their crops, and on the deposit of fertile sediments that the floods bring.

Many farmers also depend on fishing as a source of income and household protein, and there is a thriving trade in fresh and dried fish in the main towns and cities of the area. The Tana River, delta and estuary area was supporting in 1991 both subsistence and commercial fisheries, and providing a livelihood to more than 50,000 people[56].

It was reported in 1994 that dam-related changes in river hydrology had already reduced the area and longevity of flood-supported wetlands and mangrove areas, as well as diminishing fish populations and diversity in the main river channel[57].

[56] IUCN, 2003
[57] Mavuti, 1994

4.3 Regional Environmental and Socio-Economic Outlook

The Nile Equatorial Lakes Region is one of the most biologically diverse in the world, particularly in terms of endemic fish species. The climate, topography and hydrography are sufficiently varied to provide habitats for a wide variety of vegetation and wildlife.

The peoples of the region are also diverse, both culturally and linguistically, with wide regional variations in population density and economic activity. Much of the region has a very productive agriculture.

The population has, unfortunately, exceeded the carrying capacity of the natural resource base upon which the economy depends. Deforestation and forest degradation have reached endemic levels and are now adversely affecting water quality. The lakes and rivers have experienced declines in fish resources, biodiversity and overall deterioration in water quality via deforestation, over-exploitation and general poor management. This is in part due to rapid population growth in the areas bordering the water basins, hence increasing pressure on natural resources, human habitat and the economic and social infrastructure.

Overall, the population is poor and likely to get poorer if the trend toward resource depletion is not reversed. Current agricultural, pastoral and resource use (e.g. fishing practices and forest exploitation) are unsustainable and need to be upgraded or replaced by a more diversified development of the local economy.

5 REGIONAL ELECTRICITY NEEDS ASSESSMENT

5.1 Introduction

A basic foundation to the development of the region is an assessment of its electric power needs. The regional electricity needs assessment begins with a description of the key issues affecting load growth in the region, followed by a description of the current situation in terms of the availability of electric power generation in the region and the approach and methodology for load forecasting is described.

Four estimates are derived in this chapter: three are based on a continuation of the status quo, with variation in some of the input assumptions regarding the rate of growth of other economies of the countries and a fourth is based on an estimate of the needs for the region to improve significantly its economic situation.

5.2 Context

The population of the region is estimated at 117.4 million people in 2005 and the demand for electricity from customers connected to the systems in the region for 2005 (the amount supplied plus an estimate of the suppressed demand) was estimated at 11,200 GWh. This results in overall average electricity consumption per capita for the region of about 95 kWh per capita. This includes urban and rural domestic consumption plus all industrial, commercial and government consumption.

In order to put electricity consumption in the region into perspective, the unit consumption per capita for several regions are presented in Table 5-1 (note that the sources of data and the base year for the table differ from the above; care must therefore be taken in comparing these figures). This table suggests that the current consumption in the NEL Region is significantly below the average of the low income countries worldwide as well as below the average for Africa as a whole. Within each of these groups there are countries that have unusually high unit consumption due to special circumstances such as high mineral wealth; even when these countries are removed from the analysis, the NEL Region still compares very poorly.

5.3 Key Issues

Only a very small proportion of the population of the region, estimated between 2% and 9%, has access to electric power supply – see Appendix E. This low access to electricity has major consequences on social and economic development as well as on the environment. As discussed in chapter 4, this situation contributes to perpetuate poverty over the whole region. An underdeveloped manufacturing sector, high dependency for subsistence livelihoods based on natural resources (fuel wood, agriculture, fisheries), weak economy, decayed infrastructures (water system, health care, social utilities), and deforestation due to high demand in fuel wood are all major issues which have roots in the lack of access to electricity.

Table 5-1 - Comparison of Annual Electricity Consumption per Capita

Region or group	Electricity consumption per capita in 2003	Remarks
Middle income countries (all 62 countries)	2238	Includes such countries as Algeria, Botswana, Egypt, Gabon, Libya, Morocco, Namibia and South Africa
Middle income excluding outliers (54 countries)	1800	Unit consumption exceeding 3500 kWh/capita; excludes Czech Republic, Estonia, Russian Federation, Saudi Arabia, Serbia and Montenegro, Slovakia, South Africa, and Trinidad and Tobago
Developing countries (all 81 countries)	2120	Includes countries such as Algeria, Angola, Benin, Botswana, Cameroon, Cote d'Ivoire, Congo, DRC, Egypt, Eritrea, Ethiopia, Gabon, Ghana, Kenya, Libya, Morocco, Mozambique, Namibia, Nigeria, Senegal, Sudan, Tanzania, Togo, Tunisia, Zambia and Zimbabwe
Developing countries excluding outliers (68 countries)	930	Unit consumption exceeding 3500 kWh/capita; excludes Bahrain, Brunei Darussalam, Cyprus, Hong Kong, Korean Republic, Kuwait, Netherlands Antilles, Qatar, Saudi Arabia, Singapore, Taiwan, Trinidad and Tobago, and United Arab Emirates
Low Income Countries (35 countries)	500	Includes such countries as Benin, Cameroon, Cote d'Ivoire, Congo, DRC, Eritrea, Ethiopia, Ghana, Kenya, Mozambique, Nigeria, Senegal, Sudan, Tanzania, Togo, Zambia and Zimbabwe
Low Income Countries excluding outliers (29 countries)	240	Unit consumption exceeding 1000 kWh/capita; excludes Azerbaijan, Georgia, Kyrgyzstan, Republic of Moldova, Tajikistan and Uzbekistan
Africa (26 countries)	685	Does not include Burundi, Rwanda or Uganda in the database
Africa excluding outliers (22 countries)	320	Unit consumption exceeding 1200 kWh/capita which excludes Botswana, Libya, Namibia and South Africa

Source: International Energy Agency (IEA) Statistics Division. 2006. Energy Balances of OECD Countries (2006 edition)--Economic Indicators and Energy Balances of Non-OECD Countries (2006 edition)--Economic Indicators. Paris: IEA. Most recent data available are for 2003. Note that this source did not provide data for Burundi, Rwanda or Uganda. Available at http://data.iea.org/ieastore/default.asp

If the status quo on low electricity accessibility is maintained, this will worsen the current situation. To meet their basic needs for agricultural land and for fuel wood, the rural population, which is very dense in the study area, will have to continue to clear more forestland and intensify deforestation. Confronted with substantial environmental degradation, the rural population will have to deal with shortages in natural resources, on which its livelihood depends. With regard to the economy, a very low access to energy will exacerbate economic crisis now facing the region. Without a better access to electricity, it is obvious that the regional undiversified economy will be further constrained by its dependence on already diminished natural resources and will not be able to provide sustainable minimal income to the growing population.

The potential electricity demand in the region, merely from the electrification of the rural areas is enormous; full electrification could increase the load in the region by a factor of well over 2 times the current load. On the other hand, the cost of such electrification would also be very high – just the cost of service entries to the houses plus the low tension lines supplying the houses would be substantial, and might not make sense from a short-term profitability point of view. However, on the longer term, it will have positive trickled-down effects on social development and will hence be economically profitable. As well, providing electricity can contribute significantly to reducing the level of poverty in which the rural population is trapped, and considerably alleviate pressure on natural resources.

Suppressed demand is another key issue in the assessment of the demand for electric power. This is the amount of energy demanded by the customers that is not met by the utility. This would be a combination of electricity use foregone by the customer plus the amount of energy generated by the customer from its own sources due to an absence of power from the utility or a poor quality of the power that is available.

All areas of the study region have shortages of installed capacity and are, therefore, not able to satisfy the demand in the region. For instance the government of Rwanda has indicated that there is suppressed demand in the country and the local utility has estimated this amount to be about a 10% shortage of capacity at time of system peak and about a 4% shortage in energy. The Government of Burundi has indicated that there is suppressed demand in the country but has not quantified the amount. The utility in Uganda has indicated that it is not able to meet the peak demand of the country, although it is able to export power during the off-peak periods.

A third key issue is linked to the historic econometric and power availability situation in the region. Most load forecasting techniques are based on an extrapolation of past conditions. Thus, doing so in the region implies a continuation (and possibly a gradual improvement on) the current socio-economic condition in the region.

5.4 Demand Side Management

Demand side management and energy efficiency in developing regions have to be viewed in the context of the loads, the adequacy of the present supply situation, and the need for investment in corporate systems and training for the implementation of such programs.

The rational use of energy is a key objective in all jurisdictions, especially in areas where energy is at a premium. Programs to promote efficient use of energy are designed to change a customer's 'normal' consumption patterns for the benefit of both the consumer as well as the producer of power. Energy efficiency normally refers to the efficient utilization of energy through the use of energy efficient products or procedures while demand side management (DSM) programs are normally designed to shift energy used during peak periods to off-peak periods.

DSM programs are usually associated with tariff incentives to shift demand. With higher on-peak tariffs, cost conscious customers will tend to shift their demand to off-peak hours. The total amount of energy consumed does not change but the shift in usage reduces the capacity requirements of the electricity producer.

DSM programs are relatively easy to implement if there is flexibility in establishing incentives through tariffs. Energy efficiency, on the other hand, requires a significant infrastructure to design and implement programs that would produce a significant impact. Energy efficiency programs are most effective in regions where the unit cost of energy is high.

The reduction in capacity requirements that can be achieved by DSM programs is a function of the tariff structure, the system load profile, the load profile of users and the flexibility in changing the time of day where energy can be used. The capacity saving from DSM can vary from a few percentage points to a significant amount depending on specific local conditions.

Energy efficiency is normally achieved through programs that promote energy efficient products and behavioural changes. For example, the use of fluorescent tubes or compact fluorescent lights instead of incandescent lights can have a significant impact on energy consumption while maintaining adequate level of lighting. By using energy efficient products, the amount of energy is reduced as well as the capacity requirements.

The reduction in capacity and energy requirements from energy efficiency programs is a function of the effectiveness of local energy conservation and utility companies to manage the programs. Energy efficiency in small systems is sometimes not cost effective given the nature of smaller systems and the infrastructure required to manage energy efficiency programs. However this remains an option that should be promoted in the future to reduce loads and investment requirements.

Within the context of the NEL Region, and particularly taking into account the present supply deficit, DSM initiatives are not expected to have a significant impact on the growth of demand for at least the mid term. It is noted that no electric utilities in the region have initiated such demand side management programs.

5.5 Loss Reduction

Another option to reduce demands is to reduce technical losses (reduction in non-technical losses will not reduce demand). Investment in loss reduction may be more economic than new generation. Losses in the region are relatively high, as shown in Table 5-2, and this suggests that loss reduction program could provide benefits, at least in Uganda.

5.6 Current Regional Conditions in the Power Sector

The latest compilation of the existing generation facilities in the region by the SSEA Study is summarized below in Table 5-3 for the region and then presented in more detail in subsequent tables. These tables present the latest information available as reviewed by the members of the Project Steering Committee. They include all significant electric power generating sources linked to the grids of each country.

Table 5-2 – Technical Losses

Country	Technical loss %	Country	Technical loss %
Burundi	14[1]	Rwanda	14
DRC (East)	10 (total)[2]	Tanzania	12
Kenya	16[3]	Uganda	21

It should be noted that (as of mid 2006) Rwanda is in the process of installing new diesel generation capacity.

Table 5-3 - Summary of Generation Capacity in the Region[4]

(Figures in MW)	Utility, Existing Capacity	Utility, under construction	Captive Power	Isolated Generation	Total Installations
Burundi	33.6	0	0	3.6	37.2
Eastern DRC	110*	0	N/A	97†	207
Kenya	1121	60	N/A	N/A	1181
Rwanda	40.9	0	0	0	40.9
Tanzania	785	0	N/A	N/A	785
Uganda	327	80	N/A	N/A	407
Region	**2417.5**	**140.0**		**100.6**	**2658.1**

* of which 40 MW are operational
† only partly operational

The six upstream riparian countries of the Nile Equatorial Lakes (NEL) region are characterized by constrained isolated power systems where demand exceeds present generation capacity. Access to commercial energy sources is limited. In 2000[5], it was estimated that only 8% of the energy needs in Tanzania were fulfilled by electricity – the rest were met by biofuel (wood fuel) and coal. In Burundi and Rwanda, the percentage of energy needs fulfilled by non-electrical energy is about the same (i.e. 90% or more).

Table 5-4 summarizes the current load versus resources situation in every country included in the scope of this forecast and clearly shows that the entire Nile Equatorial Lakes region is facing a power shortage. The estimated year of deficit includes losses.

1 Losses for Burundi and Rwanda and based on Laymeyer International – Analysis and Projection of Rwanda's Electricity Demand. for ELECTROGAZ – May 2004

2 SNEL – 2003 – Plan directeur National de Secteur de l'Electricité à l'Horizon 2015

3 Technical losses for Kenya, Tanzania and Uganda were taken from the EAPMP

4 This table was prepared based on data collected in 2005. Subsequently, Rwanda has commissioned the construction of additional diesel generation.

5 Estimation by US/DOE/EIA.

Table 5-4 - Load vs. Resources Situation in Countries under Analysis

Country	Capacity Available		Estimated Demand		Current deficit or estimated year of deficit
	(MW)	Year	(MW)	Year	
Burundi	37.2 MW	2002	30 MW	2002	2004
East-DRC	40 MW	2002	50 MW	2002	10 MW
Kenya	1,121 MW	2002	800 MW	2002	by 2005-2007
Rwanda	28.7 MW	2002	30 MW	2002	2004
Tanzania	785 MW	2002	500 MW	2002	by 2005-2007
Uganda	327 MW	2002	280 MW	2002	by 2005

5.7 Approach and Methodology

In general terms, a power needs assessment takes account of:

1) The current amount of installed and reliable capacity;
2) The expected retirement date for the generation units in the system;
3) The expected electric power requirements in a system over a selected time horizon including:
    - Needs of current customers (including the impact of demand side management initiatives),
    - Expected increase in number of urban customers,
    - Rural electrification (degree of penetration, number of new customers and unit consumption),
    - Technical losses in the system, and
    - Non-technical losses.
4) An allowance for additional generation capacity in order to provide reliable service when one or more of the generating units is out of service due to maintenance requirements or unexpected breakdowns.

This forecast focuses on the expected electric power requirements (item No. 3 above) as seen from the demand side. The other elements are covered in subsequent chapters dealing with the proposed Nile Basin generation expansion plan.

The scope of this Electricity Needs Assessment includes Burundi, Eastern DRC, Kenya Rwanda, Tanzania, and Uganda. The selection of the forecasts in each country is carried out in the following steps:

- Review the existing load forecasting methodologies;
- Perform a review of the reference documents produced by utilities or other organizations in the case of each country; and

- Select in each case the most appropriate forecasts that will form the basis of the regional demand assessment.

5.8 Regional Electricity Needs Assessment

The power needs for the entire region under study is equal to the sum of the:

- Estimated sales to customers;
- Additional urban electrification;
- Additional rural electrification;
- Gradual reduction of technical and non-technical losses; and
- Replacement of decommissioned units, if any.

The first four elements have already been included in each country's individual forecast (see Appendix E). It is assumed for the needs of this forecast that no units will be decommissioned over the target period. However, it should also be noted that there is a significant amount of diesel generation installed in the NEL region either by the utilities or by mining loads. These rely on expensive imported fuel. As the hydroelectric potential of the region is developed, the use of these diesels will tend towards peaking and reserves, so as to reduce the utility's expenses[6]. Note that the system reserve allowance is considered in the system-planning component of the mandate.

5.8.1 Development Scenarios

Four scenarios have been developed for the purposes of this Regional Power Needs Assessment. A summary of the assumptions taken in each case is presented below. Complete details on each individual country's GDP growth rates, assumptions on domestic as well as industrial loads, rural electrification programs and loss reduction can be found in Appendix E.

The extrapolation of the existing conditions was examined under a base set of assumptions and a reasonable variation around that set of conditions was also examined. A summary of the assumptions for these conditions is given below.

Base Scenario

A base scenario was developed under the assumption that GDP growth rates will continue to be impacted negatively by several destabilizing factors such as political conditions, global economy, and conflicts in the Middle East[7]. It also reflects conditions that could be expected if each of the countries in the region continue their development plans independently. In this forecast, specific consumption is maintained at a constant level and a reduced growth rate is applied to the number of domestic clients. New industries will reach their full potential only after 5 years from commissioning and existing mines will keep using auto generation.

[6] Strategic/Sectoral, Social and Environmental Assessment of Power Development Options in Burundi, Rwanda, and Western Tanzania, Stage I, Final Report, prepared by SNC-Lavalin International, February 2005, page 4-28

[7] *East African Power Master Plan Study, Final Report*, produced by BKS Acres for the East African Community, March 2005, page 4-3

Medium Scenario

For the medium scenario the growth in the current system load, which is mainly urban, was extrapolated on the basis of historical GDP and average electrical consumption growth for each country. This scenario also reflects minimum conditions that could be expected under integrated development in which each country cooperates with its neighbours.

Ongoing loss reduction and network reinforcement projects are expected to reduce the total system losses gradually. Non-technical losses are also expected to decrease to reach a minimum amount that varies according to each country's particular situation. It is also assumed in the medium scenario that each country's rural electrification program will proceed as planned. The industrial load growth is extrapolated from sectoral GDP growth rates, and new industries (particularly mining) are expected to grow to their full potential within three years. Existing mines on the other hand will keep using auto-generation and will not contribute to grid demand.

High Scenario

For the high forecast the growth in the current system load, which is mainly urban, is based on the assumption of relative political stability in the region and on the fact that governments will achieve GDP growths higher than the World Bank predictions by resuscitating their economies.

This forecast will yield a high rate of rural electrification and increased specific consumption growth in the domestic sector. The industrial load will grow according to sectoral GDP growth rates, new industries will reach full potential within three years of commissioning and all mining loads will be connected to the national grid at specified times. Population growth is assumed to occur at the same average historical rate of 2.6%.

The Regional Transformation Scenario

The Project Steering Committee, during its meeting of April 2005, requested the Consultant to provide an alternative forecast that would reflect the optimism expressed in the ***Lake Victoria Vision*** and the ***NELSAP five-year Scaling-up Strategy*** as well as other targets that would provide the population of the region with a comfortable amount of electricity. Three approaches were used, as described below:

- A scenario that reflects the Lake Victoria Vision. This scenario is defined and developed in Appendix E. The result of these analyses is a target of 60,400 GWh in 2020, which is 2.3 times the medium growth forecast for that year of 26,800 GWh;
- A scenario in which all households are electrified but at a low level by the year 2020. In this case it is assumed that the medium growth forecast would apply AND, to this would be added the electrification of all remaining households to a level of 100 kWh per month per household (a level used by SNEL in its forecast of rural electrification in eastern DRC). This would yield a target of 67,200 GWh, as shown in Appendix E.
- A scenario in which the entire population has access to and uses electricity at the same level as is currently used. This would yield 216,900 GWh, as shown in Appendix E.

The first two targets are similar and imply an average electricity demand growth rate of about 15% per year starting in 2010 (it is assumed that several years would be required to put into place the infrastructure required to achieve these growth rates). The third scenario implies an electricity demand growth rate of 30% per year from 2010, or the same 15% growth rate applied to almost 2030. For the regional transformation scenario, the Lake Victoria Vision scenario has been retained.

5.8.2 Regional Electricity Needs Assessment Summary

The results of the regional load forecast are shown in Table 5-5, and illustrated graphically in Figure 5-1; the derivation of these forecasts is shown in Appendix E.

Table 5-6 shows the incremental capacity requirements from the demand side only. This then corresponds to the difference between the forecasted demand and the actual demand.

The relative contribution of each country to the total energy and peak demand requirements over time is illustrated for the base case in Figure 5-2.

The details of each country's contribution to the regional energy requirements and peak demand are tabulated in Appendix E.

It should be noted that even with the medium growth scenario, the unit energy consumption would only reach 60 kWh per household per month (26,800 GWh/year/12 months/37 million households). Using the current value of 485 kWh/month/customer, this implies that the electrification rate would only be about 12%. For the high load growth scenario where the expected energy consumption in the region would reach 34,400 GWh in 2020, this implies a household consumption of 77 kWh/household/month and an average electrification rate of about 16%.

Another way of comparing the degree of electrification is to refer back to Table 5-1, which gives the electricity consumption for various groups of countries. This allows a comparison of the level of electrification in 2020 as compared to the current level in these groups. Based on an estimate of the population in 2020 of 190 million people this implies a level of electricity consumption per capita as follows:

- Base forecast scenario: 103 kWh/capita, an increase of less than 10% over current levels of about 95 kWh/capita;
- Medium forecast scenario: 141 kWh/capita, an increase of 53% over current levels but not even half of the current average for all of Africa (even excluding the wealthier countries) of 320 kWh/capita, as shown in Table 5-1;
- High forecast scenario: 181 kWh/capita, an increase to almost double the current level in the region but still well under the current average for all of Africa (even excluding the wealthier countries);
- Transformation scenario: 318 kWh/capita, an increase to over three times the current level in the region but just equal to the current average for all of Africa excluding the wealthier countries. This is still only about one third of the level reached by the developing countries of the world, even when the wealthier of them are excluded from the comparison.

Table 5-5 - Regional NEL Power Needs Assessment Summary

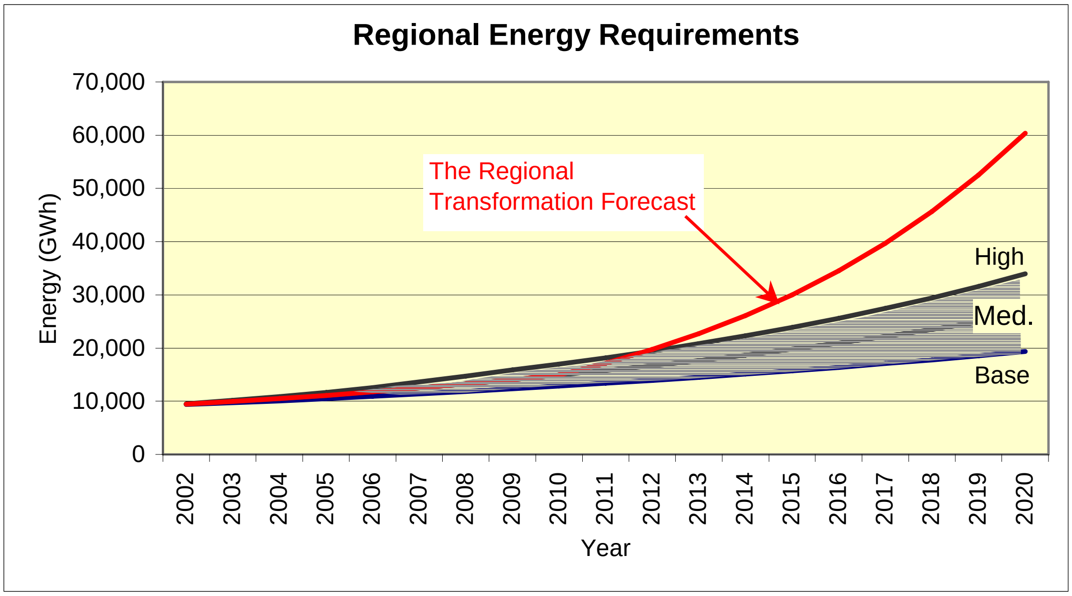
Year	Base	Growth	Medium	Growth	High	Growth	Transformation	Growth
	Energy (GWh)*							
2002	9,500	3.7%	9,500	5.6%	9,600	7.1%	9,450	5.5%
2005	10,600	4.3%	11,200	6.3%	11,800	7.8%	11,100	6.1%
2010	13,100	4.0%	15,200	5.7%	17,200	7.1%	14,900	15.0%
2015	15,900	4.3%	20,100	5.9%	24,200	7.3%	30,000	15.0%
2020	19,600		26,800		34,400		60,400	
	Demand (MW)*							
2002	1,700	3.8%	1,700	5.6%	1,700	7.3%	1,670	5.1%
2005	1,900	3.9%	2,000	6.2%	2,100	8.1%	1,940	6.0%
2010	2,300	4.0%	2,700	5.3%	3,100	6.8%	2,600	15.0%
2015	2,800	4.0%	3,500	6.1%	4,300	7.2%	5,230	15.0%
2020	3,400		4,700		6,100		10,520	

*rounded to the nearest hundred

Table 5-6 – Incremental Capacity Requirements for the NEL Region (MW)

Incremental Capacity Requirements for the NEL Region (MW)				
Year	Base	Medium	High	Transformation
2005-2010	400	700	1,000	660
2010-2015	500	800	1,200	2,630
2015-2020	600	1,200	1,800	5,290
2005-2020 Total	**1,500**	**2,700**	**4,000**	**8,580**

Figure 5-1 - Regional Power Needs Assessment in the NEL Region for the Period 2005-2020



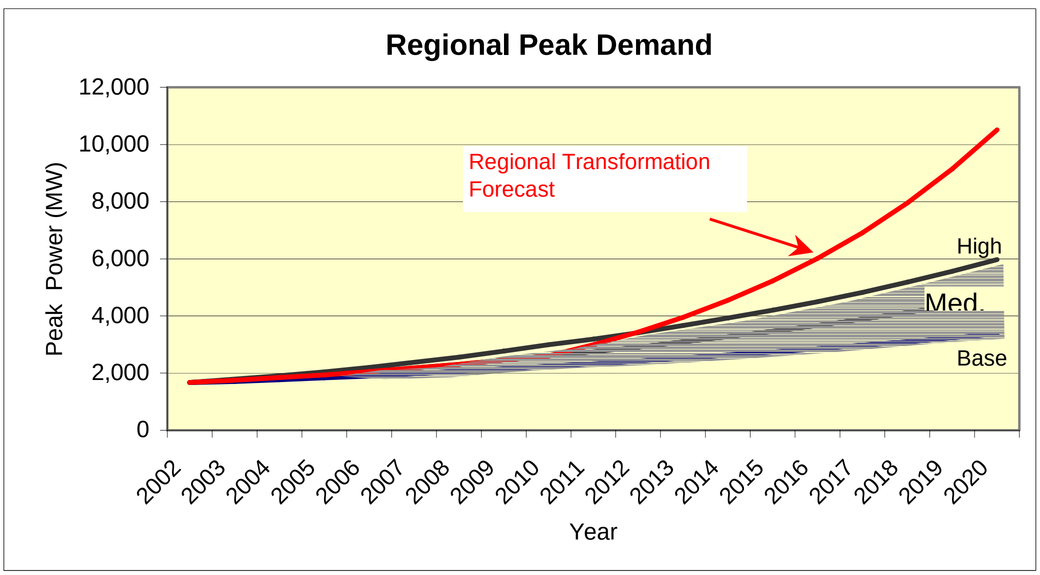
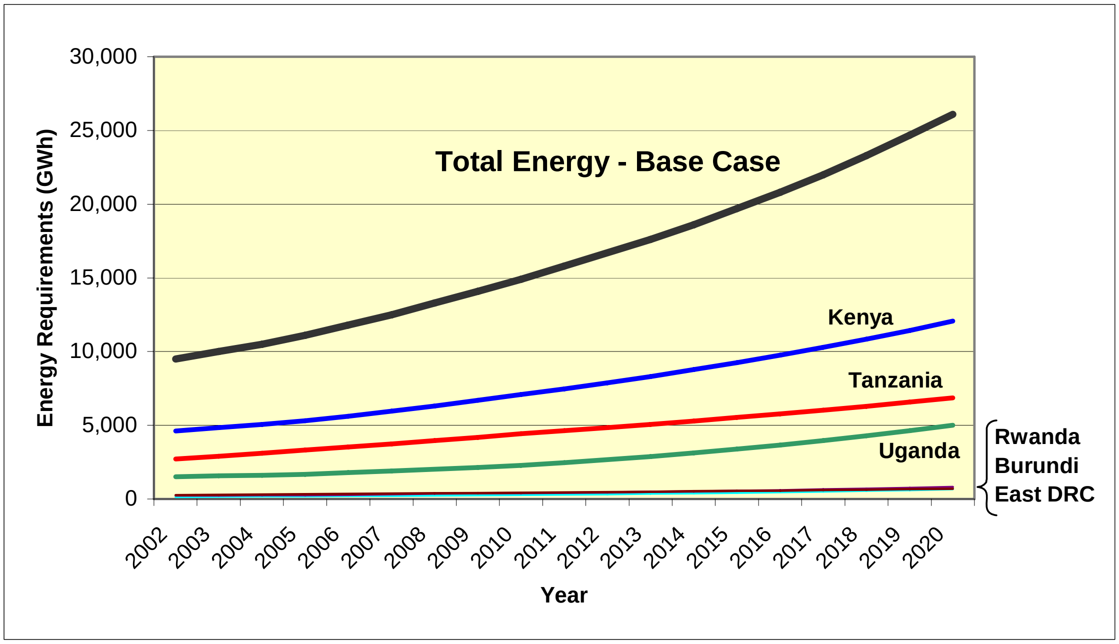
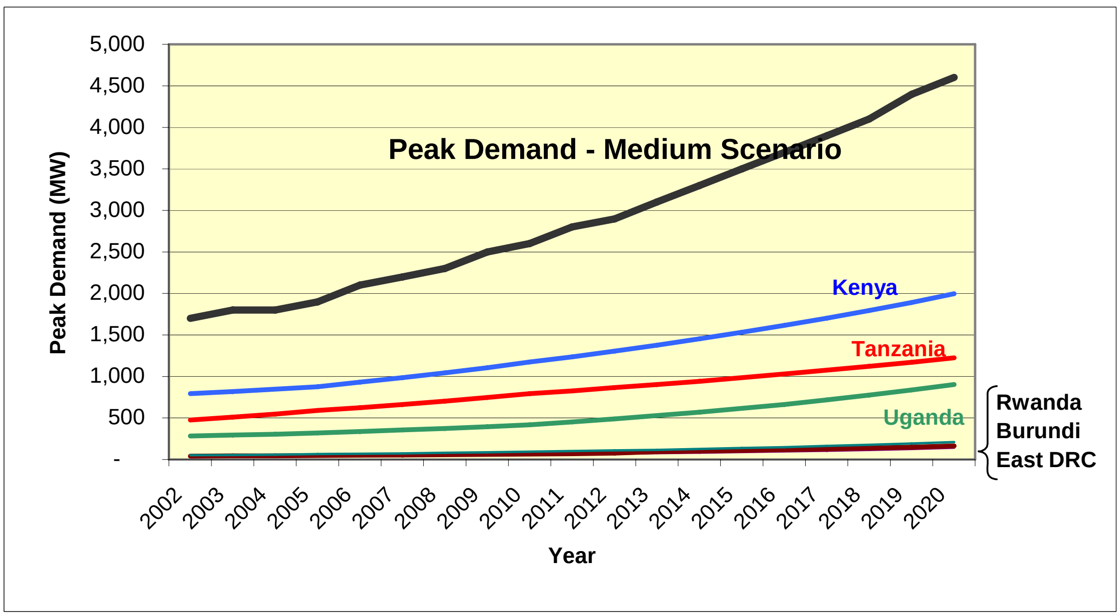


Figure 5-2 - Regional Power Needs Assessment per Country – Medium Scenario



(a) Energy Requirements



(b) Peak Demand

6 IDENTIFICATION OF NEW POWER OPTIONS

Once the needs for the region have been identified, the resources that might be available to meet those needs must also be identified. The first step is to prepare a long list of options without regard for the feasibility of their development – such feasibility will be assessed later from the full range of resources available.

This chapter provides an inventory of candidate new generation options to meet the forecast power needs of the region.

The NELSAP study area includes three sub-areas:

- The region covered by the first stage of the assessment, i.e., Burundi, Rwanda, and Western Tanzania (presently not connected to the main Tanzania grid);
- The EAC countries of Kenya, Tanzania and Uganda;
- The Eastern Democratic Republic of the Congo.

It should be noted that this document considers the region as a whole. Thus small generation units, or options such as demand side management, are treated in terms of regional demands. Specific country interests may identify other priorities for meeting local loads.

The first step was to establish an inventory of identified new generation options, and then to complement this list of known resources with conventional appropriate generic thermal options. This inventory is made up from power development options identified in three separate previous reports, one for each area,[1] [2] [3] with further reference to the original study reports. The initial inventory included all previously identified projects, whether or not they had been rejected in the previous studies. As generation cost from any given project is only one of the factors that are taken into account, it was important to include all identified projects in the starting list of candidates, and then to apply a common set of criteria to all candidate projects.

As this is a regional study it is implicit that this process should be based on energy demands and supply options for the interconnected systems. However information has also been provided on some off-grid options such as solar power PV, mini/micro hydropower, wind energy conversion systems and diesel. Indicative costs and potential application for these generic options (i.e., not assessed on a site specific basis) provide useful context for assessing cost and performance of on-grid options that are the target for this assessment. The potential for "Demand Side Management" to reduce new generation requirements was also noted in Chapter 5.

6.1 New Electricity Generation Options

An initial objective of the assessment was to identify all the hydroelectric sites that had been assessed in the past. However the study concept is that candidate projects should be selected in the context of meeting regional loads, and thus be able to provide benefits in

1 NBI/NELSAP – Final Report Strategic/Sectoral and Environmental Assessment of Power Development Options in the Nile Equatorial Region – Stage 1 – Burundi, Rwanda and Western Tanzania, February 2005. SNC-Lavalin

2 EAC – Eastern African Power Master Plan Study, final Phase II Report, March 2005, BKS Acres

3 NBI/NELSAP – Strategic/Sectoral and Environmental Assessment of Power Development Options in the Nile Equatorial Region – Stage II – Preliminary Evaluation of New Power Options in Eastern Democratic Republic of Congo – April 2005, SNC-Lavalin

neighbouring countries. This resulted in the selection of an approximate lower limit of 30 MW in the EAC Member Countries (Kenya, Tanzania and Uganda), and 10 MW in the Burundi, eastern DRC and Rwanda.

The details of the analyses and process followed are presented in Appendix F. Presented below are tabulations of the projects identified, separated by region. Each table presents the location of the option by country, the installed capacity, and the level of information available. The level of information is characterized in four levels, described simply as follows:

- Reconnaissance level: at the time the studies were carried out at the sites identified for this level the definition of the option was based usually on a review of contour mapping. It often included a brief visit to the site by an engineer specialized in hydroelectric developments. Usually, characteristics available at such site will be based on rules of thumb. There is generally no specific environmental or socio-economic information on the site available.
- Pre-feasibility level: definition of the option based on available contour mapping of the site, geological maps of the region and site visits by selected specialists such as geologists and hydro lay-out engineers. Earlier such studies would have no information on environmental or socio-economic issues and very little if any geological drilling data; more recent studies (say later than about the mid-1990's) would present some general environmental and socio-economic conditions drawn from brief site visits from specialists but no detailed site investigations.
- Feasibility level: definition based on extensive field investigations including sub-surface geology, surveying and mapping of the sites selected for each structure, investigations for sources of construction materials and environmental and socio-economic surveys. Cost estimates are based on detailed estimates of quantities and unit costs based on available databanks. An option at this stage may also have had a separate EIA and/or SIA carried out.
- Detailed design level: definition based on physical information from the feasibility study plus budget prices from suppliers of major equipment and includes the preparation of tender documents. At this stage there should usually be available and EIA and an SIA.

The full list of EAC candidate projects is shown in Table 6-1. The installed capacity of these options would be 5,511 MW

Table 6-1 - List of Identified Hydroelectric Projects in the East African Community

Name	Original Cost US $ MILLION	Installed Capacity (MW)	Average Energy (GWh)	Firm Energy (GWh)	Level of Information Available
Kenya					
Ewaso Ngiro	385.9	220	609	448	Design + outdated EIA
Low Grand Falls	378.3	140	715	324	Feasibility+ preliminary EIA
Magwagwa	294.5	120	669	244	Feasibility
Mutonga	196.7	60	328	293	Feasibility + preliminary EIA
Sub-total	***1,255.4***	***540***	***2,321***	***1,309***	
Tanzania					
Mandera	42.1	21	149	109	Feasibility
Masigira	157.0	118	695	528	Pre-feasibility
Mpanga	190.8	144	1028	863	Pre-feasibility
Ruhudji	384.0	358	1930	1476	Feasibility + outdated EIA
Rumakali	351.3	222	1141	1170	Feasibility+ outdated EIA
Songwe (3 dams-P4)	359.0	330	1352	1352	Pre-feasibility
Stiegler Gorge 1	653.4	300	2715	2598	Pre-feasibility + very old EIA
Stiegler Gorge 2	233.0	600	2525	693	Pre-feasibility + very old EIA
Stiegler Gorge 3	191.3	300	963	1754	Pre-feasibility + very old EIA
Upper Kinansi	81.2	0	124	11	Pre-feasibility
Sub-total	***2,643.1***	***2,393***	***12,622***	***10,554***	
Uganda					
Ayago North 1-4	446.6	228	1981	1981	Pre-feasibility
Ayago North 5-6	111.0	76	643	643	Pre-feasibility
Ayago South	437.2	234	2050	2050	Pre-feasibility + preliminary EIA
Bujagali 1-4	395.0	200	1703	1390	Final Design + EIA
Bujagali 5	26.4	50	222	0	Feasibility + EIA
Kalagala 1-7	444.7	315	2364	1697	Pre-feasibility + preliminary EIA
Kalagala 8-10	66.8	135	161	0	Pre-feasibility + preliminary EIA
Karuma	428.9	200	1747	1619	Pre-feasibility + EIA
Masindi -1	903.8	360	3016	2615	Pre-feasibility
Masindi - 2	729.4	360	2302	1798	Pre-feasibility
Murchison 1-6 phase 2	349.3	315	2759	2759	Pre-feasibility
Murchison 7-8	78.4	105	920	920	Pre-feasibility
Sub-total	***4,417.5***	***2,578***	***19,868***	***17,472***	
Total	**8,316.0**	**5,511**	**34,811**	**29,335**	

The projects identified from the previous study for the SSEA I region are listed in Table 6-2 and amounts to about 836.7 MW. Ruzizi I is a rehabilitation program, which has been committed. This project will increase peak capacity and ensure continued energy generation at the plant. This project has been approved as part of a short-term action plan, and therefore is not part of the project comparison process.

Table 6-2 - List of Identified Hydro-electric Options in Burundi, Rwanda and Tanzania

Name	Original Cost US$ million	Installed capacity (MW)	Average Energy (GWh)	Firm Energy (GWh)	Study level
Burundi					
Jiji 03	42.2	15.5	40	33	Pre-feasibility
Kabu 16	44.8	20.0	112	67	Feasibility
Kaburantwa		14.6			Feasibility
Kaganuzi A	45.1	34.0	98	97	Reconnaissance
Kaganuzi C		16.4			Feasibility
Kaganuzi D		24.6			Reconnaissance
Mpanda	35.3	10.4	40	?	Feasibility
Mule 34	33.0	16.5	54	39	Pre-feasibility
Siguvyaye	280	90.0	510	486	Feasibility/Design
Sub-total		***242***			
Rwanda					
Nyabarongo	77.5	27.8	142	80	Feasibility
Ruzizi I rehab		8.7			Feasibility
Ruzizi III	174.6	82.0	418	418	Pre-feasibility
Sub-total		***118.5***			
Tanzania*					
Igamba Falls Stage 2	11.3	8.0	65	58	Pre-feasibility
Igamba Falls FSL 980 m	404.0	80.0	494	464	Reconnaissance
Igamba Falls FSL 865 m	31.5	11.4	87	?	Reconnaissance
Kakono (High)	71.1	53.0	300	126	Reconnaissance
Kishanda	181.0	207.0	1087	500	Prefeasibility
Luiche	68.7	15.3	100	69	Reconnaissance
Malagarasi Cascade**		40.0			Reconnaissance
Rusumo Falls (Full) ***	94.1	61.5	403	308	Design + outdated EIA
Rusumo Falls (no reservoir) ***		50.4			Feasibility+
Rusumo Falls (low Head) ***		34.1			Reconnaissance
Sub-total++		***476.2***			
Total		**836.7**			

* Includes only smaller options in Western Tanzania; for the remainder of Tanzania, see Table 6-1.
** Malagarasi Cascade would include Uvinza, Igamba Falls Stages 1,2,3, and Illagala sites.
*** The Nile Basin Initiative has called for bids (December 2006) from international consultants for a detailed feasibility study of the Rusumo Falls option which includes an analysis of the various development options and a recommendation of the appropriate option.
\+ This option would use the same layout as the full development of Rusumo Falls. It was therefore considered to be at the Feasibility Study level.
++ Sub-toal is based on full development of Rusumo Falls

Igamba Falls Stage II is one of the options for the Malagarasi River. The project concept was for power supply to Kigoma only[4,5]. Thus this site needs to be re-evaluated as a large project to make better use of the available flow of the Malagarasi River and head at the site.

For purposes of this assessment, the five provinces of Katanga, Kivu North, Kivu South, Maniema and Oriental in the DRC were examined.

The most important of the existing and potential hydroelectric resources in the DRC are in the western part of the country, on the lower reaches of the Congo River. Such potential resources outside the study area can be taken into account through interconnections, where the availability and timing of such new generation can be reasonably established.

A number of studies have been carried out in the DRC, particularly in the period from 1970 to 1985, with the objective of identifying renewable generation sources to offset the sharp rise in thermal fuel costs in the early 1970s. These studies took the form of inventories in different regions of the country. Table 6-3 provides a listing of all identified sites in the above provinces with a potential of more than 10 MW and these amounted to 2,755 MW. This table provides basic information on cost, capacity, energy and study level.

Most of the sites for which cost information is available could be attractive if the costs shown are realistic. For this reason, they merit additional study.

The above table excludes a number of identified sites of less than 10 MW, including 17 in Haut-Zaire, 17 in Kivu provinces and 6 in Shaba.

The locations of the options are shown in Figure 6-1. Approximately 9,000 MW of capacity are identified: 5,511 MW in Table 6-1, about 720 MW (depending upon the configuration of the Malagarassi Cascade and Rusumo Falls that are included) in Table 6-2 and 2755 MW in Table 6-3.

6.2 Thermal Power Options

The major new thermal power options are in the EAC countries. However in the eastern DRC/Rwanda development of methane gas fuelled generation from Lake Kivu could provide significant new generation, and further medium speed diesel installations will be required in the SSEA 1 area until improved transmission and generation supply allow more economical power supply.

[4] Norconsult, Malagarasi Hydropower Project – Kigoma Region, Feasibility Study Report, volume 1, TANESCO/NORAD, August 1983

[5] SECSD (P) Ltd., Joint UNDP/ESMAP, Tanzania Mini Hydropower Study, Kigoma Region, Pre-Investment Report on Mini Hydropower Development, Case Study on the Malagarasi River, March 2000 and October 1999

The thermal power options for the NELSAP region are shown in Table 6-4 and amounts to about 120 MW for methane fuelled options; the capacity available from the other fuels depends upon the amount of fuel imported.

Table 6-3 - Identified Hydroelectric Sites in the Eastern DRC

Site	Original cost US $ million	Identified Capacity (MW)	Average Energy (GWh)	Firm Energy (GWh)	Level of Study
HAUT-ZAIRE					
Babeba I	94	50	351	?	Reconnaissance
Bangamisa	93	48	420	?	Reconnaissance
Budana	?	13	70	?	Reconnaissance
Kisangani		460	30		Reconnaissance
Tshopo II		17	149		Reconnaissance
Wagenia I	316	50	400	?	Reconnaissance
Wanie Rukula		688	6000		Reconnaissance
Sub-total		***1,326***	***7,420***		
KIVU NORD/SUD					
Kamanyola	390	390	1880	?	Reconnaissance
Kiliba	30	15	65	?	Reconnaissance
Kitete	154	21	153	?	Reconnaissance
Mugomba	66	40	160	?	Reconnaissance
Muhuma	54	25	100	?	Reconnaissance
Mwana ngoye	310	46	336	?	Reconnaissance
Panzi	105	36	175	?	Reconnaissance
Rutshuru		10	55		Reconnaissance
Ruzizi		270	1300		Reconnaissance
Semliki	72	28	120	?	Reconnaissance
Sisi 3	305	174	888	?	Reconnaissance
Sub-total		***1,055***	***5,232***		
SHABA					
Kiymbi (Bendera II)	?	43	377	?	Reconnaissance
Busanga		224	1304		Reconnaissance
Nzilo II		33	720		Reconnaissance
Piana Mwanga	?	38	193	?	Reconnaissance
Portes d'enfer		36	263		Reconnaissance
Sub-total		***374***	***2,857***		
Total		**2,755**	**15,509**		

Source Les ressources hydroélectriques du Zaïre - 1994 - Male Cifarha

6.3 Geothermal

The Rift Valley includes several potential geothermal areas. Generation to date has been based on 35 MW units at Olkaria II. Planning for future installation is being based on 70 MW units. Potential new plants are shown in Table 6-5 and amounts to about 315 MW.

6.4 Biomass

For a biomass option to be identified and evaluated to the point at which it could be considered as a specific alternative to other identified generation options, a feasibility study would be required to establish costs and sustainability, as the power plant size and configuration are very site-specific.

No specific biomass generation options have been identified.

Table 6-4 - NELSAP Region – New Thermal Power Options

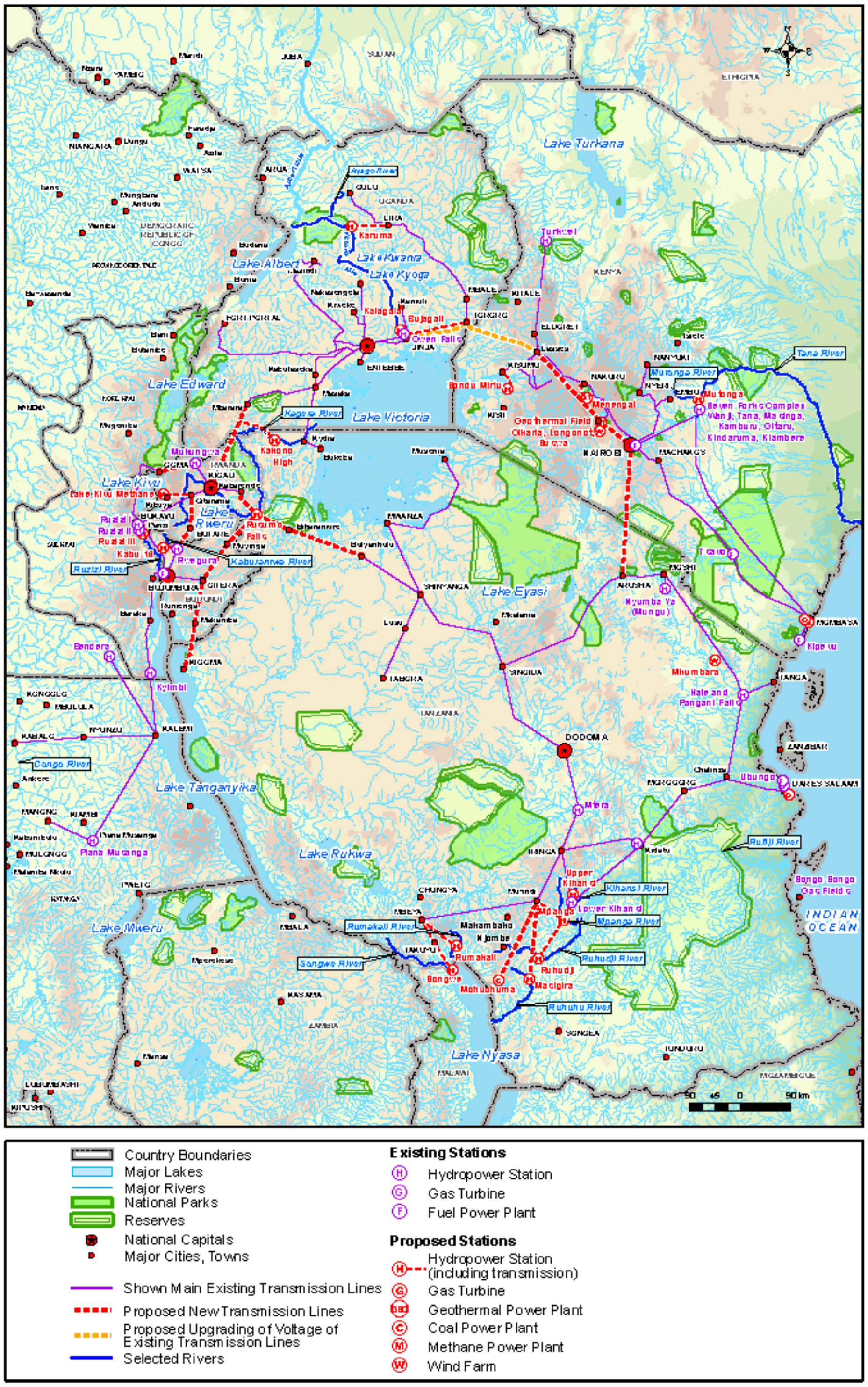
	Installed Capacity (MW)	Fuel Type	Maximum Energy (GWh)	Capital Cost US$/kW
Burundi				
MSD Generic 10 MW x 2 units	20	Imported Diesel	131	872
Kenya				
Mombasa - LNG gas CCGT-4$	180	LNG Gas	1261	895
Mombasa - LNG gas CCGT-5$	180	LNG Gas	1261	895
Mombasa - LNG gas CCGT -6$	180	LNG Gas	1261	895
Mombasa - Coal steam	300	Coal	2102	1678
GT 60 MW- gas - generic x 2 units	120	Gas	841	591
Rwanda				
Kivu methane engines 30 MW x 4 units	120	Methane	841	2505
MSD Generic 10 MW x 2 units	20	Imported Diesel	131	872
Tanzania				
Mchuchuma - Coal steam	400	Coal	2803	1909
GT 60 MW- gas - generic x 4 units	240	Gas	1682	591
CC 60 MW - gas /steam cycle x 2 units	120	Gas	841	1532
CC 60 MW - gas cycle x 3 units	180	Gas	1261	895
MSD Generic 10 MW x 2 units	20	Imported Diesel	131	872

Note: Generic units or plants can be repeated as often as desired (depending upon fuel availability, either local or imported)

Table 6-5 - NELSAP Region – New Geothermal Power Options

NAME	Installed Capacity (MW)	Maximum Energy (GWh)	Capital Cost US$/kW
Kenya			
Olkaria ext - Geothermal	35	245	2645
Longonot Geothermal	70	491	2352
Suswa Geothermal	70	491	2352
Menengai Geothermal	140	981	2352
Total	**315**	**2,207**	

Figure 6-1 - NEL Region - Identified Options and Existing Transmission Lines



6.5 Wind Energy Conservation Systems

Wind energy is being recognized as a potential new power option in the region. Wind speed has to be greater than 4 m/s to start producing energy, but a more acceptable amount of energy is produced when the wind speed is greater than 6 m/s. Most economic operation requires wind velocities in the order of 15 m/s. Economic viability of a wind generator also depends on wind distribution with time. Normally a plant has to be able to generate at a plant factor of 25% to 30% to be viable, and many wind farms are located where plant capacity factors of 35% to 40% can be achieved.

In Tanzania studies have been under way for a number of years, sponsored by the Ministry of Energy of Tanzania, TANESCO, TaTEDO (Tanzania Traditional Energy Development and Environment Organization) with technical and financial support from RISO (Denmark National Laboratory, and DANIDA. This program that resulted in a final report issued in 2003 [6]. The study involved installation of metering masts and evaluation of potential and costs at four locations:

- Gomvu near Kimbiji, southwest of Dar es Salaam;
- Litembe, southwest of Mtwara;
- Mkumbura near Mkomazi in the Pare/Usambara mountains; and
- Near Karatu.

The study concluded that the best site was Mkumbara due to local wind patterns, and the study then evaluated a 50 MW project at this site, made up of 2 MW machines. Total investment was estimated as US$ 50 million. Corresponding generation costs were estimated as 7 to 9 cents/kWh. The study concluded that wind energy was potentially viable, however more studies were required, and the equipment selection had to be optimized to match the relatively low wind velocities at the site.

However it should be noted that wind energy is not firm (i.e. equalled or exceeded all the time), and there is no firm capacity from the unit. Consequently this energy should be valued as replaced thermal, or secondary energy. This would be in the order of 6 cents/kWh for oil fired diesel or gas turbine.

It is understood that a 15 MW site is being studied for Kenya[7].

For the purposes of this study it has been assumed that one or two 30 MW wind farms may be developed and that these would be located in Tanzania at the Mkumbura site.

6.6 Demand Side Management and Loss Reduction

Demand side management and energy efficiency in developing regions have to be viewed in the context of the loads, the adequacy of the present supply situation, and the need for investment in corporate systems and training for the implementation of such programs.

The efficient use of energy is a key objective in all jurisdictions, especially in areas where energy is at a premium. Programs to promote efficient use of energy are designed to change a customer's 'normal' consumption patterns for the benefit of both the consumer as well as

[6] Danida. RISO (Denmark) – Wind Measurements and Wind Power Feasibility at Selected Sites in Tanzania – 2000-2003 – Final Report

[7] Ecogen Wind Farms Ltd – Environmental Impact Assessment for a 15 MW Proposed Wind Farm - January 2005

the producer of power. Energy efficiency normally refers to the efficient utilization of energy through the use of energy efficient products or procedures while demand side management (DSM) programs are normally designed to shift energy used during peak periods to off-peak periods.

None of the electric utilities in the region have initiated such demand side management programs. As there are no specific demand-side management initiatives that have been identified and quantified, they could not be taken into account in this study.

6.7 Imports from Outside the NELSAP Region

Potential imports from outside the study region were treated as projects located at the nearest substation in the exporting country. Potential imports from the Inga projects in DRC assumed delivery to Lubumbasha in Katanga, and thence to Pensulu in Zambia. Potential imports from Zambia would be assumed to be delivered from Pensulu in Zambia to Mbeya in southwest Tanzania. The Zambia-Tanzania interconnection would be treated as a cost for either Inga imports or Zambia imports, and therefore included in the delivery price at Mbeya.

6.8 Off-grid Options

Off-grid generation options are outside the context of this assessment, however, information is included in Appendix F on the available and more commonly used technological options for off-grid electrification. The following options are presented in the appendix:

- Mini/micro hydroelectric power;
- Diesel;
- Solar PV.

7 SCREENING OF NEW POWER DEVELOPMENT OPTIONS

In Chapter 6 the full range of regional resources that might be available to meet the needs of the region have been identified. In this chapter this list of options is screened to ensure that all are appropriate for the purpose.

In this chapter, the approach used is first defined then screening criteria are discussed and selected. As a key element of this analysis is to ensure that environmental and social issues are properly considered, the status of the environmental and social impacts assessments on the options is defined. The screening of the options is then carried out and the results of that analysis are described.

7.1 Approach

The initial step was to compile a long list of all identified specific power development options and, in the case of thermal options, potentially appropriate generic options.

It should be noted that power development options that are in an advanced state of preparation, such as Bujagali and Rusumo Falls, and power development options that are under construction or currently being financed have been included in the initial long list in Table 7-1 for screening and later evaluation. The long list of candidate new power options is identified in Chapter 6.

The resulting long list of new power options is shown in Figure 6-1 in Chapter 6 and Table 7-1. This table includes alternatives for some hydroelectric sites (that are mutually exclusive) and values have been given for the total station where applicable. The earliest on-power dates shown in Table 7-1 are based on the minimum lead times shown in Appendix G.

The next step was to screen the long list of options using agreed criteria, each of which has to be met for an option to be retained for evaluation by comparative analysis, and thus candidature for inclusion in the NELSAP Indicative Power Development Plan.

7.2 Screening Criteria

Four screening criteria were suggested by the stakeholders and approved by the PSC as follows:

- Availability of data (prefeasibility level or better), to provide an adequate basis for evaluation. In applying this criterion it is important to remember that a site discarded due to lack of sufficient information may still provide potential for development and, depending on other factors, should be investigated further.
- Options would be retained, for which residual environmental or socio-economic impacts are considered tolerable and in compliance with national laws and international conventions. One sensitive aspect to this qualification is the question of sites located in national parks or game reserves. The screening has <u>excluded</u> sites in the parks or reserves, even though such development would be permissible under present national laws.[1] However, development in National Parks or Game reserves would contravene the Algiers Convention, which is either signed by or in force in each of the countries of the region.

[1] There have been situations in the region where the designation of National Park has been downgraded to game preserve due to population pressures.

- Unit cost below a specified threshold value. A cutoff cost of 10 cents/kWh for firm energy has been set. This value is approximately 50% higher than alternative thermal power. It is considered highly unlikely that any such site, with a firm energy cost above 10 cents/kWh would ever be developed, unless there were very special offsetting factors, such as secondary benefits from multipurpose use or supply to a local load. In such a case the selection and development of such a site would not depend on it being included in any regional or national indicative generation plans.
- Size of project should be greater or equal to 10 MW for Rwanda, Burundi and Eastern DRC and greater or equal to 30 MW for the EAC countries. The 10 MW criterion refers to the minimum size that could have some impact on power supply for a neighbouring country and thus reflects regional nature of the study context. The 30 MW criterion is applied to the larger generating countries, and is the minimum value used in master plan studies in Kenya and Tanzania.

Failure to meet any of these criteria would result in an identified project being eliminated from the overall project candidate list under this screening.

7.3 Status of Environmental and Social Impact Assessments of Power Options

A review of the status of Environmental Impact Assessment (EIA) reporting of power options was carried out as part of the East African Power Master Plan Study[2]. This review indicates that EIAs are available only for a limited number of projects in the EAC region:

- Full EIAs are available for Ewaso Ngiro (reported in 1991, 1992 and 1993) and Mutonga/Grand Falls in Kenya (EIA produced in 1997), Bujagali (EIA produced in 2001) and Karuma (EIA produced in 1999) in Uganda. The Bujagali and Karuma EIAs have been accepted by the Ministry of Environment of Uganda (NEMA).
- Preliminary EIAs exist for Kalagala in Uganda and Ruhudji and Rumakali in Tanzania (produced in 1998). Environmental impact studies of the Stiegler's Gorge Project were carried out in the late 1970s and early 1980s but they do not meet current national and international funding requirements.
- A description of the environmental and social issues of hydropower projects on the Victoria Nile is included in the Hydropower Master Plan prepared by Kennedy & Donkin Power Limited in 1997.
- A first EIA of the Mchuchuma Project is reported to have been produced in 1997. This EIA could not be obtained from the National Development Corporation of Tanzania.
- An EIA has been produced for the Olkaria II geothermal project in 2004.
- An EIA for a proposed wind farm in South Kinangop, Kenya was produced in 2003.

With regards to power options in Rwanda, Burundi and eastern DRC, there is only a preliminary EIA for Kabu 16 in Burundi (produced in 1995) and a preliminary resettlement plan for Nyabarongo in Rwanda (produced in 1999). In addition, a study of water quality impacts of the Lake Kivu Gas Development was carried out in 2000.

[2] BKS Acres. 2003. East African Power Master Plan Study. Appendix H – Review of Environmental Assessment and Environmental Costs of Candidate Power and Transmission Line Projects

7.4 Results

7.4.1 Options that Passed the Screening

A successive set of screens has been applied to the long list of options in Table 7-1.

Removing the redundancies, and opting for one scheme for each site, results in 49 hydroelectric sites (excluding two sites under construction), as shown in Table 7-2. This table shows a total of 6,574 MW of hydroelectric potential, including sites with potentially unacceptable environmental risk, or high cost, or that do not meet the preparedness level or size criteria.

The next filter removed all hydroelectric sites and other options that did not meet the screening criteria. The locations of candidate power options retained on the reduced list are shown in Figure 7-1. Subsequent figures focus on specific regions:

Figure 7-2: Southern Tanzania;

Figure 7-3: Rwanda-Burundi border;

Figure 7-4: Uganda – Lake Victoria Area;

Figure 7-5: Kenya-Tanzania border; and

Figure 7-6: Eastern Tanzania respectively.

Appendix I provides summaries of these power development options. Table 7-3 shows a reduced list of 13 hydroelectric options with a total installation of 1899 MW.

7.4.2 Rejected Options

As may be determined by comparing Table 7-2 and Table 7-3, a number of power development options have been screened out because they do not meet the adopted criteria for the selection of options to be evaluated in the comparative analysis.

Power development options that met all the criteria <u>except</u> for the minimum required level of preparedness are listed in Section 7.4.2.1. This is followed by a section 7.4.2.2 that indicates the additional studies that would be required to permit those options to be considered for retention (the results of this additional work on these options may result in them failing other screens although preliminary indications are that they would pass). Options that failed other screens are described in Section 7.4.2.3.

The only non-hydro options that are not retained are:

- Demand side management: no specific options have been identified and studied to the level of detail required to be included in the analysis. As a concept, it should be developed further.
- Solar power: not economic as an on-grid application.

7.4.2.1 Options Set Aside as Needing Further Evaluations

A further listing has been made of sites that have been screened out because of insufficient information for evaluation, even though they meet the other screening criteria (environmental risk, cost, and size).

These power development options are listed in Table 7-4, which shows a further potential total of 521 MW that could be included in the project evaluation and planning process if after further studies are undertaken they remain as alternative as the preliminary information suggests.

Table 7-4 - Options Not Prepared to Prefeasibility or Better but Meeting Cost and Environmental Criteria

Name	Country	Total Cost	Installed Capacity	Energy		Generation Cost			Earliest installa-tion date	Regional benefits
		US $ million	(MW)	Ave. (GWh)	Firm (GWH)	Average c/kWh	Firm c/kWh	$/kW		
Babeba I	DRC	122.40	50	351	*	3.89		2448	2013	Yes
Bangamisa	DRC	123.47	48	420	*	3.28		2572	2013	Yes
Budana	DRC	12.72	13	70	*	2.08		979	2013	Yes
Igamba Falls FSL 865 m	Tanzania W.-Rwanda	41.74	11	87	*	5.32		3661	2013	Yes
Kiliba	DRC	39.06	15	65	*	6.70		2604	2013	Yes
Kiymbi/Bendera II	DRC	52.06	43	377	*	1.57		1211	2013	Yes
Mugomba	DRC	87.63	40	160	*	6.13		2191	2013	Yes
Muhuma	DRC	71.69	25	100	*	7.98		2868	2013	Yes
Panzi	Rwanda-DRC	136.72	36	175	*	8.66		3798	2013	Yes
Piana Mwanga	DRC	35.00	38	193	*	2.40		1065	2013	Yes
Semliki	DRC	95.59	28	120	*	8.85		3414	2013	Yes
Sisi 3	Rwanda-DRC	405.93	174	883	*	5.14		2333	2016	Yes
TOTAL			**521**							

* Insufficient data available to calculate firm energy

These options are described below, by country.

<u>Eastern DRC</u>

Babeda: The Babeda Falls are on the Tshopo River North-east of Kisangani. SICAI-Tractionel[3] studied two sites in 1972, both with a 50 MW installation, and with very similar capital cost and unit generation cost. Nominally, Babeda I was marginally cheaper. The site evaluation is at a very preliminary or reconnaissance level. The project is conventional, and well located for the load in the Oriental Province, and thus should be evaluated further.

Busanga: This site was studied by Tractionel in 1970[4]. It is on the Lualaba River immediately downstream of the N'seke existing project. It is potentially an economic site, and is well located in relation to the Nzilo 220 kV line. The site has not been studied further since 1970.

Mugomba: This 40 MW site is located on the Luholu River in the Lubero district, approximately on the equator, and North-east from Lubero. This site would be convenient to supply the Bukavu-Goma-Beni transmission line. In the ONRD 1972 study, the site ranked

[3] SICAI-Tractionel, République du Zaïre, reconnaissance des ressources hydroélectriques dans la nord-est, June 1972

[4] This report was not available, however information on the project was obtained from "Les ressources hydro-électriques du Zaïre – Male Cifarha, 1994"

second best after Sisi on the Ruzizi River. Given the medium size and convenient location, as well as being potentially economic, this site should be evaluated further.

Nepoko: This site on the Nepoko River about 90 km to the south of Isiro was originally evaluated by SEEE/OCCR in 1982[5]. The river has the potential of average energy generation (equivalent to average river flow) of 134 MW, which would suggest an installation of 270 MW. This estimate is based on an approximate estimate of precipitation, and resulting net runoff. At that time the project was considered to be far from the grid, and with difficult access. The site was not visited for that evaluation. The proposed scheme of 6 MW was based on supply to the town of Isiro only. No information is available to evaluate the site as a candidate within the SSEA study. However the site may be a potential candidate for regional supply, and should be evaluated further.

Panzi: This site, located between Ruzizi I and Ruzizi II was evaluated by SICAI in 1972, and then by Tractebel in 1992[6]. In the 1992 study two alternative baselines were evaluated and the downstream site selected. The project would have an installation of 42 MW. As it is much smaller than the Sisi bend sites (see below), and its unit generation cost would be higher than for the Sisi bend sites or the Ruzizi III site, it is assumed this site would follow development of Ruzzizi III and Sisi bend.

Sisi: Development on the Sisi bend of the upper Ruzizi was initially studied by Energoprojekt / ONRD in 1972 and a 110 MW development was proposed. It was later studied by Tractebel (1992), who evaluated two sites with larger installations.

	MW	**GWh**
Sisi 3	175	210
Sisi 5	205	1030

These evaluations are at a reconnaissance or preliminary level.

The unit costs are similar and were in 1992 marginally lower than the estimate for Ruzizi III. It is assumed that one of these sites could be an attractive new power option for the long term, based on cost, location, and the highly regulated flows from Lake Kivu.

The Tractebel study recommended the smaller Ruzizi III 82 MW development, because the Sisi bend power development options appeared uneconomic. However this was presumably because they were considered in terms of the local power demand. (The Tractebel study[7] included a base case forecast load forecast with a demand of 270 MW in 2005).

<u>Tanzania-Rwanda</u>

Igamba Falls: the Igamba Falls project is one of a series of options that have been studied at various times for the Malagarasi River in West Tanzania. The project evaluated in this screening process is the Igamba Falls Stage 2 project with a full supply level of 865 m, a

5 SEEE-OCCR.Inter G, Études inventaires des sites hydrauliques en vue de leur équipement avec des mini ou microcentrales hydro-électriques au Zaïre

6 Tractebel/EGL – Plan directeur régional de développement de l´énergie – Rapport No. 2 – Étude du potentiel hydroélectrique de la vallée de la Ruzuzi – octobre 1992

7 Tractebel/EGL – Plan directeur régional de développement de l´énergie – Rapport No. 6 – Plan directeur régional de l'énergie – février 1993

total head of 25 metres and an installation of 8 MW, or 12 MW assuming a spare unit. This was the scheme recommended in the 1999 (the latest) study[8].

The installation selected in 1999 was based on the local load in the Kigoma area, and would only use a fraction of the flow available (discharge at full plant output would be in the order of 45 m^3/s, as compared with the 140 m^3/s average river flow). Energy costs are very low (3 cents/kWh for firm energy), based on the costs escalated from the 1999 study.

Consequently this option needs to be re-evaluated in the context of full use of the head and flow available and the site.

7.4.2.2 Work Required to Improve Level of Preparedness

In the context of evaluating the level of preparedness of the new generation options that have been studied in the past one may use the expected scope of a full feasibility study as a point of reference.

The definitions of a “feasibility study“ vary. In this context it denotes the “last” study i.e., beyond this stage a reasonably firm commitment to construct a generation source is made. A feasibility study will cover the following scope:

- Conceptual design and optimization of the generation plant configuration;
- Sufficient detail design to fully define the key physical dimensions (quantities);
- Investigation of site-specific conditions, to provide the basis for a preliminary design and to ensure that any potentially serious problems are discovered;
- Confirmation of the technical feasibility of the project;
- Evaluation of the expected operating performance of the plant i.e., power and energy capability, efficiency, reliability, operation and maintenance etc.;
- Study of environmental and socio-economic impacts;
- Detailed construction schedule;
- Based on all of the above, a detailed estimate of capital and operating costs.

At this point the technical feasibility of the proposed plant should be confirmed and the cost of generation is known.

The difference between the feasibility and pre-feasibility study is the level of effort, the resulting confidence in the results, and in the near final dimensioning of the project. Typically the feasibility study includes extensive field investigations, both to confirm the technical feasibility of the project and to fully define the availability and cost of construction materials as well as the cost of managing site specific problems such as leakage or river bank instability.

The prefeasibility study will include the same components, however with less investment in each. However it is important to note that a modern prefeasibility study will include ground surveys, a limited scope drilling program and a preliminary environmental / social impact assessment to identify any major risks or mitigation requirements.

[8] SECSD (P) Ltd., Joint UNDP/ESMAP, Tanzania-Mini Hydropower Study, Kigoma Region, Pre-Investment Report on Mini Hydropower Development, Case Study on the Malagarasi River, Final Report, March 2000 and October 1999

The feasibility study provides the information for a management decision to commit, in total or conditionally, funds for the construction of the project. Consequently, expenditures on feasibility studies are more or less directly related to the estimated project capital cost. The relationship between feasibility study cost and capital cost is not linear and will vary according to the location and type of scheme and the extent of the environmental problems that are to be resolved.

Engineering costs (apart from environmental, economics and generation planning activities) for conventional projects larger than 50 MW generally are between 0.5 and 1.5% of the estimated capital cost. Approximately half of this will be for field investigations. For smaller projects the overall percentage may be higher.

7.4.2.3 Power Development Options Set Aside for Other Reasons

The options that did not meet the stipulated criteria are commented on as follows:

Burundi

Jiji 03: The Jiji 03 site is on the Jiji River in southern Burundi, immediately upstream of the confluence with the Murembwe River. The project would have an installation of 16 MW. The estimated cost of firm energy is 16 cents/kWh; consequently the project has been screened out on the basis of cost.

The project was identified by EDF in 1988 as an option for local power supply.

Kaganuzi: The Kaburantwa project would divert a maximum of 8 m^3/s, from the Kaburantwa River. This compares with the 10.6 m^3/s average flow at the downstream Kabu 16 site on this river. Consequently this diversion for either of the Kaganuzi options would both eliminate the Kabu 16 site, and would reduce the Kaburantwa average flow to 20% of its present average.

The Kaganuzi A project would develop the most head, and therefore would provide the maximum use of the hydroelectric resource. However the Kaganuzi C scheme would supply irrigation water to the Imbo plain. The Kaganuzi C project was considered ready for final design and the Kaburantwa project had been studied in detail. Little information is available on Kaganuzi A. Both Kaganuzi options would require the Kaburantwa diversion to be viable. The Kaganuzi complex (i.e., Kaganuzi C and Kaburantwa) has been rejected because of the major environmental and social risk from the required diversion of the Kaburantwa River. However with an indicated firm energy cost of over 10 cents/kWh, after allowing a credit for its multipurpose function, it is unlikely that the project would be economic, at least in a regional context.

This option was studied originally by Lahmeyer in 1983 and then by Norconsult, as described in their report of 1987[9]. Hydroplan also studied it in an undated report.[10]

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9 Norconsult, Kagunuzi Multipurpose Project, Feasibility Study, Volume III, Hydropower Scheme, Draft Report, African Development Bank, February 1987

10 Hydroplan Ingenieur-Gesellschaft mbh/Fichtner Beratende Ingenieure, *Étude finale de faisabilité du projet hydroagricole et hydroélectrique de Kaganuzi C, Rapport préliminaire de Seconde Phase, Tome I, Rapport de synthèse et volets hydro-agricole, organisationnel, électrique et économique*, République du Burundi, Ministère de l'Énergie et des Mines, Ministère de l'Agriculture et de l'Élevage

Mpanda: The Mpanda project in Burundi, 25 km north of Bujumbura was the subject of a detailed feasibility study by Hydroplan in 1977[11]. The proposed installation was 10 MW, and the project was considered in conjunction with a downstream irrigation project.

After providing a credit for multipurpose use, the cost of average energy is estimated as 14 cents/kWh. No firm energy estimates are given in the Hydroplan report, however the firm energy cost would be equal or higher. This option has therefore been screened out on the basis of high energy cost.

Mule 34: The Mule 34 project was assessed jointly with Jiji 03 in 1988. The proposed installation was 17 MW, and the energy cost derived for this study is 11 cents/kWh. Consequently this option would be screened out due to its high energy cost.

Siguvyaye: This project was originally conceived for supply to a nickel mine. The 1980 study by ITS[12] proposed an installation of 90 MW. The project would have a firm energy cost of over 9 cents/kWh; however, this is very approximate since the project feasibility study was done in 1980. The project has been screened out because it would involve the near complete diversion of three rivers, and thus would have a high environmental /social risk.

Eastern DRC

N'zilo II: This site, that may be planned for 90 or 33 MW, is close to the N'seke plant in southern Katanga. It is close to the Inga-Zambia transmission corridor. It is not considered as a candidate for supply to the NELSAP region, due to its location outside the study area.

Busanga: Like N'zilo II, this is a potentially attractive site. However it is close to the N'seke plant and the Inga-Zambia transmission corridor. It is not considered as a candidate for supply to the NELSAP region, due to its location outside the study area.

Wagenia Falls: This site is on the Lualaba (or Congon) River immediately upstream to the south east of Kinsangani. The 1972 study by SICAI-Tractionel investigated alternative 20 and 50 MW schemes, with the larger scheme providing much cheaper, but still very expensive generation. This is a low head site (2.4 m for stage 1 and 3.9 m for stage 2) on a large river. It should not be considered further. A very preliminary study of the site was made by SEEE-Inter G in 1982. This considered an 18 MW project, with a cost of 690 million Francs. This is approximately equivalent to US$ 6000/kW in 1982, which further confirms the scheme is not potentially viable.

Wanie Rukula: This is a very large potential project on the Lualaba or Congon River, upstream from Kisangani and to the south east of that city. This site is farther upstream than the Wagenia Falls site, and would not be affected by development of the Wagenia site. The project would develop 20 metres of head, and have an installed capacity of 690 MW. The estimated capital cost is stated as 119 million zaires in the SICAI-Tractionel 1972 report, and 1098 MUSD at 1990 price levels in the Cifarha report. The latter value was based on the 1976 Sogreah study, and has been retained There is minimal information on the project and it is too large for consideration in the current study.

Kamanyola: This option was first studied by SICAI in 1972, which suggested an installation of 240 MW based on a plant factor of 90%, or 390 MW installation at a plant factor of 55%. The project would divert flow from the Ruzizi at the Sisi bend. The FSL level of 1361 m

11 Groupement Hydroplan/Fichtner, Projet hydroagricole et hydroélectrique de Mpanda (Phase I), avant-projet détaillé, I. volet hydroagricole, II. volet hydroélectrique, évaluation économique, République du Burundi, Ministère de l'Énergie et des Mines, Ministère de l'Agriculture et de l'Élevage, Octobre 1997

12 ITS – Aménagement hydro-électrique de la Siguvyaye – Avant projet définitif – Rapport général – mars 1980

would be the same as for Sisi schemes (S3 and S4), and divert this flow into the adjacent Luvimvi River. The latest assessment was by Tractebel who suggested a 480 MW project in their 1992 report. This scheme would have diverted the Ruzizi at elevation 1276 M (FSL), at approximately the dam site for the RA sites.

The studies by Tractebel should be considered as preliminary or reconnaissance, as no field investigations were carried out.

This site/scheme is either the same as or very similar to the Ruzizi scheme referred to in the ONRD 1972 study.

This project would eliminate Ruzizi III and any other downstream development. It is considered to be unacceptable.

Kiliba: The site is on the Kiliba River in Kivu province. The proposed installation is 15 MW, and the indicated cost of average energy is about 7 cents/kWh. Information is limited to a reconnaissance assessment by ONRD in 1972[13]. There is no information on any more recent study. The project was screened out because of lack of data for assessment.

Muhuma: This site on the Talya sud River in Kivu province was also identified and assessed in the same ONRD 1972 reconnaissance level study. The proposed installation was 25 MW, and the currently estimated cost of average energy is 8 cents/kWh. There is no information on any more recent study. The project was screened out because of lack of data for assessment.

Mwana Ngoye: This site is located on the Lualaba River in Kivu province. It was identified and assessed in a study by TEE/PDN in 1977[14]. The proposed installation was 46 MW, and the currently estimated cost of average energy is 13 cents/kWh. There is no information on any more recent study. The project was screened out because of lack of data for assessment and because of its high generation cost.

Kitete: This site is also located on the Lualaba River in Kivu province and was identified and assessed in the study by TEE/PDN in 1977. The proposed installation was 21 MW, and the currently estimated cost of average energy is 14 cents/kWh. There is no information on any more recent study. The project was screened out because of lack of data for assessment and because of its high generation cost.

Portes d'enfer: This project is located on the Lualaba River in Katanga south and was identified and assessed in the study by TEE/PDN in 1977. The proposed installation was 36 MW, and the currently estimated cost of average energy is 14 cents/kWh. There is no information on any more recent study. The project was screened out because of lack of data for assessment and because of its high generation cost.

Kenya

Ewaso Ngiro: KenGen has developed this project to the design stage[15]. This followed successive studies. In the 1980 National Master Water Plan, a high head development was proposed (469 m). In 1987, the National Power Development Plan by Acres proposed the

[13] ENERGOPROJECKT et École polytechnique de Varsovie en collaboration avec la Section Énergétique de l´ONRD. Étude du système électroénergétique de la province du Kivu, Kinshasa 1972

[14] This report covers projects on the Lualaba River. It was not available, however information on the project was obtained from "Les ressources hydro-électriques du Zaïre – Male Cifarha, 1994"

[15] Ewaso Ngiro (South) Hydroelectric Project - Tender stage design report, July 2001, Knight Piesold (Scott Wilson Piesold)

development of the Leshota and Oldorko sites with a combined output of 138 MW. In 1990, a prefeasibility study by Knight Piesold proposed schemes at Leshota and Oldorko with a combined output of 118 MW.

In 1993, a feasibility study by Knight Piesold proposed schemes at Oletukat, Leshota and Oldorko with a transfer tunnel in the headwaters to provide addition at flow for generation. The total proposed installation was 180 MW. The development of 1000 ha of irrigation was included in the scheme.

The latest studies provided tender level document for the three sites and the river transfer scheme, as well as site investigations, environmental studies and a prefeasibility study of rangeland irrigation.

These final studies resulted in a recommended installation of 220 MW, and initial energy estimates of 589 GWh average and 328 GWh firm (which were increased in the EAPMP to 609 GWh average and 448 GWh firm).

Based on the capital costs (approximately the same as in the 2001 study), and after allowing a credit to reflect multipurpose benefits, the cost of firm energy for the three plant complex was derived as 12.29 cents/kWh based on the energy values in the EAPMP. This is above the screening maximum cost of 10 cents, consequently the project was rejected. However this project has been developed to the design stage and no major environmental or social risks have been identified. It is assumed this project will remain a candidate for future IPP development.

However it is noted that the EAPMP recommended that the project only be considered after severe erosion conditions (and thus sedimentation) are controlled. In this context, sedimentation is a cost rather than environmental issue.

Low Grand Falls: This project on the Tana River, some 40 km downstream of the Kiambere plant, was assessed at the feasibility study level in 1998 by JICA (Nippon Koei and Pasco International). An installed capacity of 140 MW was proposed. The project was studied jointly with Mutonga. The study concluded that the two sites should be developed separately.

Based on the capital cost and energy values given in the EAPMP, the cost of firm energy from this site was estimated as 15.6 cents/kWh, and therefore the project was rejected in the screening process. The environmental review included in the EAPMP Phase 1 report also referred to the high sedimentation rates on the Tana River, and consequent overestimates of reservoir capacity and firm energy in previous studies[16]. This report suggested that land use / erosion aspects had to be resolved before a reliable estimate of generation from the site could be made.

It is assumed that this project will remain a long-term future option for Kenya.

Magwagwa: This project has a proposed installed capacity of 120 MW. It was evaluated in a 1991 feasibility study[17]. It was not considered in the EAPMP. The project may be considered as a future stage of the Sondu Miriu project now under construction, and would provide additional energy benefits at Sondu Miriu, which is a run of the river scheme. It was screened out because of the high cost of firm energy, estimated as 17 cents/kWh, based on the capital costs and energy values provided in the feasibility study, with costs adjusted for

[16] EAPMP Phase 1 Report - Appendix H- Review of Environmental Assessment and Environmental Costs of Candidate Power and Transmission Line Projects, BKS-Acres 2003

[17] Kenya Power Company Limited - Feasibility study on Magwagwa hydroelectric power development project - JICA 1991

escalation and multipurpose benefits. The project would provide increased flows to the Kano irrigation project. The project would result in displacement of more than 4000 persons (1991 estimate) from the reservoir area.

However it should be noted the indicated average energy cost is relatively low (6.4 cents/kWh) and if the downstream energy benefits at Sondu Miriu are assumed to be an increment to the system firm energy, the cost of Magwagwa firm energy would be about 10.6 cents/kWh, which is still above the cut-off cost ceiling. This also reflects the adjustment for multipurpose project use. It is therefore concluded that this project will remain a future candidate for development, however this would depend on what additional benefits from the Kano project would accrue to the hydro project.

Rwanda

Nyabarongo: The Nyaborongo project would provide power to the Kigali area. The project was studied in 1999 by SOGREAH, who issued a feasibility study[18] and an environmental study[19]. The project would involve diversion from the river from the dam/intake to the powerhouse over some 8 km. However the projected energy cost from the project is high, with the firm energy cost estimated as 15 cents/kWh, and the project has been screened out on that basis.

It may be noted that the 1999 study was not a complete feasibility study, as it only included limited field investigations.

Panzi: The Panzi project is one of a series of options to develop head on the Ruzizi River. As for the other Ruzizi River existing and future sites, this would be a shared resource between Rwanda and the DRC. This site is located in the upper reach between the existing Ruzizi 1 and 2, and had been included in various assessments since the 1980's.

Sisi 3 / 5: The Sisi 3 and 5 sites are on the Ruzizi River at the Sisi bend, downstream of Ruzizi 2, were evaluated as part of 1992 Tractebel study of the Ruzizi River[20]. This study covered 5 alternative sites on the Sisi bend. The Sisi 3 site had a proposed installed capacity of 174, and the Sisi 5 site a proposed capacity of 205 MW. The unit cost of the two sites was approximately the same. No further assessment has been made of development on the Sisi bend. This would be a shared resource between Rwanda and DRC.

The indicated cost of average energy at the site, based on the escalated project cost is about 5 cents/kWh. However information the site is at the reconnaissance level, so the project could not be considered further in the current study. Given the highly regulated flows on the Ruzizi River, and the indicated low generation cost, this option should be considered further by Rwanda and DRC.

18 SOGREAH Consultants, Faisabilité détaillée de l'aménagement hydroélectrique de Nyabarongo, Dossier final d'avant-projet détaillé, Rapport principal, République Rwandaise, Ministère de l'Énergie, de l'Eau et des Ressources Naturelles, Projet de Réhabilitation du secteur de l'énergie, 40 0196 R8, novembre 1999

19 SOGREAH Consultants, Faisabilité détaillée de l'aménagement hydroélectrique de Nyabarongo, Rapport final d'environnement, (étude d'impact socio-économique complémentaire), République Rwandaise, Ministère de l'Énergie, de l'Eau et des Ressources Naturelles, novembre 1999

20 Tractebel, E.G.L. Organisation de la C.E.P.G.L. pour l'énergie des pays des grands lacs, Plan directeur régional de développement de l'Énergie, Rapport no 6, Étude du potentiel hydroélectrique de la vallée de la Ruzizi, Phase 2, Étude de préfaisabilité du site RD2, octobre 1992, Édition finale

Tanzania

Igamba Falls: The Igamba Falls project is one of a series of options that have been studied at various times for the Malagarasi River in West Tanzania. The project evaluated in the screening process is the Igamba Falls Stage 2 project with a full supply level of 865 m, a total head of 25 metres and an installation of 8 MW. This was the scheme recommended in the 1999 (the latest) study.

The alternatives identified and evaluated in the past for the Malagarasi River are listed in Table 7-5. These options are described in reports by the Tanzania Ministry of Water, Energy and Minerals[21] in 1976, by Norconsult[22] in 1983 and by SECSD in their 1999 study[23].

Table 7-5 - Identified Projects on the Malagarasi River

Designer (Date)	Project Name	Level of Study	FSL (m)	Capacity (MW)	Average Energy (GWh/y)
Norconsult (1983)	Phase I (2 units)	Prefeasibility	865	7.6	67
	Phase II (3 units)	Conceptual	865	11.4	87[1]
Acres (1984) Single Project	Igamba Falls	Prefeasibility	980	80	494
Acres (1984) Cascade	Masofya	Conceptual	1057	35	220
	Uvinza	Conceptual	1020	30	315
	Igamba Falls	Conceptual	980	170	1450
	Lower Malagarasi	Conceptual	820	60	545
SECSD (1999)	Uvinza	Conceptual	1000	4	35
	Igamba Falls – Stage 1	Conceptual	890	8	65
	Igamba Falls – Stage 2	Prefeasibility	865	8	65
	Igamba Falls – Stage 3	Conceptual	840	12	91
	Illagala	Conceptual	800	8	70
	5 Scheme Cascade[2]	Conceptual	1000	40	280

Notes 1: Evaluation provided or adjusted by the Consultant.
2: This cascade is composed of the five plants listed above (Uvinza, Stages 1, 2 and 3 and Illagala)

21 Tanzania Ministry of Water Energy and Minerals. The hydropower and irrigation study of Western Tanzania, Report No. 2- Hydropower Potentials in Western Tanzania – A report on 52 Investigated Rivers, April 1976

22 Norconsult, Malagarasi Hydropower Project - Kigoma Region, Feasibility Study Report, Volume 1, Main text, TANESCO/NORAD, August 1983

23 ECSD (P) Ltd., Joint UNDP/ESMAP, Tanzania-Mini Hydropower Study, Kigoma Region, Pre-Investment Report on Mini Hydropower Development, Case Study on the Malagarasi River, Final Report, March 2000 and October 1999

The installation selected in 1999 was based on the local load in the Kigoma area. As for the previous proposals this development as planned would only use a fraction of the flow available (discharge at full plant output would be in the order of 45 m^3/s, as compared with the 140 m^3/s average river flow). An option was to use three units with an installation of 12 MW (one unit reserve). Energy costs are very low (3 cents/kWh for firm energy, based on the costs escalated from the 1999 study. Project information is at the reconnaissance or prefeasibility level. Clearly this project needs to be re-evaluated in the context of full use of the head and flow available and the site.

Kishanda: The Kagera River drops more than 100 metres between 120 and 90 km upstream of the river mouth. Several power development options for the development of the hydroelectric potential of this stretch of the river were studied in 1976 by Norconsult[24], as part of a study that included Rusumo Falls. This report is referred to as a "pre-feasibility" study.

The Kishanda Project is a diversion scheme, which would divert the water of the Kagera River downstream of Lake Rushwa. The water would pass successively through an arm of Lake Rushwa, then into a reservoir along the valley of the Kishanda River created by a dam built at Murongo. This reservoir would extend 60 km up the Kishanda River. Flow would be used at a powerhouse located close to Bugara and returned to the Kagera River.

The Kishanda project, as would the Kakono scheme farther downstream, would provide improved regulated flows for possible additional irrigation in the Kyaka area. There is a potential for 160 km^2 of irrigation at Kyaka, and further opportunities farther downstream. These are outlined in the 1976 report by Norconsult/Electrowatt, and in the 1982 report for the KBO[25]. The 1976 report refers to pre-feasibility level studies of the Kyaka irrigation project as part of the same study.

The Norconsult study proposed an installed capacity of 180 MW and corresponding annual energy of 1087 GWh. The later KBO study refers to an installed capacity of 207 MW and firm energy of 500 GWh.

The project would have a high environmental/social risk, and thus has been screened out. The primary reason is the diversion of flows out of the Kagera River over an extended distance, and flooding from the reservoir in the Kishanda River. The Akagera National Park in Rwanda and the presence of extensive wetlands of importance to the regional biodiversity in Tanzania and Rwanda would also be of international concern.

These studies are now almost 30 years old and they have not been updated.

Lower Kihansi: This project would be a 2 x 60 MW addition to the existing project. The project is not listed as a candidate in the EAPMP, and no cost data or energy estimates were available to evaluate it in terms of energy costs. (The Upper Kihansi project, with storage only was assessed in the EAPMP). Its exclusion from the EAPMP suggests that it is uneconomic. The project was one of the options considered in the Tanzania VI project[26].

Luiche: The Luiche project in West Tanzania, with a capacity of 15 MW, was identified as part of identification of flood control options for the Luiche Basin, with power as a secondary

[24] Norconsult A.S./Electrowatt, Kagera River Basin Development, Phase II – Prefeasibility Studies, Kagera River Hydropower Developments, Rusumo Falls Hydropower Project, Kishanda Valley Hydropower Project, Kakono Dam Hydropower Project, April 1976

[25] KBO, United Nations, Development of the Kagera Basin, Final Report, Volume 3 – Energy, February 1982

[26] TANESCO - Tanzania Power VI Project, Feasibility Studies for Hydropower Projects, Interim Report No. 2, March 1997, SwedPower

objective. It was further considered in 1976[27] and was then evaluated by Norconsult in 1983[28]. In the latter study, the project was rejected for power supply to Kigoma, in favour of development on the adjacent Malagarasi River.

There is very little specific information on the project in the references referred to above, and the indicated cost of firm energy, as shown in Table 7-1 is over 14 cents/kWh. Consequently the project has been screened out.

Mandera: This project would have an installed capacity of 21 MW, which is below the minimum for power development options in the EAC region. However it is noted that the indicated cost of firm energy is low at 5 cents/kWh. Consequently it is assumed that this project will remain a candidate for TANESCO to develop in the future.

The project site is on the Pangani River 65 km upstream of Grand Pangani Falls. The site was studied by Balfour Beatty in 1965, and Mosha et al in 1990. The latest assessment was by TANESCO in 1995[29].

Stiegler's Gorge Hydroelectric Development

The Stiegler's Gorge hydroelectric development would be located in the Selous Game reserve on the Rufiji River in Tanzania, 230 km from the Indian Ocean. The project would be built in four phases. The total capacity would be 1200 MW (300 MW for the first phase).

Main Legal and Administrative Issue

As mentioned above, the hydropower site is located within the Selous Game Reserve. Although there seems to be no legal prohibition under Tanzanian Law to implementing projects, power or otherwise in game preserves, the Country is a signatory to the African Convention of Nature and Natural Resources (Algiers Convention). Under this convention, "any work tending to alter the configuration of the soil or the character of the vegetation" is forbidden in strict nature reserves and in national parks.

Thus, under the Algiers Convention, this option should not be considered.

Main Environmental Issues

The creation of the reservoir (some 130,000 ha) would entail the transformation of terrestrial to lacustrine habitat in the Selous Game Reserve. The 45,000 km^2 reserve is renowned for its biodiversity and the quality of its natural habitats. The reservoir would trap about 25 million tonnes (Mt) of sediments per year. There would be a degradation of the riverbed in a 100 km river section downstream. The modification of the hydrological regime could have effects on the configuration of the delta and on salt intrusion.

The size of the reservoir could lead to significant evaporation. A rate of evaporation of one metre per year could result in a loss of about 40 m^3/sec.

[27] Tanzania Ministry of Water Energy and Minerals. The hydropower and irrigation study of Western Tanzania, Report No. 2- Hydropower Potentials in Western Tanzania – A report on 52 Investigated Rivers, April 1976

[28] Norconsult, Malagarasi Hydropower Project - Kigoma Region, Feasibility Study Report, Volume 1, Main text, TANESCO/NORAD, August 1983

[29] TANESCO- Feasibility Study of the Mandera Hydroelectric Power Project, Field Studies Unit, December 1995

Uganda

Ayago South Hydroelectric Development: The 234 MW Ayago South hydroelectric project would be a run of river project with no pondage. It would be located on the Victoria Nile in Uganda, about 3.5 km upstream of the confluence with the Ayago River in Murchison National Park.

Main Legal and Administrative Issue

As mentioned above, the Ayago South Hydropower site is located within the Murchison National Park. Although there seems to be no legal prohibition under Uganda Law to implementing projects, power or otherwise in National Parks in Uganda, the Country is a signatory to the African Convention of Nature and Natural Resources (Algiers Convention). Under this convention, “any work tending to alter the configuration of the soil or the character of the vegetation” is forbidden in strict nature reserves and in national parks.

Thus, under the Algiers Convention, this option should not be considered.

Main Environmental Issues

The reservoir impact would be minimal due to its small area (67 ha) and volume. There would be a 10 km river stretch with reduced flow between dam and tailrace. A minimum flow release of some 200 m^3/s in the dry season would be maintained in the bypassed river section, which would preserve natural habitats, including mist flora habitats. The creation of the pondage reservoir would provide additional habitats for wildlife. The dam would constitute a barrier to fish movement. As the project is located in Murchison National Park, it would be subjected to Uganda’s laws pertaining to protected areas.

Main Socio-economic Issues

Because the project would be located in a national park there are no people to be displaced. The minimum flow release in the bypassed river section would maintain the spectacle of the falls. There would be no immediate impacts on white water safaris but potential impacts on planned activities. The construction of two access roads totalling 43 km would provide better access to markets and services.

Kalagala: The project would be located on the Victoria Nile 25 km downstream of Owen Falls and also downstream of the proposed Bujagali project. The project would be a conventional run of river development comprising 7 45 MW units (315 MW) in a first phase, and a further 3 units (135 MW) in the second stage for a total capacity of 450 MW.

The project could provide low cost energy, at an average cost in the order of 4 cents/kWh, and firm energy would be relatively high, due to the regulating effect of Lake Victoria. The project has been studied to the prefeasibility level[30], and a preliminary assessment of environmental potential impacts has been prepared[31].

It has long been recognized that development of the three projects of Bujagali, Kalagala and Karuma would result in a major risk to tourism, as well as resulting in other significant social and environmental impacts. Consequently recent planning has assumed that either, but not both, Kalagala and Karuma could be constructed. In line with this concept, in 2002 the Uganda Government signed an offset agreement with the World Bank, as part of the

[30] Kennedy and Donkin, (Uganda) Hydropower development master plan, 1997

[31] ESG International Inc., WS Atkins (Epsom UK), Bujagali Hydropower Project - Environmental Impact, prepared for AES Nile Power, March 2001

agreements related to the Bujagali project, which set aside the Kalagala project to protect its natural habitat, environmental and spiritual values and for tourism development[32]. Consequently the Kalagala project has not been considered as a candidate for inclusion in any portfolios to meet future loads.

Masindi 1-2: The Masindi scheme consists of two 360 MW stages, to divert flow from the Nile downstream of Lake Kyoga to Lake Albert, some 200 km downstream. This project would therefore provide a major reduction in flows of the Nile between these two points, and has therefore been rejected because of major environmental / social risk. This project would also displace the Ayago and Murchison Falls hydro options. It would therefore be a trade-off between reduced Nile flows through the park, and possible new infrastructure construction in the park.

The indicated cost of firm energy is 6 cents/kWh or more, and may be significantly higher depending on the construction time, primarily to complete the 70 km power tunnels. Information on the project is limited, and for this reason it was not considered in the EAPMP.

Murchison Falls Hydroelectric Development: The 222 MW Murchison Falls hydroelectric project would be located at Murchison Falls on the Victoria Nile in Uganda in Murchison National Park. It would be a run of river project with hourly pondage.

Main Legal and Administrative Issue

As mentioned above, the Murchison Falls Hydropower site is located within the Murchison National Park. Although there seems to be no legal prohibition under Uganda Law to implementing projects, power or otherwise in National Parks in Uganda, the Country is a signatory to the African Convention of Nature and Natural Resources (Algiers Convention). Under this convention, “any work tending to alter the configuration of the soil or the character of the vegetation” is forbidden in strict nature reserves and in national parks.

Thus, under the Algiers Convention, this option should not be considered.

Main Environmental Issues

The reservoir impact would be minimal due to its small area (67 ha) and volume. There would be some loss of crocodile breeding grounds. The 2.9 km bypassed river section between dam and tailrace includes Murchison Falls. A minimum flow release could maintain the main falls. There would be a loss of mist flora and associated fauna sustained by subsidiary falls. As the project would be located in Murchison Falls National Park, it would be subjected to Uganda’s laws pertaining to protected areas.

Main Socio-economic Issues

Because the option would be located in a national park there would be relatively few people to displace. The dam would cause an obstruction to white water safaris (some 6 km out of 40 km) and would entail a reduction of the visual amenity of Murchison Falls and Gorges, an internationally recognized landscape.

[32] IBRD/IDA Management report and recommendation in response to the inspection panel investigation report, Uganda, Third Power Project, fourth Power Project and Bujagali Hydropower project, June 2002, and Annex 2 letter from the Minister of Finance, Planning and Economic Development to the World Bank, June 4, 2002

Figure 7-1 - Retained Candidate Power Options

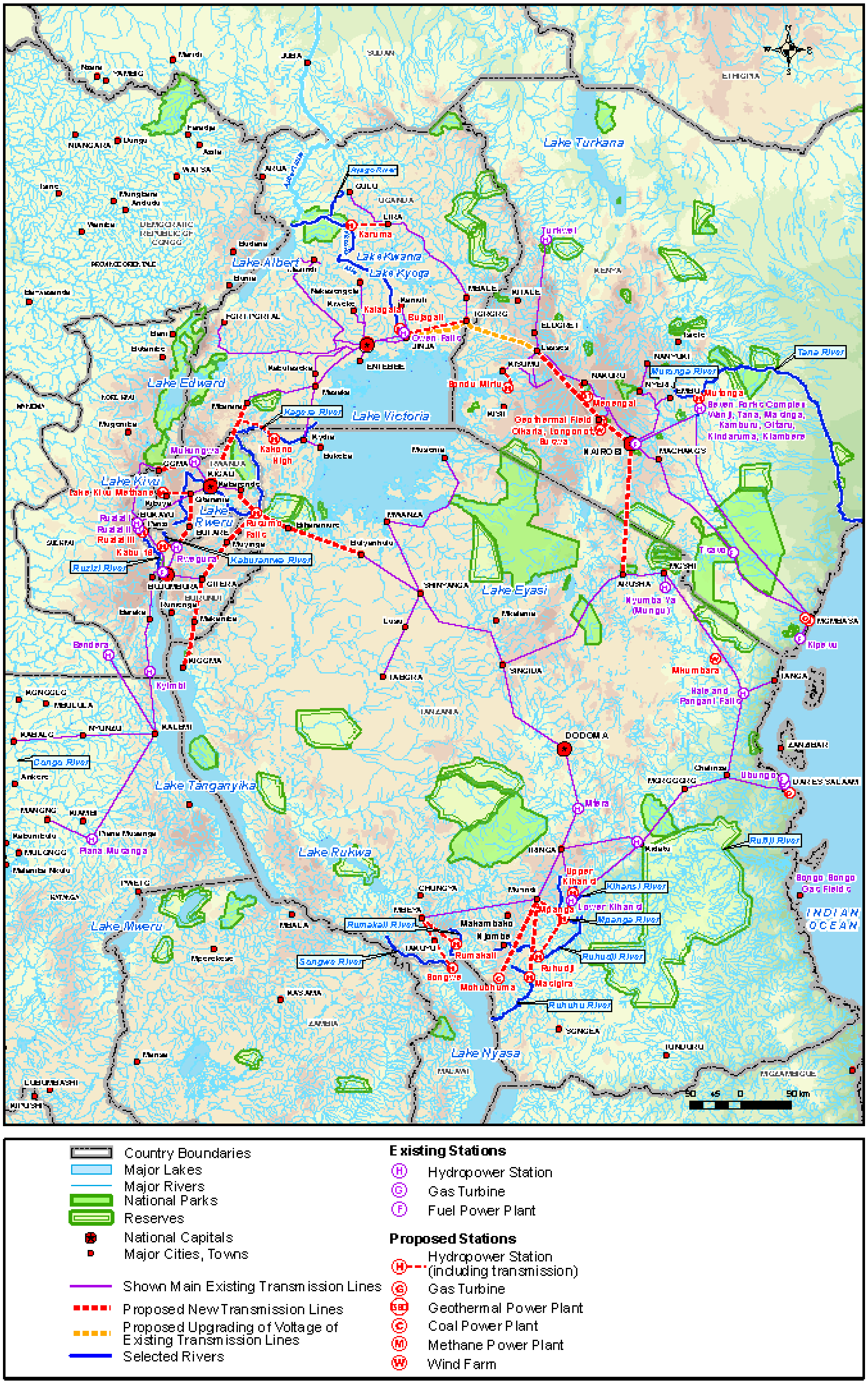


Figure 7-2 - Retained Candidate Power Options in Southern Tanzania

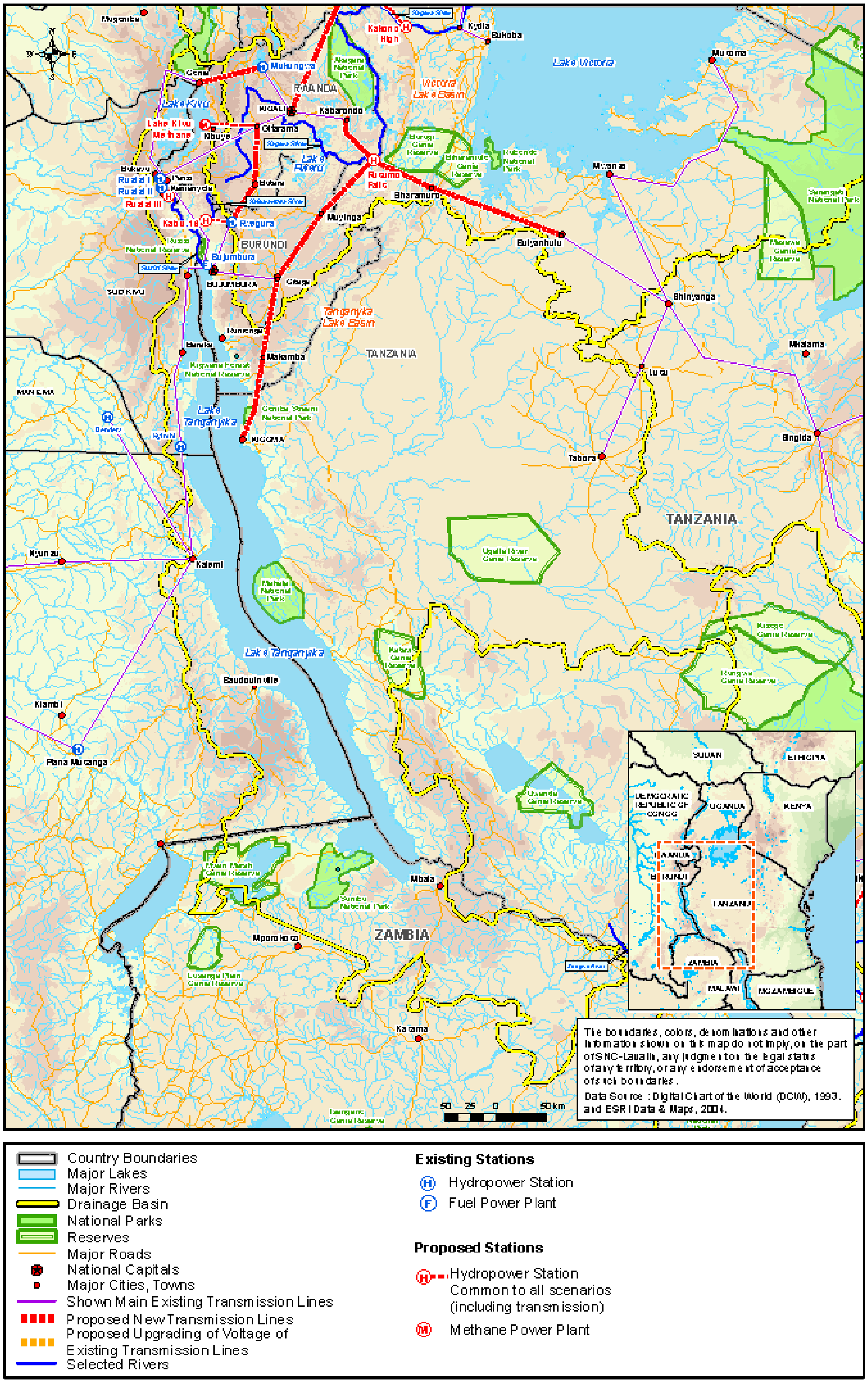


Figure 7-3 - Retained Candidate Power Options in Rwanda-Burundi Border

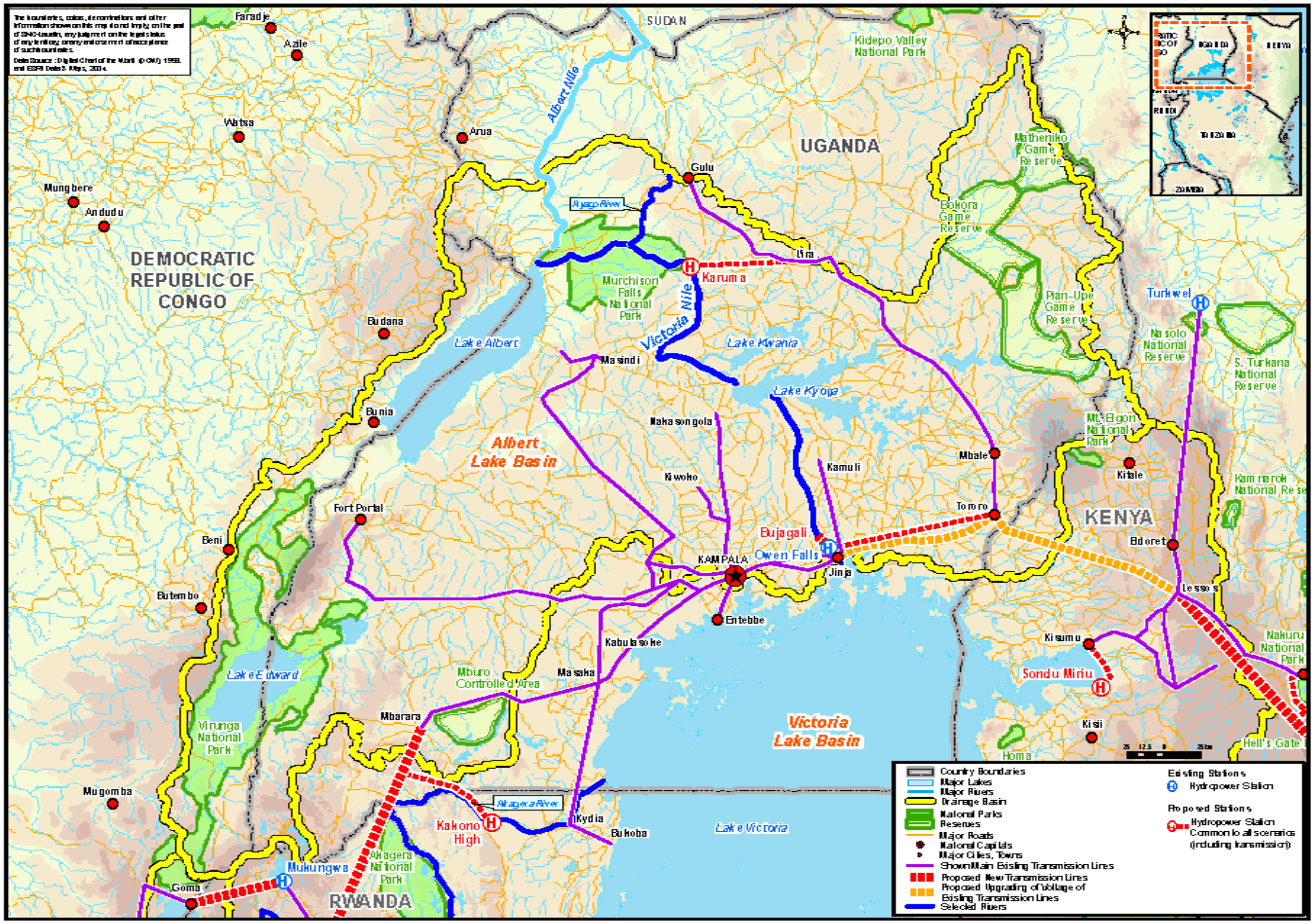


Figure 7-4 - Retained Candidate Power Options in Uganda – Lake Victoria Area

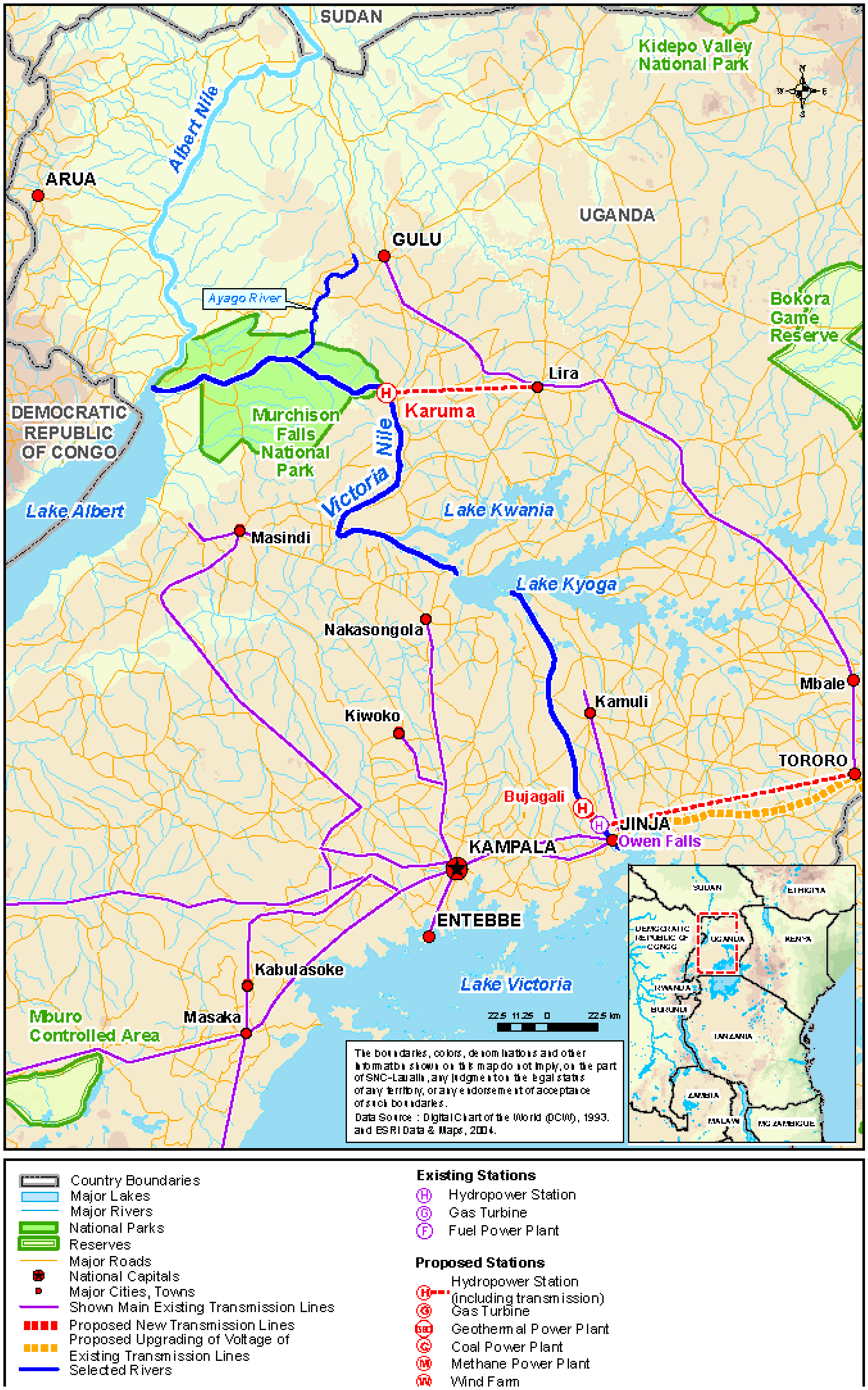


Figure 7-5 - Retained Candidate Power Options in Kenya-Tanzania Border

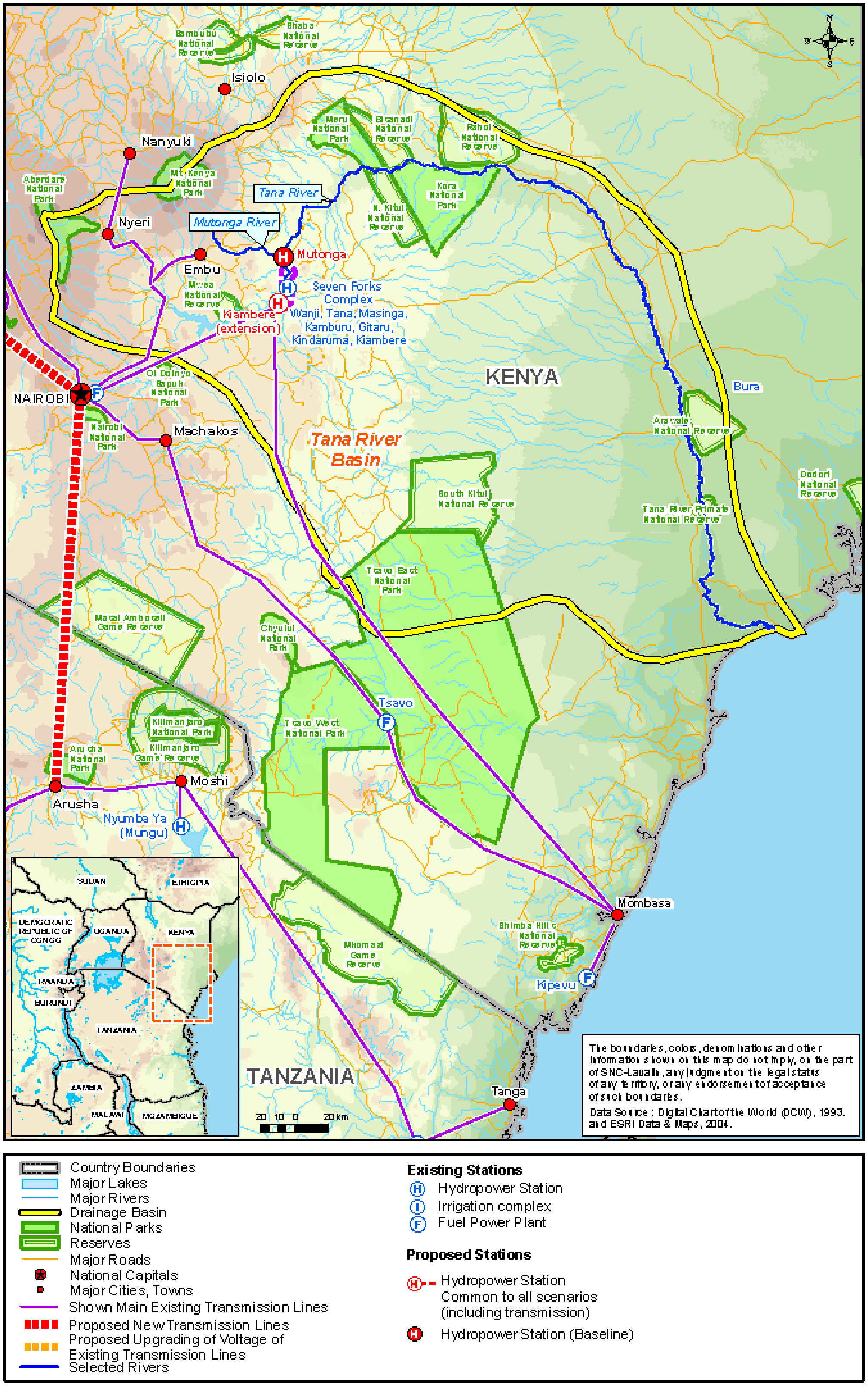


Figure 7-6 - Retained Candidate Power Options in Eastern Tanzania

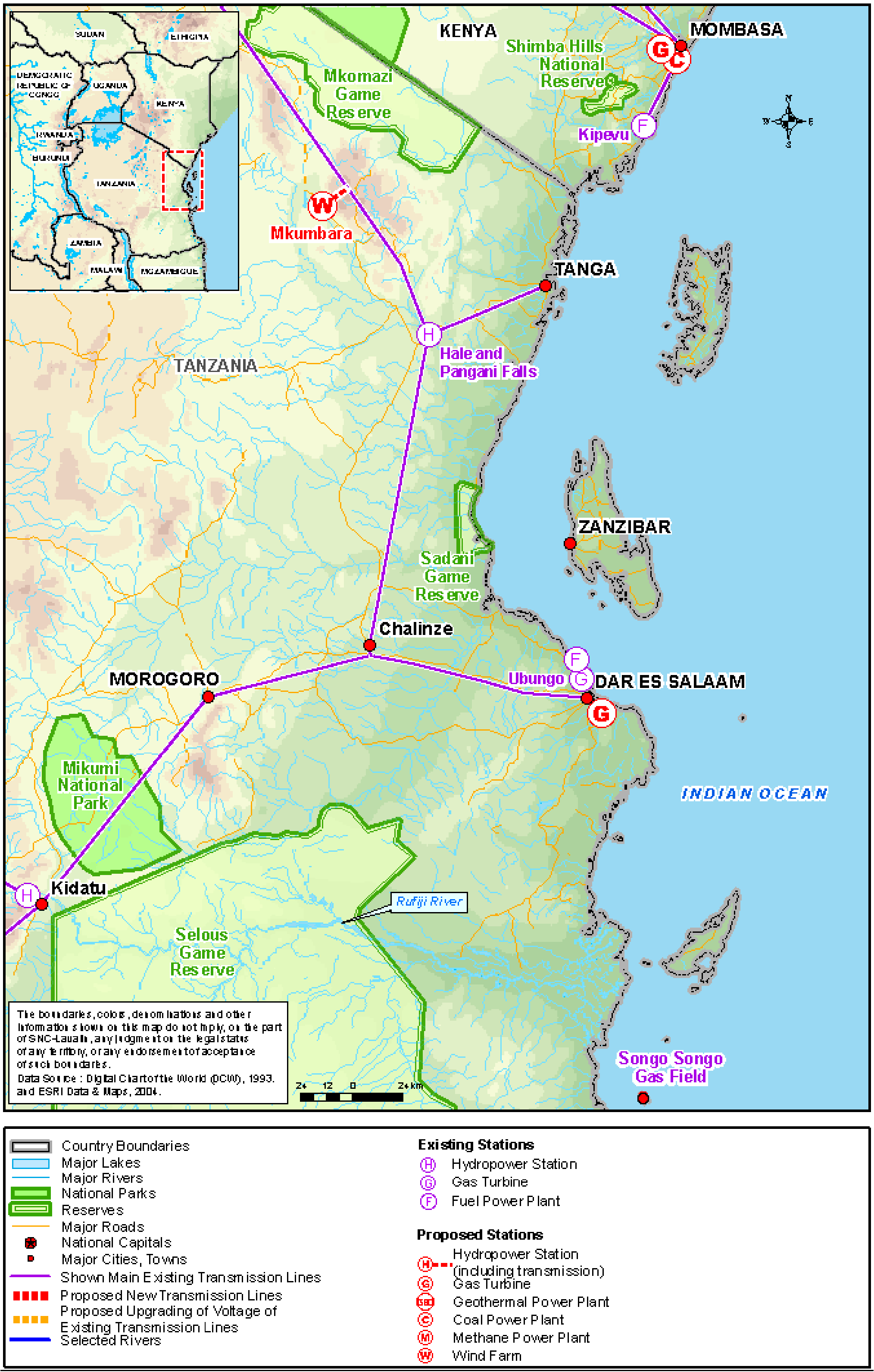


Table 7-1 - NELSAP Region - Screening of New Power Options

Name	COUNTRY	Original cost $ MILLION	Multi-purpose Factor	MITIG-ATION $ MILLION	TOTAL COST $ MILLION	INSTAL CAP (MW)	ENERGY AV (GWh)	ENERGY FIRM (GWH)	GENERATION COST Average c/kWh	GENERATION COST Firm c/kWh	GENERATION COST $/kW	Earliest installat-ion date	Preparedness	SCREENING ASSESSMENT	Observations
A: HYDROELECTRIC OPTIONS															
Ayago North 1-4	Uganda	446.60	1.00	29.40	589.44	228	1981	1981	3.32	3.32	2585	2014	prefeasibility	Out - located in national park	Alternatve to South scheme
Ayago North 5-6	Uganda	111.00	1.00	9.80	140.84	76	643	643	2.46	2.46	1853	2024	prefeasibility	Out - located in national park	Alternatve to South scheme
Ayago North Total	Uganda	557.60	1.00	39.20	730.27	304	2624	2624	3.11	3.11	2402	2025	prefeasibility	Out - located in national park	Alternatve to South scheme
Ayago South	Uganda	437.20	1.00	29.30	577.55	234	2050	2050	3.14	3.14	2468	2016	prefeasibility	Out - located in national park	Against Algiers Convention
Babeba I	DRC	94.00	1.00	5.07	122.40	50	351		3.89		2448	2013	Reconnaissance	Out - insufficient data	Long term - prelim. eval only - for study
Bangamisa	DRC	93.00	1.00	5.02	123.47	48	420		3.28		2572	2013	Reconnaissance	Out - insufficient data	Long term - prelim. eval only - for study
Budana	DRC		1.00	0.00	12.72	13	70		2.08		979	2013	N/A	Out - insufficient data	Rehabilitation - for study
Bujagali 1-4	Uganda	395.00	1.00	0.00	495.33	200	1703	1390	3.25	3.98	2477	2012	Feas/design	Included	Candidate
Bujagali 5	Uganda	26.40	1.00	0.00	30.54	50	222	0	1.62	N/A	611	2013	Feasibility	Included	Candidate - has EIA
Bujagali total	Uganda	421.40	1.00	0.00	525.87	250	1925	1390	3.06	4.24	2103	2012	Feasibility	Included	Total scheme
Ewaso Ngiro	Kenya	385.90	0.95	16.50	492.55	220	609	448	9.04	12.29	2275	2013	Design	Out on cost	Only long term - erosion problem-old EIA
Igamba Falls (Stage 2)*	Tanzania	11.30	1.00		15.44	8	65	56	2.67	3.09	1930	2012	Prefeasiiblity	Out - less than 10 MW	Needs to be restudied with larger scheme
Igamba Falls 980 m	Tanzania	404.00	1.00		544.80	80	494	464	12.17	12.95	6810	2015	Reconnaissance	Out - insufficient data/cost	Out - lack of data and cost
Igamba Falls FSL 865 m	Tanzania	31.50	1.00		41.74	11	87		5.32		3661	2013	Reconnaissance	Out - insufficient data	Out - insufficient data
Jiji 03	Burundi	42.20	1.00		48.82	16	40	33	13.57	16.44	3149	2012	Prefeasiiblity	Out on cost	Out - high cost
Kabu 16	Burundi	44.85	1.00		44.35	20	112	67	4.43	7.40	2218	2012	Feasibility	Included	Candidate
Kaganuzi A	Burundi	45.10	1.00	2.54	61.37	34	98	97	7.04	7.11	1805	2013	Reconnaissance	Out on env risk and cost	Alt to Kag complex - major diversion
Kaganuzi Complex	Burundi	120.72	0.92	6.59	162.11	39	184	171	9.76	10.50	4136	2012	Feasibility	Out on env risk and cost	Major diversion environmental risk
Kakono (High)	Tanzania	65.00	0.82	3.55	85.80	53	300	126	3.22	7.67	1619	2012	Prefeasibility	Included	Candidate
Kalagala 1-7	Uganda	444.70	1.00	5.90	563.55	315	2364	1697	2.68	3.73	1789	2013	Prefeasibility	Out - environment	Against Government agreement with WB
Kalagala 8-10	Uganda	66.80	1.00	0.00	78.86	135	161	0	5.79	N/A	584	2016	Prefeasibility	Out - environment	Against Government agreement with WB
Kalagala 10 total	Uganda	511.50	1.00	5.90	642	450	2525	1697	2.88	4.29	1428	2016	Prefeasibility	Out - environment	Against Government agreement with WB
Kamanyola	Rwanda-DRC	390.00	1.00	21.04	517.79	390	1880		3.12		1328	2016	Reconnaissance	Out - environmental risks	Alt Ruzizi III/Major diversion environmental risk
Karuma	Uganda	428.90	1.00	6.60	544.44	200	1747	1619	3.47	3.74	2722	2014	Feasibility	Included	Candidate - has EIA
Kiliba	DRC	30.00	1.00	1.62	39.06	15	65		6.70		2604	2013	Reconnaissance	Out - insufficient data	Out - small - lack of data
Kisala-Iwuga	DRC					13	52	52				2008	N/A	Financing/construction	Rehabilitation
Kishanda	Tanzania	181.00	0.97	10.59	260.67	207	1087	500	2.72	5.92	1259	2015	Reconnaissance	Out - environmental risks	Major diversion environmental risk
Kitete	DRC	154.00	1.00	8.31	200.52	21	153		14.43		9549	2013	Reconnaissance	Out - insufficient data/cost	Out - very high energy cost
Kiymbi/Bendera II	DRC		1.00	0.00	52.06	43	377		1.57		1211	2013	N/A	Out - insufficient data	Rehabilitation- for study
Low Grand Falls	Kenya	378.30	1.00	8.60	455.18	140	715	324	7.07	15.61	3251	2013	Feasibility	Out - env risks/costs	Only very long term socio-env risk- prelim EIA
Lower Kihansi	Tanzania					120	54			N/A		2012	Design	Out on cost	Out - high cost
Luiche	Tanzania	68.70	0.85	3.71	89.55	15	100	69	9.89	14.33	5853	2013	Reconnaissance	Out - insufficient data/cost	Out - insufficient data
Magwagwa	Kenya	294.50	0.86	34.00	382.99	120	669	244	6.36	17.44	3192	2013	Feasibility	Out - env risks/costs	phase 2 Sondu Miriu Env/social risks
Mandera	Tanzania	42.10	1.00	1.40	50.10	21	149	109	3.76	5.13	2386	2012	Feasibility	Out - less than 30 MW	Only long term - environment / national park
Masigira	Tanzania	157.00	1.00	4.90	190.24	118	695	528	3.08	4.06	1612	2013	Prefeasibility	Included	Candidate - long term - more studies-EIA
Masindi - 2	Uganda	729.40	1.00	5.00	1088.16	360	2302	1798	5.26	6.73	2555	2020	Prefeasibility	Out - environmental risks	Major diversion environmental risk
Masindi -1	Uganda	903.80	1.00	5.00	1347.14	360	3016	2615	4.95	5.71	3162	2020	Prefeasibility	Out - environmental risks	Major diversion environmental risk
Mpanda	Burundi	35.31	0.80	2.13	51.48	10	40		14.23		4950	2012	Feasibility	Out on cost	Out - high cost
Mpanga	Tanzania	190.80	1.00	7.20	232.44	144	1028	863	2.55	3.03	1614	2014	Prefeasibility	Included	Out - long term - more studies-EIA
Mugomba	DRC	66.00	1.00	3.56	87.63	40	160		6.13		2191	2013	Reconnaissance	Out - insufficient data	Long term - prelim. eval only - for study
Muhuma	DRC	54.00	1.00	2.91	71.69	25	100		7.98		2868	2013	Reconnaissance	Out - insufficient data	Out -- lack of data
Mule 34	Burundi	33.00	1.00		38.17	17	54	39	7.90	10.94	2314	2012	Prefeasibility	Out on cost	Only candidate for isolated SSEA1 area
Murchison 1-6 phase 2	Uganda	427.70	1.00	25.30	561.64	315	2759	2759	2.29	2.29	1783	2019	Prefeasibility	Out - located in national park	Alternative to base scheme
Murchison 7-8	Uganda	78.40	1.00	3.20	95.75	105	920	920	1.20	1.20	912	2023	Prefeasibility	Out - located in national park	Alternative to base scheme
Murchison Base - Opt2	Uganda	297.00	1.00	24.50	396.94	222	1773	1773	2.52	2.52	1788	2014	Prefeasibility	Out - located in national park	Against Algiers Convention
Mutonga	Kenya	196.70	1.00	1.90	229.44	60	328	293	7.76	8.68	3824	2013	Feasibility	Included	Only very long term socio-env risk- prelim EIA

Table 7-1 - NELSAP Region - Screening of New Power Options (Continued)

Name	COUNTRY	Original cost $ MILLION	Multi-purpose Factor	MITIG-ATION $ MILLION	TOTAL COST $ MILLION	INSTAL CAP (MW)	ENERGY AV (GWh)	ENERGY FIRM (GWH)	GENERATION COST Average c/kWh	GENERATION COST Firm c/kWh	GENERATION COST $/kW	Earliest installat-ion date	Preparedness	SCREENING ASSESSMENT	Observations
Mwana Ngoye	DRC	310.00	1.00	16.72	403.65	46	336		13.23		8775	2013	Reconnaissance	Out - insufficient data/cost	Out - high energy cost
Nyabarongo	Rwanda	77.50	1.00		111.92	28	142	80	8.73	15.50	4026	2012	Feasibility	Out on cost	Out - high energy cost
Panzi	Rwanda-DRC	105.00	1.00	5.66	136.72	36	175		8.66		3798	2013	Reconnaissance	Out-insufficient data	Long term after Sisi - for study
Piana Mwanga	DRC		1.00	0.00	35.00	38	193		2.40		1065	2013	N/A	Out-insufficient data	Rehabilitation - for study
Ruhudji	Tanzania	384.00	1.00	5.30	486.84	358	1930	1476	2.86	3.74	1360	2014	Feasibility	Included	Candidate - needs EIA update
Rumakali	Tanzania	351.30	1.00	10.10	450.63	222	1141	1170	4.43	4.32	2030	2016	Feasibility	Included	Candidate - needs EIA update
Rusumo Falls (Full)	Tanzania-Rwanda	91.60	1.00	4.70	113.52	62	403	308	3.16	4.14	1846	2012	Feas/design	Included	Candidate
Ruzizi (Diversion)	DRC-Rwanda	240.00	1.00	12.95	318.64	270	1300		2.79		1180	2016	Reconnaissance	Out - environmental risks	Alt Ruzizi III/Major diversion environmental risk
Ruzizi III	DRC-Rwanda-Bur	174.58	1.00		105.17	82	418	418	2.86	2.86	1283	2014	Prefeasibility	Included	Candidate
Semliki	DRC	72.00	1.00	3.88	95.59	28	120		8.85		3414	2013	Reconnaissance	Out - insufficient data	Long term - prelim. eval only - for study
Siguvyaye	Burundi	280.00	1.00		420.06	90	510	486	9.11	9.56	4667	2013	Feas/design	Out - environmental risks	Major diversion environmental risk
Sisi 3	Rwanda-DRC	305.00	1.00	16.49	405.93	174	883		5.14		2333	2016	Reconnaissance	Out - insufficient data	Alt to sisi 5
Sondu Miriu	Kenya					60	240	240				2008	Construction		Under construction for 2008
Songwe	Tanz/Malawi	359.00	0.81	17.95	407.60	330	1352	1352	3.43	3.43	1235	2015	Prefeasibility	Included	Extensive multipurpose studies -report 2003
Stiegler Gorge 1	Tanzania	653.40	1.00		819.36	300	2715	2598	3.36	3.51	2731	2020	Prefeasibility	Out - located in game park	Against Algiers Convention
Stiegler Gorge 2	Tanzania	233.00	1.00		292.18	600	2525	693	1.39	5.05	487	2025	Prefeasibility	Out - located in game park	Against Algiers Convention
Stiegler Gorge 3	Tanzania	191.30	1.00		239.89	300	963	1754	2.89	1.58	800	2029	Prefeasibility	Out - located in game park	Against Algiers Convention
Stiegler Gorge total	Tanzania	1077.70	1.00		1351.44	1200	6203	5045	2.48	3.05	1126	2029	Prefeasibility	Out - located in game park	Against Algiers Convention
Upper Kinansi (storage)	Tanzania	81.20	1.00	4.20	98.13	0	124	11	8.67			2014	Prefeasibility	Included	Out - long term - more studies-EIA-storage only
Wagenia I	DRC	316.00	1.00	17.05	411.46	50	400		11.33		8229	2013	Reconnaissance	Out - insufficient data/cost	Out - high energy cost
TOTAL HYDRO MW - excluding duplications annd under construction						**6494**									
TOTAL RETAINED HYDRO MW -excluding duplications and under construction						**2571**									
B: THERMAL AND COMBUSTION									(CF=75%)	(CF=75%)					
Olkaria ext - Geothermal	Kenya					35	245	245	5.62	5.62	2645	2009		Included	
Longonot Geothermal	Kenya					70	491	491	5.05	5.05	2352	2010		Included	
Suswa Geothermal	Kenya					70	491	491	5.05	5.05	2352	2012		Included	
Menengai Geothermal	Kenya					140	981	981	5.05	5.05	2352	2015		Included	
Other Geothermal	Kenya					140	981	981	5.05	5.05	2352	2015			
Mombasa - Gas/LNG steam (4$/GJ) -2units	Kenya					300	2102	2102	7.39	7.39	895	2015		Included	
Mombasa - Coal steam-2 units	Kenya					300	2102	2102	6.88	6.88	1678	2012		Included	
Mchuchuma - Coal steam	Tanzania					400	2803	2803	6.50	6.50	1909	2012		Included	
GT 60 MW- gas - generic x 4 units	Tanzania					240	1682	1682	3.84	3.84	591	2008		Included	
GT 60 MW- diesel - generic x 2 units	Kenya					120	841	841	3.84	3.84	591	2008		Included	
CC 60 MW - gas /steam cycle x 2 units	Tanzania					120	841	841	5.13	5.13	1532	2008		Included	
CC 60 MW - gas comb cycle x 3 units	Tanzania					180	1261	1261	3.93	3.93	895	2008		Out	Insufficient Songo songo
Kivu methane engines 30 MW x 4 units	Rwanda/DRC					120	841	841	6.11	6.11	2505	2007		Included	
MSD Generic 10 MW x 2 units	Rwanda					20	140	140	13.11	13.11	872	2006		Out - high cost*	
MSD Generic 10 MW x 2 units	Burundi					20	140	140	13.11	13.11	872	2006		Out - high cost*	
MSD Generic 10 MW x 2 units	W. Tanzania					20	140	140	13.11	13.11	872	2006		Out - high cost*	
TOTAL THERMAL POTENTIAL MW - excludes later units at Mombasa						**2295**									
C: OTHER OPTIONS															
Solar power PV														Out - insufficient data/cost	Too expensive and too small
Wind energy conversion systems	**generic**					**30**	63	63	8.33	8.33				Included	Preliminary info only
Demand side management														Out - insufficient data	No current plans

Legend	
(light blue)	Committed / under construction
(white)	Retained for MCA
(yellow)	Excluded

Imports and interconnections not shown

Notes

Sites outside project area are not shown in list
Earliest on power refers to nominally in January of the year
MSD generic diesels in Rwanda, Burundi and Western Tanzania included in SSEA Stage I
because of urgency to eliminate load shedding; no additional such plants considered because of high cost

Table 7-2 - NELSAP Region - Screening of New Power Options – Excluding Duplications

Name	COUNTRY	Original cost $ MILLION	Multi-purpose Factor	MITIG-ATION $ MILLION	TOTAL COST $ MILLION	INSTAL CAP (MW)	ENERGY AV (GWh)	ENERGY FIRM (GWH)	GENERATION COST Average c/kWh	GENERATION COST Firm c/kWh	GENERATION COST $/kW	Earliest installat-ion date	Preparedness	SCREENING ASSESSMENT	Observations
A: HYDROELECTRIC OPTIONS															
Ayago South	Uganda	437.20	1.00	29.30	577.55	234	2050	2050	3.14	3.14	2468	2016	prefeasibility	Out - located in national park	Against Algiers Convention
Babeba I	DRC	94.00	1.00	5.07	122.40	50	351		3.89		2448	2013	Reconnaissance	Out - insufficient data	Long term - prelim. eval only - for study
Bangamisa	DRC	93.00	1.00	5.02	123.47	48	420		3.28		2572	2013	Reconnaissance	Out - insufficient data	Long term - prelim. eval only - for study
Budana	DRC		1.00	0.00	12.72	13	70		2.08		979	2013	N/A	Out - insufficient data	Rehabilitation - for study
Bujagali 1-4	Uganda	395.00	1.00	0.00	495.33	200	1703	1390	3.25	3.98	2477	2012	Feas/design	Included	Candidate
Bujagali 5	Uganda	26.40	1.00	0.00	30.54	50	222	0	1.62	N/A	611	2013	Feasibility	Included	Candidate - has EIA
Ewaso Ngiro	Kenya	385.90	0.95	16.50	492.55	220	609	448	9.04	12.29	2275	2013	Design	Out on cost	Only long term - erosion problem-old EIA
Igamba Falls (Stage 2)*	Tanzania	11.30	1.00		15.44	8	65	56	2.67	3.09	1930	2012	Prefeasiiblity	Out - less than 10 MW	Needs to be restudied with larger scheme
Igamba Falls 980 m	Tanzania	404.00	1.00		544.80	80	494	464	12.17	12.95	6810	2015	Reconnaissance	Out - insufficient data/cost	Out - lack of data and cost
Igamba Falls FSL 865 m	Tanzania	31.50	1.00		41.74	11	87		5.32		3661	2013	Reconnaissance	Out - insufficient data	Out - insufficient data
Jiji 03	Burundi	42.20	1.00		48.82	16	40	33	13.57	16.44	3149	2012	Prefeasiiblity	Out on cost	Out - high cost
Kabu 16	Burundi	44.85	1.00		44.35	20	112	67	4.43	7.40	2218	2012	Feasibility	Included	Candidate
Kaganuzi Complex	Burundi	120.72	0.92	6.59	162.11	39	184	171	9.76	10.50	4136	2012	Feasibility	Out on env risk and cost	Major diversion environmental risk
Kakono (High)	Tanzania	65.00	0.82	3.55	85.80	53	300	126	3.22	7.67	1619	2012	Prefeasibility	Included	Candidate
Kalagala 1-7	Uganda	444.70	1.00	5.90	563.55	315	2364	1697	2.68	3.73	1789	2013	Prefeasibility	Out-environment	Against Government Agreement with WB
Kalagala 8-10	Uganda	66.80	1.00	0.00	78.86	135	161	0	5.79	N/A	584	2016	Prefeasibility	Out-environment	Against Government Agreement with WB
Karuma	Uganda	428.90	1.00	6.60	544.44	200	1747	1619	3.47	3.74	2722	2014	Feasibility	Included	Candidate - has EIA
Kiliba	DRC	30.00	1.00	1.62	39.06	15	65		6.70		2604	2013	Reconnaissance	Out - insufficient data	Out - small - lack of data
Kisala-Ivuga	DRC					13	52	52				2008	N/A	Financing/construction	Rehabilitation
Kishanda	Tanzania	181.00	0.97	10.59	260.67	207	1087	500	2.72	5.92	1259	2015	Reconnaissance	Out - environmental risks	Major diversion environmental risk
Kitete	DRC	154.00	1.00	8.31	200.52	21	153		14.43		9549	2013	Reconnaissance	Out - insufficient data/cost	Out - very high energy cost
Kiymbi/Bendera II	DRC		1.00	0.00	52.06	43	377		1.57		1211	2013	N/A	Out - insufficient data	Rehabilitation- for study
Low Grand Falls	Kenya	378.30	1.00	8.60	455.18	140	715	324	7.07	15.61	3251	2013	Feasibility	Out - env risks/costs	Only very long term socio-env risk- prelim EIA
Lower Kihansi	Tanzania					120	54			N/A		2012	Design	Out on cost	Out - high cost
Luiche	Tanzania	68.70	0.85	3.71	89.55	15	100	69	9.89	14.33	5853	2013	Reconnaissance	Out - insufficient data/cost	Out - insufficient data
Magwagwa	Kenya	294.50	0.86	34.00	382.99	120	669	244	6.36	17.44	3192	2013	Feasibility	Out - env risks/costs	phase 2 Sondu Miriu Env/social risks
Mandera	Tanzania	42.10	1.00	1.40	50.10	21	149	109	3.76	5.13	2386	2012	Feasibility	Out - less than 30 MW	Only long term - environment / national park
Masigira	Tanzania	157.00	1.00	4.90	190.24	118	695	528	3.08	4.06	1612	2013	Prefeasibility	Included	Candidate - long term - more studies-EIA
Masindi - 2	Uganda	729.40	1.00	5.00	1088.16	360	2302	1798	5.26	6.73	2555	2020	Prefeasibility	Out - environmental risks	Major diversion environmental risk
Masindi -1	Uganda	903.80	1.00	5.00	1347.14	360	3016	2615	4.95	5.71	3162	2020	Prefeasibility	Out - environmental risks	Major diversion environmental risk
Mpanda	Burundi	35.31	0.80	2.13	51.48	10	40		14.23		4950	2012	Feasibility	Out on cost	Out - high cost
Mpanga	Tanzania	190.80	1.00	7.20	232.44	144	1028	863	2.55	3.03	1614	2014	Prefeasibility	Included	Out - long term - more studies-EIA
Mugomba	DRC	66.00	1.00	3.56	87.63	40	160		6.13		2191	2013	Reconnaissance	Out - insufficient data	Long term - prelim. eval only - for study
Muhuma	DRC	54.00	1.00	2.91	71.69	25	100		7.98		2868	2013	Reconnaissance	Out - insufficient data	Out -- lack of data
Mule 34	Burundi	33.00	1.00		38.17	17	54	39	7.90	10.94	2314	2012	Prefeasibility	Out on cost	Only candidate for isolated SSEA1 area
Murchison Base - Opt 2	Uganda	297.00	1.00	24.50	396.94	222	1773	1773	2.52	2.52	1788	2014	Prefeasibility	Out - located in national park	Against Algiers Convention
Mutonga	Kenya	196.70	1.00	1.90	229.44	60	328	293	7.76	8.68	3824	2013	Feasibility	Included	Only very long term socio-env risk- prelim EIA

Table 7-2 - NELSAP Region - Screening of New Power Options – Excluding Duplications (Continued)

Name	COUNTRY	Original cost $ MILLION	Multi-purpose Factor	MITIG-ATION $ MILLION	TOTAL COST $ MILLION	INSTAL CAP (MW)	ENERGY AV (GWh)	ENERGY FIRM (GWH)	GENERATION COST Average c/kWh	GENERATION COST Firm c/kWh	GENERATION COST $/kW	Earliest installat-ion date	Preparedness	SCREENING ASSESSMENT	Observations
Mwana Ngoye	DRC	310.00	1.00	16.72	403.65	46	336		13.23		8775	2013	Reconnaissance	Out - insufficient data/cost	Out - high energy cost
Nyabarongo	Rwanda	77.50	1.00		111.92	28	142	80	8.73	15.50	4026	2012	Feasibility	Out on cost	Out - high energy cost
Panzi	Rwanda-DRC	105.00	1.00	5.66	136.72	36	175		8.66		3798	2013	Reconnaissance	Out-insufficient data	Long term after Sisi - for study
Piana Mwanga	DRC		1.00	0.00	35.00	38	193		2.40		1065	2013	N/A	Out-insufficient data	Rehabilitation - for study
Ruhudji	Tanzania	384.00	1.00	5.30	486.84	358	1930	1476	2.86	3.74	1360	2014	Feasibility	Included	Candidate - needs EIA update
Rumakali	Tanzania	351.30	1.00	10.10	450.63	222	1141	1170	4.43	4.32	2030	2016	Feasibility	Included	Candidate - needs EIA update
Rusumo Falls (Full)	Tanzania-Rwanda	91.60	1.00	4.70	113.52	62	403	308	3.16	4.14	1846	2012	Feas/design	Included	Candidate
Ruzizi (Diversion)	DRC-Rwanda	240.00	1.00	12.95	318.64	270	1300		2.79		1180	2016	Reconnaissance	Out - environmental risks	Alt Ruzizi III/Major diversion environmental risk
Ruzizi III	DRC-Rwanda-Bur	174.58	1.00		105.17	82	418	418	2.86	2.86	1283	2014	Prefeasibility	Included	Candidate
Semliki	DRC	72.00	1.00	3.88	95.59	28	120		8.85		3414	2013	Reconnaissance	Out - insufficient data	Long term - prelim. eval only - for study
Siguvyaye	Burundi	280.00	1.00		420.06	90	510	486	9.11	9.56	4667	2013	Feas/design	Out - environmental risks	Major diversion environmental risk
Sisi 3	Rwanda-DRC	305.00	1.00	16.49	405.93	174	883		5.14		2333	2016	Reconnaissance	Out - insufficient data	Alt to sisi 5
Sondu Miriu	Kenya					60	240	240				2008	Construction		Under construction for 2008
Songwe	Tanz/Malawi	359.00	0.81	17.95	407.60	330	1352	1352	3.43	3.43	1235	2015	Prefeasibility	Included	Extensive multipurpose studies -report 2003
Stiegler Gorge 1	Tanzania	653.40	1.00		819.36	300	2715	2598	3.36	3.51	2731	2020	Prefeasibility	Out - located in game park	Against Algiers Convention
Stiegler Gorge 2	Tanzania	233.00	1.00		292.18	600	2525	693	1.39	5.05	487	2025	Prefeasibility	Out - located in game park	Against Algiers Convention
Stiegler Gorge 3	Tanzania	191.30	1.00		239.89	300	963	1754	2.89	1.58	800	2029	Prefeasibility	Out - located in game park	Against Algiers Convention
Upper Kinansi (storage)	Tanzania	81.20	1.00	4.20	98.13	0	124	11	8.67			2014	Prefeasibility	Included	Out - long term - more studies-EIA-storage only
Wagenia I	DRC	316.00	1.00	17.05	411.46	50	400		11.33		8229	2013	Reconnaissance	Out - insufficient data/cost	Out - high energy cost
TOTAL HYDRO MW - excluding duplications annd under construction						**6764**									
TOTAL RETAINED HYDRO MW - excluding duplications annd under construction						**2349**									
B: THERMAL AND COMBUSTION									(CF=75%)	(CF=75%)					
Olkaria ext - Geothermal	Kenya					35	245	245	5.62	5.62	2645	2009		Included	
Longonot Geothermal	Kenya					70	491	491	5.05	5.05	2352	2010		Included	
Suswa Geothermal	Kenya					70	491	491	5.05	5.05	2352	2012		Included	
Menengai Geothermal	Kenya					140	981	981	5.05	5.05	2352	2015		Included	
Other geothermal	Kenya					140	981	981	5.05	5.05	2352	2015			
Mombasa - Gas/LNG steam (4$/GJ) -2units	Kenya					300	2102	2102	7.39	7.39	895	2015		Included	
Mombasa - Coal steam-2 units	Kenya					300	2102	2102	6.88	6.88	1678	2012		Included	
Mchuchuma - Coal steam	Tanzania					400	2803	2803	6.50	6.50	1909	2012		Included	
GT 60 MW- gas - generic x 4 units	Tanzania					240	1682	1682	3.84	3.84	591	2008		Included	
GT 60 MW- diesel fuel - generic x 2 units	Kenya					120	841	841	3.84	3.84	591	2008		Included	
CC 60 MW - gas /steam cycle x 2 units	Tanzania					120	841	841	5.13	5.13	1532	2008		Included	
CC 60 MW - gas comb cycle x 3 units	Tanzania					180	1261	1261	3.93	3.93	895	2008		Out	Insufficient Songo Songo gas
Kivu methane engines 30 MW x 4 units	Rwanda/DRC					120	841	841	6.11	6.11	2505	2007		Included	
MSD Generic 10 MW x 2 units	Rwanda					20	140	140	13.11	13.11	872	2006		Out - high cost*	
MSD Generic 10 MW x 2 units	Burundi					20	140	140	13.11	13.11	872	2006		Out - high cost*	
MSD Generic 10 MW x 2 units	W. Tanzania					20	140	140	13.11	13.11	872	2006		Out - high cost*	
TOTAL THERMAL POTENTIAL MW - excludes later units at Mombasa						**2295**									
C: OTHER OPTIONS															
Solar power PV														Out - insufficient data/cost	Too expensive and too small
Wind energy conversion systems	**generic**					**30**	63	63	8.33	8.33				Included	Preliminary info only
Demand side management														Out - insufficient data	No current plans

Legend:
- Committed / under construction
- Retained for MCA
- Excluded

Imports and interconnections not shown

Notes

Sites outside project area are not shown in list
Earliest on power refers to nominally in January of the year
MSD generic diesels in Rwanda, Burundi and Western Tanzania included in SSEA Stage I
because of urgency to eliminate load shedding; no additional such plants considered because of high cost

Table 7-3 - NELSAP Region Screening of New Power Options- Options Retained after Screening

Name	COUNTRY	Original cost $ MILLION	Multi-purpose Factor	MITIG-ATION $ MILLION	TOTAL COST $ MILLION	INSTAL CAP (MW)	ENERGY AV (GWh)	ENERGY FIRM (GWH)	GENERATION COST Average c/kWh	GENERATION COST Firm c/kWh	GENERATION COST $/kW	Earliest installat-ion date	Regional benefits	Preparedness	SCREENING ASSESSMENT	Observations Based on SSEA 1 and EAPMP App H
A: HYDROELECTRIC OPTIONS																
Bujagali total	Uganda	421.40	1.00	0.00	525.87	250	1925	1390	3.06	4.24	2103	2012	Yes	Feasibility	Included	Total scheme
Kabu 16	Burundi	44.85	1.00		44.35	20	112	67	4.43	7.40	2218	2012	Yes	Feasibility	Included	Candidate
Kakono (High)	Tanzania W.	65.00	0.82	3.55	85.80	53	300	126	3.22	7.67	1619	2012	Yes	Prefeasibility	Included	Candidate
Karuma	Uganda	428.90	1.00	6.60	544.44	200	1747	1619	3.47	3.74	2722	2014	Yes	Prefeasibility	Included	Candidate - has EIA
Masigira	Tanzania	157.00	1.00	4.90	190.24	118	695	528	3.08	4.06	1612	2013	Yes	Prefeasibility	Included	**Candidate - long term - more studies-EIA**
Mpanga	Tanzania	190.80	1.00	7.20	232.44	144	1028	863	2.55	3.03	1614	2014	Yes	Prefeasibility	Included	Out - long term - more studies-EIA
Mutonga	Kenya	196.70	1.00	1.90	229.44	60	328	293	7.76	8.68	3824	2013	Yes	Feasibility	Included	Only very long term socio-env risk- prelim EIA
Ruhudji	Tanzania	384.00	1.00	5.30	486.84	358	1930	1476	2.86	3.74	1360	2014	Yes	Feasibility	Included	**Candidate - needs EIA update**
Rumakali	Tanzania	351.30	1.00	10.10	450.63	222	1141	1170	4.43	4.32	2030	2016	Yes	Feasibility	Included	**Candidate - needs EIA update**
Rusumo Falls (Full)	Tanzania W-Rwanda	91.60	1.00	4.70	113.52	62	403	308	3.16	4.14	1846	2012	Yes	Feas/design	Included	**Candidate**
Ruzizi III	Rwanda-DRC	174.58	1.00		105.17	82	418	418	2.86	2.86	1283	2014	Yes	Prefeasibility	Included	**Candidate**
Songwe	Tanz/Malawi	359.00	0.81	17.95	407.60	330	1352	1352	3.43	3.43	1235	2015	Yes	Prefeasibility	Included	Extensive multipurpose studies -report 2003
Upper Kihansi (storage)	Tanzania	81.20	1.00	4.20	98.13	0	124	11	8.67			2014	Yes	Prefeasibility	Included	Out - long term - more studies-EIA-storage only
TOTAL RETAINED HYDRO MW -excluding duplications and under construction						**1899**										
B: THERMAL AND COMBUSTION									(CF=75%)	(CF=75%)						
Olkaria ext - Geothermal	Kenya					35	245	245	5.62	5.62	2645	2009	Yes		Included	
Longonot Geothermal	Kenya					70	491	491	5.05	5.05	2352	2010	Yes		Included	
Suswa Geothermal	Kenya					70	491	491	5.05	5.05	2352	2012	Yes		Included	
Menengai Geothermal	Kenya					140	981	981	5.05	5.05	2352	2015	Yes		Included	
Mombasa - Gas/LNG steam (4$/GJ) -2units	Kenya					300	2102	2102	7.39	7.39	895	2015	Yes		Included	
Mombasa - Coal steam-2 units	Kenya					300	2102	2102	6.88	6.88	1678	2012	Yes		Included	
Mchuchuma - Coal steam	Tanzania					400	2803	2803	6.50	6.50	1909	2012	Yes		Included	
GT 60 MW- gas - generic x 4 units	Tanzania					240	1682	1682	3.84	3.84	591	2008	Yes		Included	
GT 60 MW- gas - generic x 2 units	Kenya					120	841	841	3.84	3.84	591	2008	Yes		Included	
CC 60 MW - gas /steam cycle x 2 units	Tanzania					120	841	841	5.13	5.13	1532	2008	Yes		Included	
CC 60 MW - gas cycle x 3 units	Tanzania					180	1261	1261	3.93	3.93	895	2008	Yes		Included	
Kivu methane engines 30 MW x 4 units	Rwanda/DRC					120	841	841	6.11	6.11	2505	2007	Yes		Included	
TOTAL THERMAL POTENTIAL MW - excludes later units at Mombasa						**2095**										
C: OTHER OPTIONS																
Wind energy conversion systems	**Generic**					**30**	63	63	8.33	8.33					Included	Preliminary info only

Committed / under construction

Retained for MCA

Excluded

Imports and interconnections not shown

Notes

Sites outside project area are not shown in list

Earliest on power refers to nominally in January of the year

MSD generic diesels in Rwanda, Burundi and Western Tanzania included in SSEA Stage I

because of urgency to eliminate load shedding; no additional such plants considered because of high cost

8 RETAINED OPTIONS

This chapter contains a tabulation of the options retained after the screening described in the previous chapter and a description of the main environmental and social issues affecting those options.

8.1 General Environmental and Social Issues of Retained Power Options

Power development options all have environmental and social impacts some of which are positive and some of which are negative. Table 8-1 provides an overview of the major impacts by technology.

As can be seen from this table, all options create employment, both during construction and during operation. Hydroelectric options tend to provide more employment than thermal options during construction; the reverse is generally true during the operations phase. This is a significant positive impact that applies to all options. In addition, several measures can significantly enhance local employment such as the preferential hiring of local workers, training programs, splitting contracts in order to allow smaller companies to bid, etc. It is, however difficult to indicate the relative benefit on the region of each individual option.

In addition, all power projects that are located in areas with no access to electricity facilitate rural electrification, which in turn allows for improved health and education services and more opportunities for business development. The options providing the greatest opportunities are the hydroelectric options and possibly geothermal options. Transmission lines also provide some such benefits.

Other positive impacts are specific to hydroelectric projects with a reservoir that offer opportunities for other uses such as flood control, irrigation, fisheries and water supply.

This chapter presents the environmental and social issues associated with the options retained at the end of the screening process. It also presents the specific mitigation measures that affect project design such as the release of a minimum flow in the bypassed river section of a hydroelectric development or air pollution abatement measures for thermal stations. Standard mitigation measures that could be used for the retained options are described in Appendix H. Information on the cost and technical characteristics of each option as well as references of consulted studies and reports can be found in Appendix I. Where an option offers greater benefits than others in the same technology, these are highlighted below.

Table 8-1 - Overview of Major Impacts by Technology

Positive Impacts	Negative Impacts
Hydroelectric Options[1]	
• Job creation during construction and during operation • Potential for multiple use of reservoir (flood control, irrigation, fisheries, water supply, etc.) • Open up remote areas to development o Economic activities o Tourism o Health services o Education services	• (Involuntary) displacement • Increased risk of waterborne diseases • Impacts on vulnerable minority groups • Proliferation of invasive aquatic vegetation • Impact on landscapes, cultural sites and tourism • Flooding of natural habitats and reduction of biological diversity • Modifications to hydrological regimes • Sedimentation, erosion and changes in water quality • Barriers to fish migration and river navigation • Greenhouse gases during first year of reservoir operation (if not run-off the river scheme)
Thermal Options	
• Job creation during construction and during operation	• Greenhouse gas emissions • Impacts on natural habitats and public health due to acid rain emissions and other pollutant emissions • Noise pollution • Waste disposal
Geothermal Options	
• Job creation during construction and during operation • Open up remote areas to development: o Economic activities o Tourism o Health services o Education services	• Possible contamination of soil and groundwater table • Possible emissions
Wind	
• Job creation during construction and during operation	• Land use conflicts • Impacts on landscapes • Noise pollution
Transmission Lines	
• Job creation during construction and during operation	• Land use conflicts • Impacts on landscapes

[1] International Energy Agency. 2000. *Hydropower and the Environment: Present Context and Guidelines for Future Action*. Volume II Main Report.

8.2 Hydroelectric Options

8.2.1 Bujagali Hydroelectric Development

The Bujagali hydroelectric project would be a run of river project with about 12 hours of pondage. It would be located on the Victoria Nile in Uganda, 8 km downstream of the existing Kiira/Owen Falls hydroelectric projects. The first phase of the project would involve the installation of four 50 MW turbines and provision for a later fifth unit[2]. An Environmental Impact Assessment has been completed and approved by the National Environment Management Authority of Uganda.

<u>Main Environmental Issues</u>

The creation of the reservoir would require 125 ha of land (75% agricultural land). The flooding of riverbanks and islands would result in loss of habitats for birds, bats and other animals. Mitigation measures (enhancement planting) are planned to compensate for impacts on Jinja Wildlife Sanctuary. There would be no additional impacts on water flows downstream (already influenced by the Owen Falls hydropower project). The project involves the loss of natural habitats of Bujagali Falls.

<u>Main Socio-economic Issues</u>

Resettlement in the project-affected areas has already been carried out. The flooding of Bujagali Falls would involve impacts on aesthetics, loss of tourism revenues and loss of white water rafting opportunity over 2.5 km from Bujagali Falls to Dumbbell Island. The majority of the rapids used for rafting are downstream of Dumbbell Island and would not be affected. Mitigation measures include the construction of a Cultural Centre, of a Visitors Centre and of launching facilities for white water rafting. The project would include the provision of potable water and of alternative boat launching sites to eight affected villages that will lose access to water. The creation of the pondage reservoir would involve a risk of increase of breeding sites for snail vectors of bilharzia. The development of snail colonies would have to be monitored.

8.2.2 Kabu 16 Hydroelectric Development

The 20 MW Kabu 16 hydroelectric project would be located in Burundi on the Kaburantwa River, 16 km above its confluence with the Ruzizi River. It would be a run of river project with hourly pondage.

<u>Main Environmental Issues</u>

The reservoir impact would be minimal due to its small area (14 ha) and volume. There would be a 3 km river stretch with reduced flow between dam and tailrace, which would require a minimum flow release. During the dry period of 5 months/year, flow and level variations would be experienced downstream in the river stretch between the tailrace and the Ruzizi River.

<u>Main Socio-economic Issues</u>

Some 75 persons (1995 estimate) would be displaced from the small head pond and project area. The construction of a 10.5 km road would provide better access to markets and services.

[2] Recent information (December 2006) suggests that the site will be developed in one stage only consisting of 5 x 50 MW units.

8.2.3 Kakono Hydroelectric Development

The 53 MW Kakono hydroelectric project would be located in Tanzania, on the Kagera River near the Uganda border, approximately 90 km to the west of the city of Bukoba and Lake Victoria. Part of the benefit of this option would be the provision of irrigation water.

Main Environmental Issues

The project would flood part of the Minziro Forest Reserve. The plant could provide daily peaking, with consequent downstream flow and level variations over 75% of the year.

Main Socio-economic Issues

The reservoir would be located in a medium population density area and could involve significant resettlement. Several potential irrigation areas near Kyaka exist.

8.2.4 Karuma Hydroelectric Development

The 200 MW Karuma hydroelectric project (previously named Kamdini) would be located on the Victoria Nile in Uganda, immediately upstream of the limit of Murchison National Park. It would be a run of river project with hourly pondage. An Environmental Impact Assessment has been completed and approved by the National Environment Management Authority of Uganda.

Main Environmental Issues

The reservoir impact would be minimal due to its small area (1.8 ha) and volume. There would be a 2.8 km river section with reduced flow between dam and tailrace. A flow of 50 m^3/s would be maintained in this river section. There would be no natural flow modification downstream from the outlet. About 7 hectares of terrestrial habitat would be lost.

Main Socio-economic Issues

The project would involve the resettlement of some 35 households. The project would entail a reduction of the visual amenity of Karuma Falls and of potential for tourism. There is no white water rafting opportunity in the impacted area. The construction of access roads (about 4.5 km) would provide better access to markets and services.

8.2.5 Masigira Hydroelectric Development

The 118 MW Masigira hydroelectric project would be located in Tanzania on the Ruhuhu River, 80 km to the east of Lake Nyasa. High erosion risk has been observed in the proposed reservoir area. The project would be located in a pristine environment rich in wildlife. Change in flow and nutrient transport could affect Nyasa Lake and its exceptionally rich biodiversity. As the project would be located in a low density population area, the resettlement issue is likely to be minor.

8.2.6 Mpanga Hydroelectric Development

The 144 MW Mpanga project would be located in Tanzania on the Mpanga River, 40 km downstream of the Lower Kihansi project. The project could affect the hydrology of the Mpanga River which flows in Kilambero, an important floodplain and Ramsar site. Annual flooding is a crucial factor in the maintenance of the wetland habitats and the fertility of the soils for vegetation and fisheries. No settlement or farmland would be affected by the reservoir.

8.2.7 Mutonga Hydroelectric Development

The 60 MW Mutonga hydroelectric project would be located on the Tana River in Kenya, immediately downstream of the Kiambere hydroelectric power plant. It would have pondage equivalent 6 days of full plant discharge.

Main Environmental Issues

With the creation of the reservoir, some 11 km^2 of terrestrial habitat would become lacustrine[3] habitats. Sediment trapping in the reservoir (at least some 5.5 million tonnes (Mt) per year) would lead to degradation of bottom life and productivity in the reservoir. Degradation of the riverbed downstream of the dam would affect river morphology, particularly in a 40 km reach downstream of Kora Rapids and the possible reduction of riverine forest area. Provision would be made to release sediments.

Main Socio-economic Issues

The project would involve the resettlement of some 1000 people from the reservoir area (estimate of people that would have been displaced in 2003). There would be a risk of increase of malaria and bilharzia.

8.2.8 Ruhudji Hydroelectric Development

The 358 MW Ruhudji hydroelectric project would be built on the Ruhudji River in Tanzania, approximately 70 km to the east of Njombe. The project would include a separate upstream reservoir.

Main Environmental Issues

The project would involve the modification of terrestrial to lacustrine habitats, especially in the Zanziberi storage reservoir. The total reservoir area would be 1560 ha. There would be a modification of hydrological and nutrient transport conditions in the stretch of river between the storage dam and the intake dam. The length of the bypassed river section between the intake dam and the tailrace would be approximately 15 km. A minimum water flow release would be required in that section. The project could affect the hydrology of the Ruhudji River which flows into Kilambero, an important floodplain and Ramsar site. Annual flooding is a crucial factor in the maintenance of the wetland habitats and the fertility of the soils for vegetation and fisheries.

Main Socio-economic Issues

The reservoir and bypassed river section would be located in a low population density area so the resettlement issue is likely to be minor. The construction of access roads would provide better access to markets and services.

8.2.9 Rumakali Hydroelectric Development

The 222 MW Rumakali hydroelectric project would be built on the Rumakali River in Tanzania, 85 km west of Njombe.

[3] "of, relating to, formed in or growing in lakes" such as deposits or fauna (Webster's Ninth New Collegiate Dictionary)

Main Environmental Issues

The creation of a 1320 ha reservoir would involve the modification of terrestrial to lacustrine habitat. There would be a 17 km river stretch with reduced flow between dam and tailrace, which would require the release of a minimum water flow. The project could entail a modification of water flows and levels in the wetlands downstream of the dam before Nyasa Lake. Modification of sedimentation patterns could also impact the exceptional biodiversity of the lake.

Main Socio-economic Issues

The creation of the reservoir would involve the flooding of agricultural land and of a village with 80 buildings. The storage reservoir would allow for a reduction of flood risks downstream. The construction of access roads would provide better access to markets and services.

8.2.10 Rusumo Falls Hydroelectric Development

The 61.5 MW Rusumo Falls hydroelectric project would be built on the Kagera River at the border between Rwanda and Tanzania. An optimization study is recommended during the stage of feasibility study.

Main Environmental Issues

Upstream flooding from the dam is estimated in the order of 400 km^2, which would include 125 km^2 of existing lake, 250 km^2 of existing wetlands and 15 km^2 of valley slopes. The reduction in downstream flood flows and levels could affect wetlands downstream, including in the Akagera National Park. The increased surface area of the reservoir (as compared to the lake) would result in an increase in evaporation; however, the current rate of evapotranspiration in the wetlands is estimated to be similar to the evaporation rate. Thus the net impact on loss of water is expected to be minimal. Greenhouse gas will be emitted following flooding of the reservoir, although the total quantity would be less than what would be theoretically expected from a new 400 km^2 reservoir because 125 km^2 are already a lake and another 250 km^2 is constituted of wetlands already emitting some GHG. The construction of the dam will have a positive impact on the water quality of the Kagera river by trapping an estimated 15 to 20% of the quantity of nutrients flowing into the system.

A run of river option would reduce the extent of the reservoir area. Whichever design option is selected care is needed to take account of the sedimentation issue.

Main Socio-economic Issues

Approximately 3000 persons may be affected and some displaced based on a rough estimate by SNC-Lavalin using the latest census data upstream of the dam. Increase in water areas upstream could increase health risks due to bilharzia and malaria.

8.2.11 Ruzizi III Hydroelectric Development

The 82 MW Ruzizi III hydroelectric project would be built on the Ruzizi River which forms the border between Rwanda and the Democratic Republic of Congo, 25 km downstream (south) of the outlet of Lake Kivu. The river flows into Lake Tanganyika which forms part of the Congo Basin.

Reservoir impact would be minimal due to its small area (10 ha) and volume. River flows would be diverted through the power facilities at all times except during floods, affecting

1 km of river (need for minimum flow release). Downstream flows may vary considerably during normal daily operation (from 50 to 175 m^3/s). The reservoir would be located in a low population density area. Population farther downstream would be affected by flow and level variations, and sedimentation could impact aquatic habitats and the high biodiversity of the lake.

8.2.12 Songwe Hydroelectric Development

The 330 MW Songwe hydroelectric development would comprise three dams and hydro plants in cascade on the Songwe River. The upper dam would be on the border between Tanzania and Malawi. The middle and lower dams would be in Malawi. The power projects would be part of an overall basin development plan for the stabilization of the Songwe River.

Main Environmental Issues

The creation of three reservoirs (total area: 5600 ha) would involve the loss of wetlands, the modification of terrestrial habitat to lacustrine habitats and a seasonal regulation of water flows that would modify sedimentation patterns in the lake and ultimately impact the lake's very high biodiversity. The bypassed river sections would total approximately 12.4 km (need for minimum flow release). There would be an increase in riverbank erosion downstream of the dams. Dams would block fish migration. The projects could involve encroachment in protected areas.

Main Socio-economic Issues

The two downstream reservoirs would be located in a high population density area and would involve significant population displacement. The presence of the reservoir would entail increased health risks (malaria and bilharzia). The project could generate significant flood control and irrigation benefits.

8.2.13 Upper Kihansi Hydroelectric Development

The Upper Kihansi hydroelectric development would comprise the construction of a storage dam to regulate flows to an existing downstream hydro project. The dam would be located on the Kihansi River in the Rufiji River basin, 12 km upstream of Lower Kihansi existing power project. The regulation of river flows would allow for an increase in the average annual generation of the existing plant by about 124 GWh.

The reservoir would possibly encroach on primary forest habitat. The project could regulate the flow of the Kihansi River, which flows into Kilambero, an important floodplain and Ramsar site. Annual flooding is a crucial factor in the maintenance of the wetland habitats and the fertility of the soils for vegetation and fisheries. Available documentation suggests that the project would not involve any population displacement. A 3 km road stretch would be flooded.

8.3 Gas-fired and Coal-fired Thermal Options

The main environmental and social issues of fossil-fuelled thermal stations are the following:

- Social and environmental impacts of climate change due to greenhouse gas emissions: coal plants have the highest emission factor, with twice the emissions of natural gas fired combined cycle plants.

- Impacts of acid rain due to sulphur dioxide (SO2) and nitrogen oxide (NOx) emissions: acid rain may affect the productivity of lakes, rivers and forests. The vulnerability of forests varies significantly depending on the types of soil involved. Coal and oil thermal stations are important contributors to acid rain. Natural gas, when considering the processing of fuel and NOx emissions, can also be a significant source of acid rain.

- Impacts on public health: NOx emissions, together with volatile organic compounds, lead to the formation of ground-level ozone. Ozone causes breathing problems, reduced lung function, asthma and reduced resistance to cold and other infections. SO2 emissions also cause permanent damage to lungs. Particulate matter emissions infiltrate into the respiratory system and may cause significant damage. The main sources of NOx emissions come from the transportation sector. However, any form of combustion can contribute significantly to ground-level ozone if it is located in a region with many other sources, such as in a major city.

- Impacts on land use, habitats and resources due to ash disposal in the case of coal-fired power plants: using coal with high ash content involves large areas for ash disposal (approximately 0.6 ha per MW).

Appendix H describes the available control technology for air pollution emissions as well as recommended maximum emissions levels.

8.4 Geothermal Power Options

Geothermal power stations, with appropriate siting and plant design, do not involve significant environmental and social issues. Atmospheric emissions from geothermal plants average only about 5% of the emissions from equivalent sized fossil fuel power plants. The actual land use for geothermal energy production is relatively small for both the fuel acquisition and the energy production. When they contain sulphur compounds, the re-injection of geothermal waters must be considered so as to avoid air pollution and impacts on lacustrine habitats. An appropriate disposal of solid waste coming from boreholes must also be included in project design.

8.5 Wind Power Options

Most impacts of wind power options can be minimized with an appropriate selection of the wind farm site that takes into account land tenure systems and land use conflicts, effects on landscapes and effects on wildlife. Main principles to be followed are described in Appendix F with regards to land use, noise, natural and biological resources, visual impacts and soil erosion.

8.6 Lake Kivu Methane Development

The Lake Kivu gas thermal plant would be located on the Rwanda side of Lake Kivu. Possible sites are at Kibuye and Kigufi. No significant negative impacts have been identified. Greenhouse gas and air pollutant emission will be comparable to a thermal power plant. There will be an expansion of oxygen bearing waters in Lake Kivu. Siting and design of plant must take into account potential land use conflicts and noise effects.

9 COMPARATIVE ANALYSIS OF POWER DEVELOPMENT OPTIONS

The options retained from the screening and described in Chapter 8 are presented with a description of the environmental and social issues associated with each one. In this chapter they need to be compared with each other. This is carried out using a multi-criterion analysis (MCA). The characteristic feature of MCA methods is the establishment of formal and to some extent quantified procedures for the following three phases of options assessment1:

- Identification of criteria, i.e. points of view or axes of preference according to which possible courses of action can be distinguished;
- Ranking, or more extensive evaluation, of alternative courses of action according to each identified criterion;
- Aggregation across criteria to establish an overall preference ranking for the alternatives.

There are a variety of MCA methods that define the procedures to be followed in each phase and several ways of classifying them. The following four methods or "schools" of methods can be considered: 1) value measurement, 2) goal programming and aspiration levels, 3) outranking methods and 4) ordinal methods. Each is summarized in Appendix J.

After examining various methods (as described in Appendix J), it was decided to rank options on the basis of a Multi-attribute method. This method is part of the value measurement category of MCA school of methods referred to by the World Commission on Dams. With this method, each option is scored against each criterion and not simply ranked from the most preferred to the least preferred. Percentage points are associated with each criterion as an indication of their relative importance (the sum of the weights must add to 100). The final value score of each option is obtained as a weighted average of the scores for the individual criteria.

9.1 Steps Involved in the Multi-Criteria Analysis Method

The five steps followed in the MCA method are described below.

9.1.1 Step 1: Identification of Evaluation Criteria and Indicators

Each power development option is evaluated against a set of criteria, i.e. points of view to be taken into consideration when comparing power options. One indicator will be associated with each criterion so as to guide the rating and the scoring of options. The list of criteria and indicators retained for the comparison of power options on the basis of the MCA method was based on three categories (cost, socio-economic and environmental) and 11 criteria, as presented in Figure 9-1. The list of criteria, indicators and project risks was validated with participants at the end of Fourth Stakeholder Consultation Workshop.

[1] Nichols, David and David Von Hippel (Tellus Institute, USA), Theo Stewart (University of Cape Town, South Africa). November 2000. Thematic Review. VI Planning Approaches. Chapter 4: Multi-Criteria Analysis Methods. Report Prepared for the World Commission on Dams.

Table 9-1 - Criteria and Indicators Used for the Comparison of Power Options on the Basis of the MCA Method

Criteria	Indicators
Category: Cost	
Economic Viability	Unit cost of firm energy per kWh over the projected life of the facility (US¢/kWh), taking into account: - Direct investment – plant - Engineering and owners costs - Interest during construction - Operating and maintenance costs - Environmental and social mitigation costs (included in the civil works contingency amount) - Multi-purpose benefits (irrigation, fisheries) – treated by cost sharing for the dam (unless a specific allowance has been included in the estimates, in which case that estimate is used) - Contingency allowance for uncertainties (e.g. technical, financial and geological risks)
Category: Socio-economic	
Impacts Due to Population Displacement	Number of persons affected by project infrastructure and ancillary facilities (People/GWh)
Promotion of Rural Electrification	Number of rural persons living in a 10 km radius of the power station and in a 10 km wide corridor along the transmission line between the option and the main transmission grid (People/GWh)
Socio-economic Impacts on the Downstream Reaches	Number of persons living in a 1 km corridor along the river stretch with altered flow downstream of the dam (People/GWh)
Land Issues	Area required for project infrastructure, including reservoir and transmission facilities (ha/GWh)
Category: Environment	
Impact on Resource Depletion	Energy payback ratio: ratio of energy produced during the normal life span of the option divided by the energy required to build, maintain and fuel the generation equipment. This indicator is a measure of the global pressure of an option on the environment
Impacts of Greenhouse Gas Emissions	Net CO_2 equivalent emissions over the life cycle of the project (t/GWh)
Impacts of Air Pollutant Emissions on Biophysical Environment	SO_2 equivalent emissions over the life cycle of the project (t/GWh)
Land requirements	Area required for project infrastructure, including reservoir and transmission facilities (ha/GWh)
Waste Disposal	Land area required for ash disposal (ha/TWh)
Environmental Impacts on the Downstream Reaches	Length of river with altered flow downstream of the dam (km/TWh)

The definitions of the selected Socio-economic and Environmental criteria are provided in Appendix J.

9.1.2 Step 2: Determination of the Relative Importance of Criteria

Within the Socio-economic and Environmental categories, weights are assigned to each criterion to reflect their relative importance using percentage points. Table 9-2 shows the weights assigned to the selected evaluation criteria. These weights were validated with participants at the end of the Fourth Stakeholder Workshop. In order to evaluate to what extent the results of the comparison of options on the basis of the MCA method are dependent on ascribed weights, sensitivity analyses were carried out on alternative sets of weights.

Table 9-2 - Weights assigned to Criteria Selected for the Comparison of Options on the Basis of the MCA Method

Criteria	Class of Importance	Weight (%)
Category: Cost		
Economic Viability		100
Category: Socio-economic		
Impacts Due to Population Displacement	Important	15
Promotion of Rural Electrification	Very important	35
Socio-economic Impacts on the Downstream Reaches	Important	15
Land Issues	Very important	35
Category: Environmental		
Impact on Resource Depletion	Important	25
Impacts of Greenhouse Gas Emissions	Less important	10
Impacts of Air Pollutant Emissions on Biophysical Environment	Less important	10
Land Requirements	Important	25
Waste Disposal	Less important	5
Environmental Impacts on the Downstream Reaches	Important	25

9.1.3 Step 3: Ranking of Options for Each Criterion

During this step of the comparative analysis, the performance of each option against each criterion is assessed according to quantitative indicators defined on the basis of ratio scales so as to measure the magnitude of impacts related to each criterion per unit of energy generated.

Under the Cost category, there is only one criterion: “Economic viability” with only one quantitative indicator: “Average cost per kWh over the projected life of the facility”. This indicator can thus be used directly for rating and ranking options in this category. This indicator includes a number of elements that must be factored into the cost assessment.

In the Socio-economic and Environmental categories, there are several criteria and indicators. In order to arrive at a ranking within each category, the indicators are represented in terms of numerical scores on an absolute scale from 0 (best) to 10 (worst). For each criterion, the best value (conceivable from a practical point of view regardless of whether or not such a value applies to any of the options in the list) for the selected indicator will be defined as 0 and the worst value (again from a practical point of view) will be defined as 10. All power options are then scored on a pro-rata basis using the numerical values of their indicators, as calculated for them. When an extreme value cannot be defined on the basis of existing literature on environmental and social impacts of electricity production options, the extreme value calculated for an option in the SSEA region is taken as a reference.

It is important to note that full Environmental Impact Assessments (EIAs) are available only for the Bujagali, Karuma and Mutonga hydropower projects. Preliminary EIAs are available for the Ruhudji and Rumakali hydropower projects[2]. In most cases, the evaluation of the performance of power options against criteria has been made on the basis of the following:

- Environmental impacts known to occur in similar projects;
- Internationally recognized mitigation measures;
- Information from government sources on environmental and socio-economic characteristics at country, province or district levels;
- Visits made by the consultant to the Rusumo Falls, Murchison Falls, Karuma and Ruzizi III Project sites;
- Information on technical characteristics of project components available in technical reports.

When information required for the evaluation of the indicators is not available, assumptions made are indicated at the bottom of tables presenting the detailed results of the comparative analysis shown in Appendix J. The Masigira, Mpanga and Upper Kihansi options could not be scored because the required information on technical characteristics of project components was not available in technical reports. For the latter project, some information on environmental and socio-economic impacts could be derived from the Lower Kihansi EIA report.

For air pollutant emissions, mitigation measures are explicitly taken into account when determining the value of the indicator for each option. For other indicators, it is assumed that internationally recognized mitigation measures are applied to all options, such as the implementation of a resettlement and rehabilitation plan or the release of a minimum water flow in a bypassed river section.

The indicators associated with each criterion are defined in Appendix J.

9.1.4 Step 4: Ranking of Options within Each Category of Criteria

Following the scoring of power options for each criterion, the options are subsequently ranked within the Socio-economic and Environmental categories on the basis of the weighted average of the scores for each individual criterion.

[2] BKS Acres. November 2003. The East African Power Master Plan Study. Draft Phase 1 Report. Appendix H. and SNC-Lavalin International/HQI. February 2005. Strategic/Sectoral, Social and Environmental Assessment (SSEA) of Power Development Options in Burundi, Rwanda and Western Tanzania, Final Report, Stage I. Chapter 6.

9.1.5 Step 5: Selection of Options to be Included

Comparisons across sets of evaluation criteria involve normative judgments (e.g. the importance of the Cost category of criteria relative to the Environmental category of criteria or Socio-economic category of criteria) and would be beyond the scope of this study. The cost ranking is used as a reference base for the discussion on the selection of options to be included in power development portfolios since dilemmas are generally raised as trade-offs to be made between least cost and other factors. When conclusions reached for the Socio-economic and Environmental categories of criteria differ from the cost ranking of power options, dilemmas raised are spelled out and analysed. In addition, inputs from the assessment of project risks are also considered and discussed in Section 10.

Consequently, options to be considered in power development portfolios will be identified on the basis of the following categories of considerations: 1) Cost criterion; 2) Socio-economic criteria; 3) Environmental criteria; 4) Project risks. On this basis, two groups of options to be considered in power development portfolios will be identified: 1) best evaluated options and 2) other options.

9.2 Ranking of Options

9.2.1 Technical Criteria

The following technical criteria have been taken into account in the analysis, although not as part of the ranking of options in this chapter of the report:

- Technology used: all proven technologies have been considered and those relevant to the region have been included. These include hydroelectric, geothermal, fossil-fuelled (coal, fuel oil, natural gas) heat recovery steam generators, simple cycle and combined cycle combustion turbines, diesel generators using various fuels, wind energy conversion systems, solar (photovoltaic) systems;
- Size of plant – one of the screening criteria;
- Time required to implement the option – taken into account in the preparation of power development portfolios;
- Synergies between technologies – taken into account in the system simulations when developing the portfolios and in the definition of development strategies.

9.2.2 Ranking on Economic Criterion

Table 9-3 presents the ranking of options for the Cost category of criteria, i.e. on the basis of unit costs for the electricity generated.

Figure 9-1 presents the results graphically using scores from 0 (best) to 10 (worst). A score of 0 corresponds to a cost of 1 ¢/kWh and a score of 10 corresponds to the cost of a diesel power plant (15 ¢/kWh).

Most hydroelectric options are below 4.32 ¢/kWh, including all options on the Victoria Nile. Thermal options using natural gas are also in this cost range. When considering unit costs above 4.32 ¢/kWh, the next best option – geothermal – is 17% more expensive. After this option come all other thermal options, Mombasa gas being the thermal option with the highest cost at 7.39 ¢/kWh. Finally, between 7.40 ¢/kWh and 8.68 ¢/kWh are the generic wind option and the last four hydroelectric options: Kabu 16, Kakono, Upper Kihansi and Mutonga.

9.2.3 Ranking on Social Criteria

Table 9-4 presents the summary results of the MCA in the Socio-economic category. Detailed results are provided in Appendix J, including results of the sensitivity analyses on the weighting of Socio-economic criteria. Figure 9-2 presents the results graphically using three different weightings: the base case as shown in Table 9-4, all criteria weighted equally and where the weightings have a wider spread. The weightings selected are shown below:

Criterion	Weighting		
	Equal	Base	Wider Spread
Population Displacement	25%	15%	10%
Rural Electrification	25%	35%	40%
Downstream Effects	25%	15%	10%
Land Issues	25%	35%	40%
	100%	100%	100%

The following options could not be scored because of insufficient information: Masigira, Mpanga and Upper Kihansi.

The main conclusions of the MCA for the Socio-economic category are the following:

- Over half of the options fall within a very narrow band of overall impact: between 3.3 and 3.6 out of 10. Most of the others rank even better.
- The score of better-ranked options is generally due to a higher potential contribution to rural electrification. In particular, Rusumo Falls, which is the option with the highest potential contribution to rural electrification, is at the third rank despite expected high land and resettlement requirements. Rusumo Falls is also strategically placed on the border between Rwanda and Tanzania close to Burundi and would contribute significantly to regional integration and stability.
- Songwe, with a score of 4.2, ranked last. It has higher land and resettlement requirements and offers little potential contribution to rural electrification.
- The Kivu methane engines option has a good overall performance with a score of 2.8. All other thermal options (including the geothermal option) have a score between 3.4 and 3.5 because of their lower potential contribution to rural electrification.
- With a score of 2.2, the generic wind option is the second best-ranked option. It has low land and resettlement requirements and offers an average potential contribution to rural electrification.

Two sensitivity analyses have been carried out on ascribed weights within the Socio-economic category. In the first sensitivity analysis, by giving equal weight to all criteria, less emphasis is put on rural electrification and land issues. In such a case, thermal options have a much better overall performance with scores between 2 an 2.5, while the Rusumo Falls option loses several ranks. Hydroelectric options that offer little contribution to rural electrification, such as options on the Victoria Nile, also have a much better overall performance.

Conversely, when more weight is put on rural electrification and land issues (40%) and less weight on population displacement and downstream impacts (10%), the gap between thermal options and the best-ranked hydroelectric options widens. Overall, such changes in weightings do not significantly change the above conclusions.

Table 9-3 - Ranking of Power Options on the Basis of Unit Costs (listed in order of increasing cost)

Options	Unit cost of FIRM energy over the life of the facility (US cents/kWh)
Ruzizi III	2.86
Mpanga	3.03
Songwe	3.43
Karuma	3.74
Ruhudji	3.74
GT 60 MW gas - generic x 4 units	3.84
CC gas x 3 units	3.93
Masigira	4.06
Rusumo Falls	4.14
Bujagali	4.24
Rumakali	4.32
Geothermal - Generic	5.05
Kivu methane engines 30 MW x 4 units	6.11
Mchuchuma - Coal steam	6.50
Mombasa - Coal steam	6.88
Mombasa - Gas/LNG steam	7.39
Kabu 16	7.40
Kakono (High)	7.67
Generic Wind 30 MW	8.33
Upper Kihansi (storage)	8.67
Mutonga	8.68

9.2.4 Ranking on Environmental Criteria

Table 9-5 presents the summary results of the MCA in the Environmental category. Detailed results are provided in Appendix J, including results of the sensitivity analyses on the weighting of Environmental criteria. Figure 9-2 presents the results graphically for the base case set of weightings as well as two sensitivity tests. The weightings selected are shown below:

Criterion	Weighting		
	Equal	Base	Wider Spread
Resource Depletion	19%	25%	30%
CO2 Emissions	19%	10%	5%
Air Pollutants	19%	10%	5%
Land Area	19%	25%	30%

Waste Disposal[3]	5%	5%	5%
Downstream Effects	19%	25%	25%
	100%	100%	100%

As for Socio-economic criteria, the following options could not be scored because of insufficient information: Masigira, Mpanga and Upper Kihansi.

The main conclusions of the MCA for the Environmental category are the following:

- Hydroelectric options on the Victoria Nile – Bujagali and Karuma – as well as Ruzizi III have a good performance with regards to Environmental criteria with scores between 0.1 and 0.3. All have a high energy payback ratio and relatively low land requirements and downstream effects.
- Another group of hydroelectric options – Ruhudji, Mutonga, Rumakali, Kakono, Songwe, Kabu 16 and Rusumo Falls – either have a lower energy payback ratio, higher land requirements or more significant downstream impacts. But they all have a fair overall performance with scores between 0.7 and 1.9.
- The geothermal option has a very good performance, similar to the best-scored hydroelectric options, because of its high energy payback ratio, low greenhouse gas and air pollutant emissions and its limited land requirements.
- Other thermal options, with scores between 3.1 and 4.5, are much less attractive because of their much lower energy payback ratio and higher greenhouse gas and air pollutant emissions. Coal-fired thermal options have the lowest ranked scores with respect to Environmental criteria.
- With a score of 2.3, the generic wind option is between the hydroelectric options and the thermal options. It has a very good performance against all criteria except for the energy payback ratio.

The above conclusions remain the same when more weight is given to important Environmental criteria or when all Environmental criteria are given equal weight (except for ash disposal which was kept at 5%).

[3] The land required for waste disposal is also included in the land area criterion. This criterion is included to account for the additional environmental impact waste disposal would have. Giving it too high a weighting would lead to double counting; hence the weighting was retained at 5% for all sensitivities.

Figure 9-1 - Comparison of Options on Basis of Economic Viability

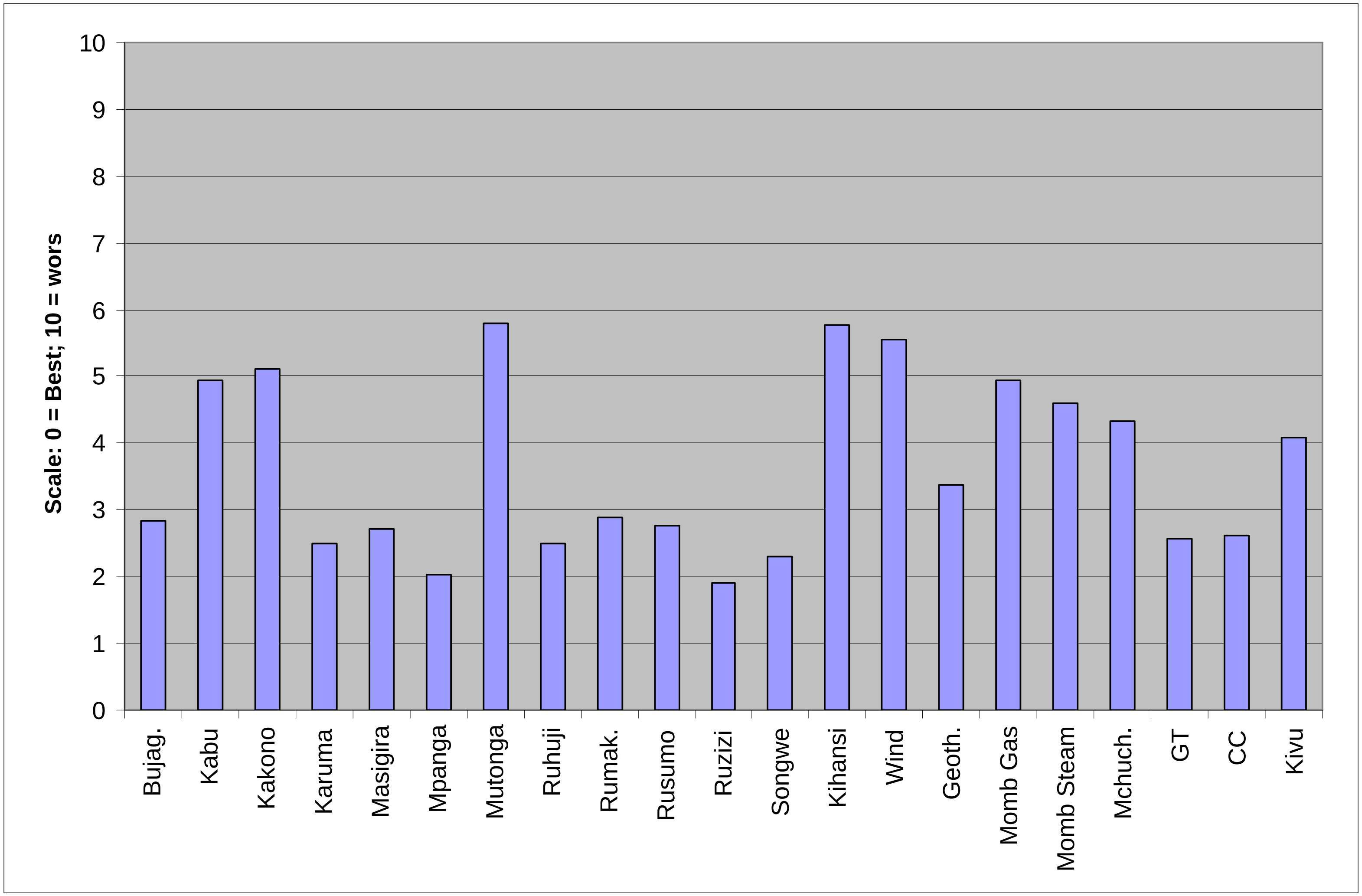


Table 9-4 - Ranking of Options within the Socio-economic Category (listed in order of increasing overall impact)

Options	Scores per Criterion				Final Score
	S1	S2	S3	S4	
Weighting	***15%***	***35%***	***15%***	***35%***	
Kabu 16	0.6	1.9	3.4	0.0	**1.3**
Generic Wind 30 MW	-	5.8	-	0.4	**2.2**
Rusumo Falls	5.0	-	1.1	3.9	**2.3**
Bujagali	-	7.0	0.0	0.0	**2.5**
Ruzizi III	-	5.8	3.8	0.0	**2.6**
Kivu methane engines 30 MW x 4 units	0.1	8.0	-	0.0	**2.8**
Kakono (High)	4.7	5.7	0.9	0.3	**3.0**
Karuma	0.1	9.3	0.0	0.0	**3.3**
Rumakali	1.0	9.0	0.5	0.1	**3.4**
Geothermal - Generic	0.0	9.8	-	0.0	**3.4**
Mchuchuma - Coal steam	0.2	9.8	-	0.0	**3.5**
Ruhudji	0.1	9.9	0.1	0.1	**3.5**
GT 60 MW gas - generic x 4 units	0.1	10.0	-	0.0	**3.5**
CC gas x 3 units	0.1	10.0	-	0.0	**3.5**
Mombasa - Gas/LNG steam	0.1	10.0	-	0.1	**3.5**
Mombasa - Coal steam	0.1	10.0	-	0.1	**3.5**
Mutonga	1.1	9.6	0.1	0.2	**3.6**
Songwe	4.5	8.3	3.4	0.3	**4.2**
Masigira	Insufficient data				
Mpanga	Insufficient data				
Upper Kihansi (storage)	Insufficient data				

S1: Impacts due to population displacement
S2: Promotion of Rural Electrification
S3: Socio-economic Impacts on the Downstream
S4: Land Issues

Figure 9-2 - Comparison of Options on the Basis of Socio-economic Issues

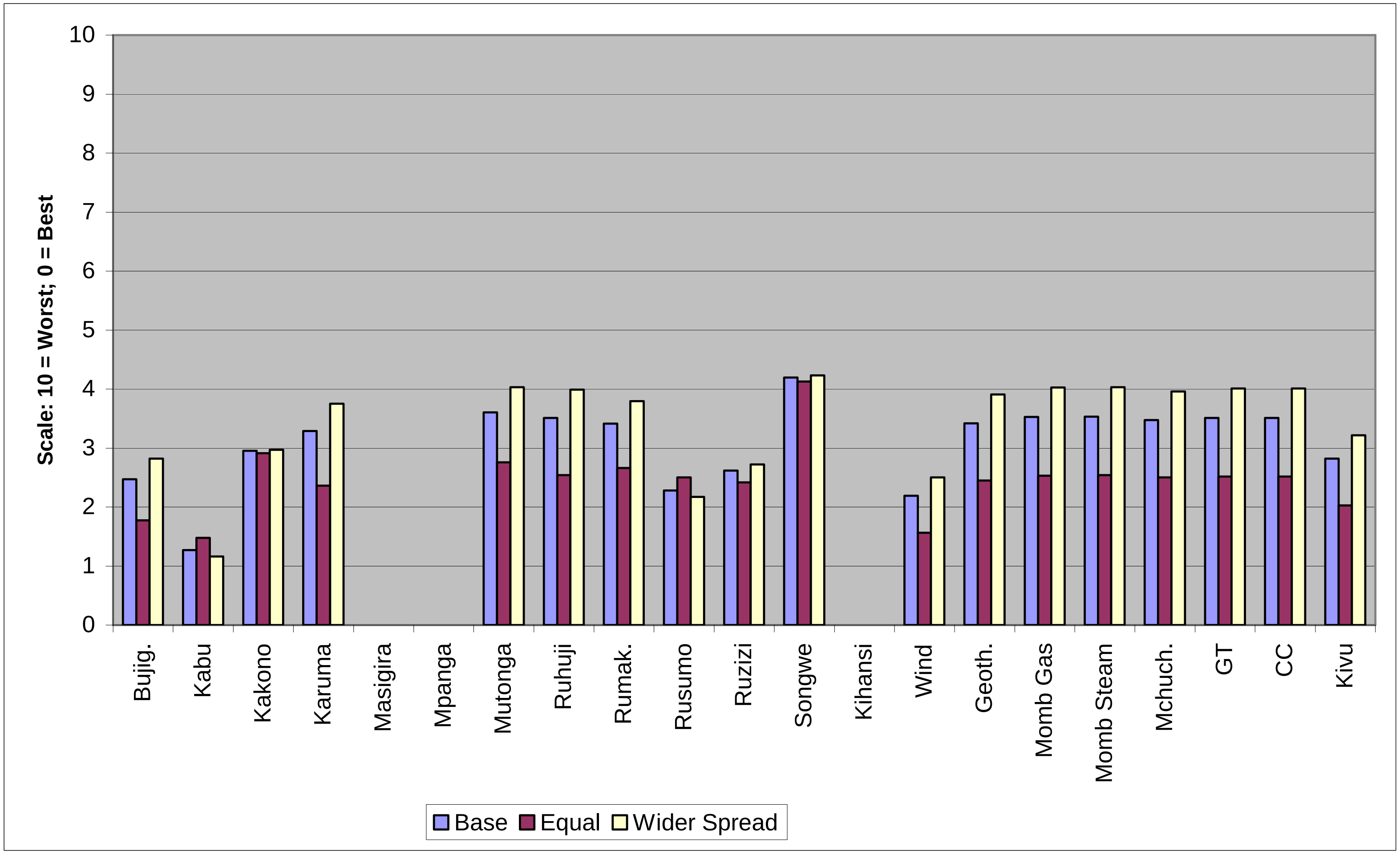
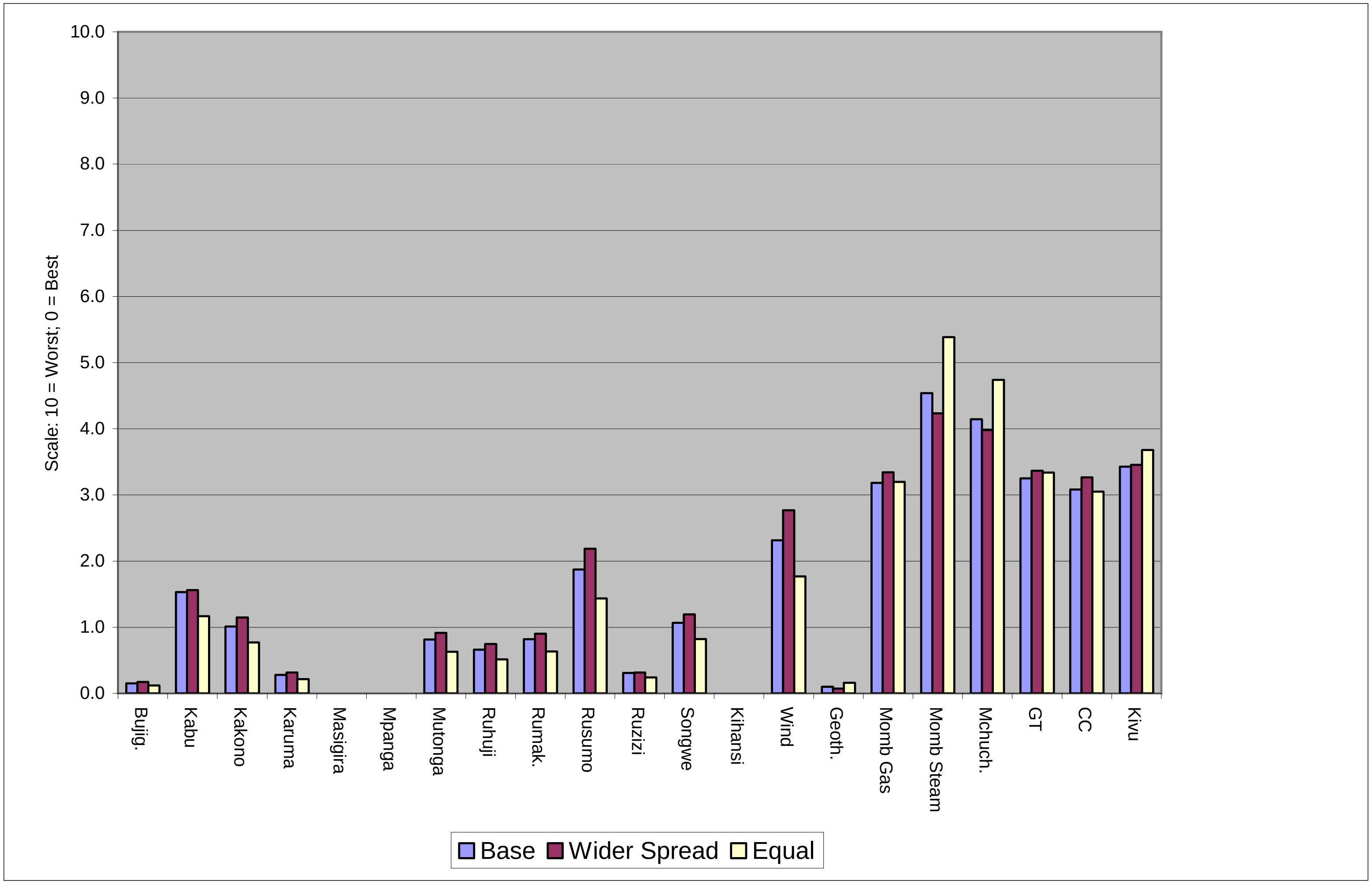


Table 9-5 - Ranking of Options within the Environmental Category (listed in order of increasing overall impact)

Options	Scores for Each Criterion						Final Score
	E1	E2	E3	E4	E5	E6	
Weighting	***25%***	***10%***	***10%***	***25%***	***5%***	***25%***	
Geothermal - Generic	0.11	0.72	-	0.01	-	-	**0.1**
Bujagali	0.37	0.04	-	0.03	-	0.20	**0.2**
Karuma	0.74	0.04	-	0.02	-	0.34	**0.3**
Ruzizi III	0.11	0.03	-	0.01	-	1.11	**0.3**
Ruhudji	1.67	0.09	-	0.06	-	0.88	**0.7**
Mutonga	1.86	0.09	-	0.19	-	1.17	**0.8**
Rumakali	1.67	0.09	-	0.08	-	1.49	**0.8**
Kakono (High)	2.42	0.04	-	0.32	-	1.29	**1.0**
Songwe	2.42	0.09	-	0.25	-	1.57	**1.1**
Kabu 16	0.56	0.03	-	0.04	-	5.52	**1.5**
Rusumo Falls	2.42	0.09	-	3.90	-	1.15	**1.9**
Generic Wind 30 MW	8.77	0.09	-	0.45	-	-	**2.3**
CC gas x 3 units	9.85	3.65	2.54	0.00	-	-	**3.1**
Mombasa - Gas/LNG steam	9.96	4.02	2.80	0.05	-	-	**3.2**
GT 60 MW gas - generic x 4 units	9.94	4.47	3.15	0.00	-	-	**3.2**
Kivu methane engines 30 MW x 4 units	9.93	5.27	4.15	0.02	-	-	**3.4**
Mchuchuma - Coal steam	9.85	7.67	5.53	0.05	7.00	-	**4.1**
Mombasa - Coal steam	9.94	10.00	6.08	0.06	8.60	-	**4.5**
Masigira	Insufficient Data						
Mpanga	Insufficient Data						
Upper Kihansi (storage)	Insufficient Data						

E1: Impact on Resource Depletion
E2: Impacts of Greenhouse Gas Emissions
E3: Impacts of Air Pollutant Emissions on Biophysical Environment
E4: Land Requirements
E5: Waste Disposal
E6: Environmental Impacts on the Downstream Reaches

Figure 9-3 - Comparison of Options on the Basis of Environmental Issues



10 RISK ANALYSIS

10.1 Introduction

The purpose of this chapter is to identify and assess the risks that a power development option might face that would result in its performance being different from that planned (costs higher or lower than estimated, output higher or lower than expected, on-power date earlier or later than expected, etc.). During the review of power development options in Chapter 7 several such risks were identified:

- Risks of opposition from internal and external groups;
- Risks related to institutional and legal frameworks;
- Increased risks to public health;
- Risks to designated habitats or natural sites;
- Risks to sites of exceptional biodiversity value;
- Risks in the use of resources;
- Risks of sedimentation;
- Gestation period in delivering benefits;
- Hydrological risk; and
- Financial risk.

Each of these elements of risk is discussed below.

It should be noted that all of the risks being evaluated in this section are, by their very nature, unquantifiable. In particular, they include environmental and social issues that cannot be readily quantified and could not be considered in the MCA. This distinguishes this section from the preceding one on the comparison of alternatives based on the multi-criteria analysis using ratio scales on quantified indicators.

10.1.1 Opposition from Pressure Groups

The risk of attracting opposition from external groups is affected by, among other reasons, (1) the need for resettlement of populations (even though the cost estimates include an allowance to compensate people who are displaced and the multi-criterion analysis includes a criterion for the number of people displaced normalized to eliminate the effect of size of project, it is the Consultant’s opinion that significant population displacement could attract opposition from social NGOs), (2) impacts on unique habitats (such as National Parks, Ramsar sites, exceptional biodiversity sites, etc.) or on scenery of exceptional beauty, as a result of reservoir impoundment or hydraulic modifications downstream of the dam, (3) the potential for significant increased risks to public health (malaria and bilharzia for hydroelectric projects and pulmonary diseases for thermal projects), (4) potential impacts on cultural, historical and religious sites, and (5) potential impacts on indigenous communities.

10.1.2 Institutional and Legal Framework

Risks related to the legal and regulatory framework in each of the countries in the region are primarily affected by (1) projects located in a country with a weak framework or one whose framework has been affected by recent social unrest, (2) projects that have a direct impact on two or more countries and (3) projects located in a national park or natural reserve with a similar status.

10.1.3 Public Health

For thermal options, increased risks to public health are related to nitrogen oxides (NO_x) emissions, sulphur dioxides (SO_2) emissions and particulate matter emissions. NO_x

emissions, together with volatile organic compounds, lead to the formation of ground-level ozone. Ozone causes breathing problems, reduced lung function, asthma and reduced resistance to cold and other infections. SO_2 emissions also cause permanent damage to lungs. Particulate matter emissions infiltrate into the respiratory system and may cause significant damage, especially PM10 or particulate matter up to 10 micrometers in size. Risks to public health are considered to be higher for the Mombasa coal-fired steam plant: air pollutant emissions from this plant, together with air pollutant emissions from other sources in the Mombasa region, could generate a risk of increase of pulmonary diseases.

For hydroelectric options, the presence of the reservoir and changes in water flows downstream of the dam may provide favourable habitats to vectors of waterborne diseases, in particular malaria and bilharzias (or schistosomiasis). Risks to public health are considered to be higher for Rusumo Falls and Kakono because these projects would entail an increase of bilharzia related to water hyacinth accumulation in the reservoir. The Songwe option also involves risks of increase of bilharzia in the reservoirs and in irrigation zones.

10.1.4 Risks to Designated Habitats or Natural Sites

The assessment of this risk factor is based on the following three indicators:

- Projects affecting a National Park or a Ramsar site downstream of the dam: a Ramsar site is designated under the Convention on Wetlands, signed in Ramsar, Iran, in 1971. This Convention is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.
- Projects affecting important scenic area.
- Projects affecting other important habitats, such as important wetlands other then Ramsar sites or forest reserves.

10.1.5 Risk to Sites of Exceptional Biodiversity Value

The region, particularly the Lake Nyasa/Malawi, the Lake Tanganyika and several mountain ranges surrounding the Great Lakes, are renowned for their exceptional biodiversity. These areas contain several hundreds of endemic species (fish, amphibians, reptiles, birds, plant) that are not found anywhere else, many in a precarious situation because of a number of threats.

10.1.6 Use of Local Resources

A hydroelectric plant uses the natural resources of a country and these resources are, in principle, renewed continuously.

A class of risk that also needs to be considered is the risk associated with the supply of fuel for the plant and the control that a country has over the fuel that is used in a power plant. A thermal plant using imported fuel (oil, gas or coal) is at the mercy of policies of foreign governments or of international market forces, which can have a significant impact on the cost and availability of power.

Between these two extremes are plants that use local but finite resources, such as coal. The supply of methane gas from Lake Kivu and geothermal energy might also be considered as a local but finite resource.

10.1.7 Risks of Sedimentation

Studies by Electrowatt and Norconsult in December 1975 indicate that the sediment load in the Ruvuvu and Kagera Rivers is less than 100 grams per cubic metre[1]. However, site visits in the rainy season indicate that the sediment load of Kagera River is now more significant. It was thus rated with some sedimentation risk. This risk is considered for all power development options.

10.1.8 Gestation Period

There are two technical risks associated with an option that can be considered together; one is related to the amount and reliability of the data available for an option and the other is its size. Both of these affect the time required to implement an option.

10.1.9 Hydrological Risks

The energy potential of a hydroelectric scheme is calculated from the historical hydrologic record obtained at the site, or a synthetic record based on historic records. This assumes that the hydrological pattern that will be observed in the future will be similar to the hydrological pattern observed in the past, and that the hydrological record available is accurate and representative.

Most of the power development options that were identified in Section 6 are hydro-electric. Systems relying solely or principally on hydro options are open to the risk of droughts that could be more severe than experienced historically, which could, in turn, lead to either occasional power shortages or excess investment in generation to reduce these risks. For this reason, prudent planning suggests that technological diversification of power development options should be considered in the development of generation expansion portfolios

10.1.10 Financial Risks

Financial risk can be considered at two levels: (1) the risk of not being able to attract sufficient financing and (2) the risk of financial over-runs.

10.2 Overall Assessment of Risk

It would be convenient if an overall assessment of risk could be assigned to each option. However, there are two difficulties associated with that desire:

- These risks cannot be quantified;
- The relative importance of each risk is subjective; each analyst is likely to assign different weighting to each risk.

An attempt is made at providing an overall assessment of risk using the following approach:

1. Each option is assigned a subjective score on the scale of 0 (best) to 10 (worst) for each of the following risks:
    - Risks of opposition from external groups;
    - Risks related to institutional and legal frameworks;

[1] By way of comparison, a river with a heavy sediment load can have a concentration of 1000 g/m^3.

- Increased risks to public health;
- Risks to designated habitats or natural sites;
- Risks to sites of exceptional biodiversity value;
- Risks in the use of resources;
- Risks of sedimentation;
- Gestation period in delivering benefits;
- Hydrological risk;
- Financial risk.

2. Because the values assigned to the different risk factors are not ratio data and lack reliability, it is not appropriate to calculate an overall weighted average risk score and conduct sensitivity tests. An un-weighted average risk score is thus only presented.

The detailed tables showing the risk factors used, their indicators and the values selected for each indicator are shown in Appendix J. Table 10-1 summarizes these tables. Figure 10-1 presents the results graphically.

It should be noted that the data available for the Masigira, Mpanga and Upper Kihansi options was less than for the other options.

The results of the above analysis indicate that:

Of the 21 options evaluated five had scores under 2.5, eleven had scores between 2.5 and 3.5 and five had scores above 3.5 (up to 4.7).

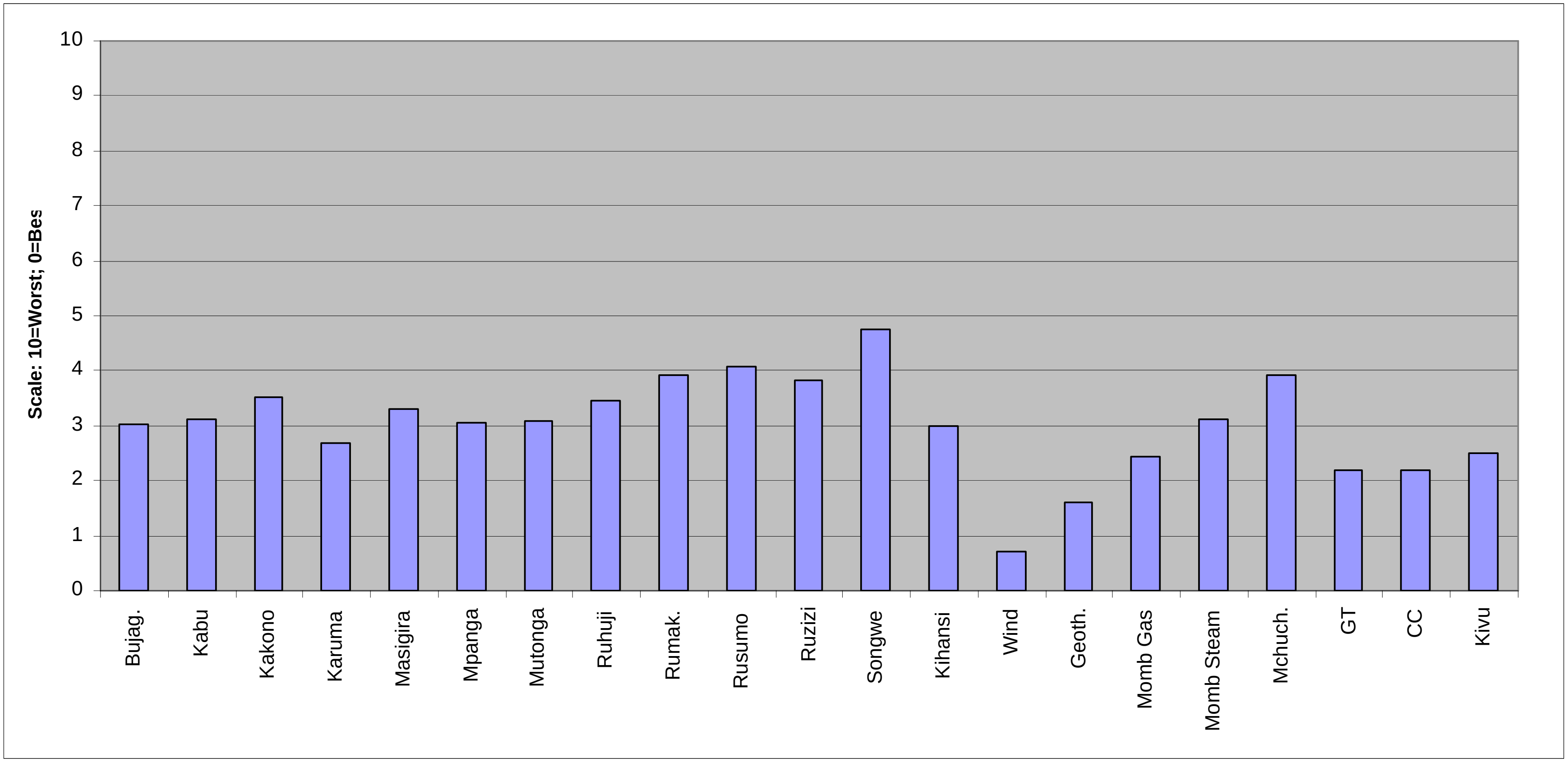
- The band indicates that, overall, most options have low risks, even though each option has its risky features.
- All options have a relatively high financial risk: between 6.2 and 8.0.
- There are two hydroelectric options with a risk score exceeding 3.5 out of 10: Rusumo Falls at 4.1 and Songwe at 4.2.
  - Both have significant risk of opposition.
  - Songwe has a long gestation period.
  - Rusumo Falls and Songwe seem to have increased risks to public health.
  - Rusumo Falls may have risks to designated habitats or natural sites.

Table 10-1 - Ranking of Power Options on the Basis of Risks (listed in order of increasing risk)

Options	Scores for Each Criterion										Final Score
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	
Weighting	***10%***	***10%***	***10%***	***10%***	***10%***	***10%***	***10%***	***10%***	***10%***	***10%***	
Generic Wind 30 MW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	6.2	0.7
Geothermal - Generic	0.0	0.0	1.0	0.0	2.0	3.0	0.0	3.8	0.0	6.2	1.6
GT 60 MW gas - generic x 4 units	0.0	0.0	1.0	0.0	5.0	9.0	0.0	0.8	0.0	6.3	2.2
CC gas x 3 units	0.0	0.0	1.0	0.0	5.0	9.0	0.0	0.8	0.0	6.3	2.2
Mombasa - Gas/LNG steam	0.0	0.0	1.0	0.0	2.0	9.0	0.0	6.2	0.0	6.2	2.4
Kivu methane engines 30 MW x 4 units	0.0	5.0	1.0	0.0	8.0	3.0	0.0	0.0	0.0	8.0	2.5
Karuma	3.0	0.0	3.0	0.0	4.0	0.0	1.0	5.4	4.0	6.4	2.7
Upper Kihansi (storage)	3.0	0.0	1.0	5.0	5.0	0.0	2.0	4.6	3.0	6.3	3.0
Bujagali	5.0	0.0	3.0	3.0	4.0	0.0	1.0	3.8	4.0	6.4	3.0
Mpanga	5.0	0.0	1.0	3.0	5.0	0.0	2.0	5.4	3.0	6.3	3.1
Mutonga	5.0	0.0	1.0	5.0	2.0	0.0	4.0	4.6	3.0	6.2	3.1
Mombasa - Coal steam	5.0	0.0	5.0	0.0	2.0	9.0	0.0	3.8	0.0	6.2	3.1
Kabu 16	3.0	0.0	1.0	3.0	8.0	0.0	2.0	3.8	3.0	7.3	3.1
Masigira	3.0	0.0	1.0	3.0	10.0	0.0	2.0	4.6	3.0	6.3	3.3
Ruhudji	7.0	0.0	3.0	3.0	5.0	0.0	2.0	5.4	3.0	6.3	3.5
Kakono	9.0	0.0	5.0	3.0	4.0	0.0	2.0	3.8	2.0	6.3	3.5
Ruzizi III	3.0	5.0	1.0	3.0	8.0	0.0	2.0	5.4	3.0	8.0	3.8
Mchuchuma - Coal steam	7.0	0.0	5.0	0.0	10.0	7.0	0.0	3.8	0.0	6.3	3.9
Rumakali	5.0	0.0	3.0	3.0	10.0	0.0	2.0	6.9	3.0	6.3	3.9
Rusumo Falls	9.0	3.0	5.0	5.0	4.0	0.0	2.0	3.8	2.0	6.7	4.1
Songwe	9.0	3.0	5.0	3.0	10.0	0.0	2.0	6.2	3.0	6.3	4.7

Notes:
Criterion 1: Risks of opposition from external groups
Criterion 2: Risks related to institutional and legal frameworks
Criterion 3: Increased risks to public health
Criterion 4: Risks to designated habitats or natural sites
Criterion 5: Risks to sites of exceptional biodiversity value
Criterion 6: Risks in the use of local resources
Criterion 7: Risks of sedimentation
Criterion 8: Gestation period in delivering benefits
Criterion 9: Hydrological risk
Criterion 10: Financial risk

Figure 10-1 - Comparison of Options on the Basis of Risks



11 RANKING OF OPTIONS

11.1 Introduction

Chapter 8 provides a tabulation of all of the power development options that were retained after the screening analysis. These options were then compared using a multi-criterion analysis based on the categories of cost, environmental issues and socio-economic issues in Chapter 9. The various risks associated with each of these options was then analyzed in Chapter 10. In this chapter 11, these elements are brought together to arrive at a ranking of the options.

11.2 Dilemmas Raised by Environmental and Socio-economic Considerations and by Project Risks

Figure 11-1 presents graphically the scores obtained by each option against Cost, Socio-economic and Environmental criteria and project risks.

The following dilemmas are raised when comparing the cost ranking with the above results of the MCA within the Socio-economic and Environmental categories, and when taking into account the assessment of project risks:

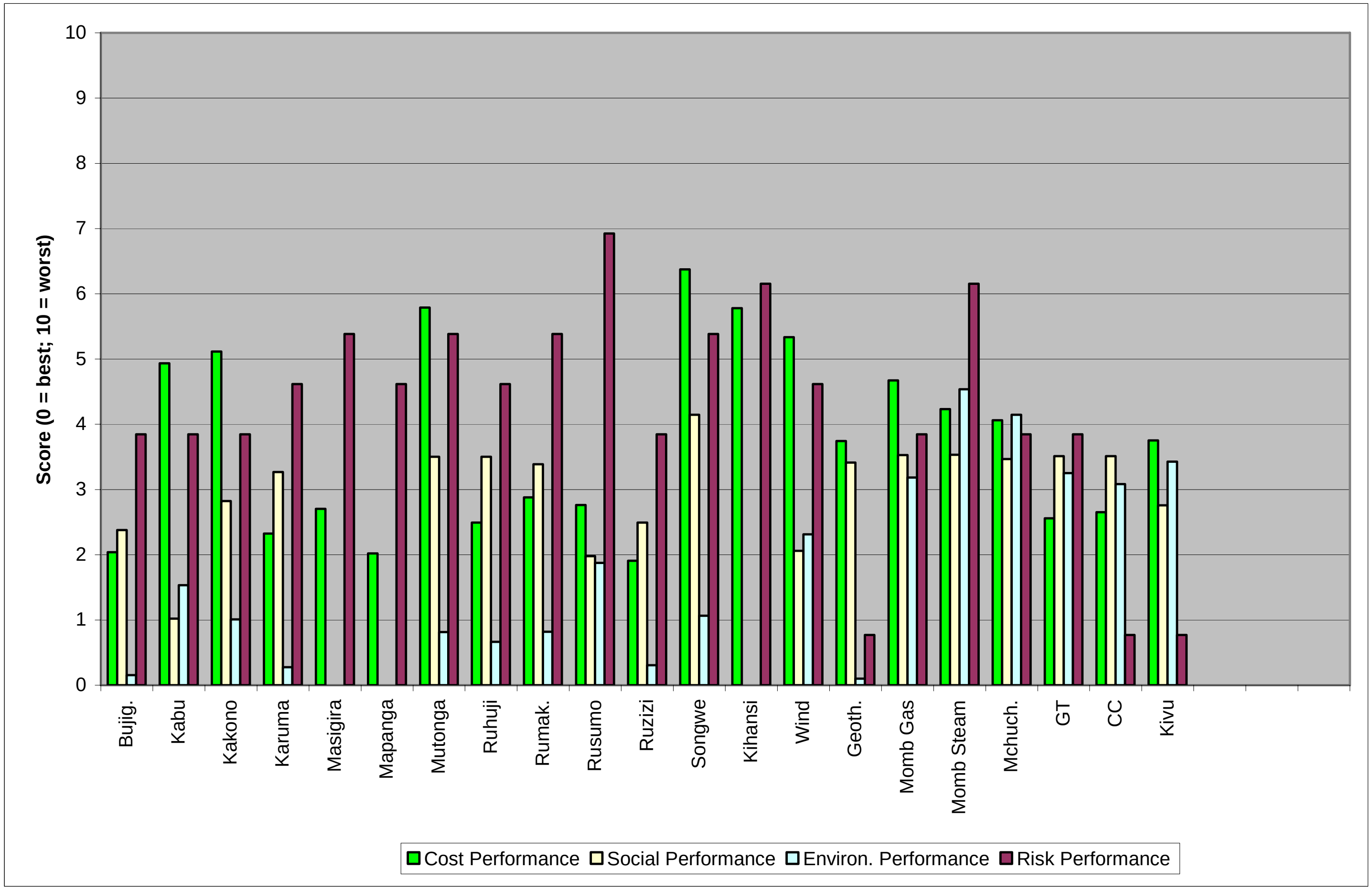
- All run-of-river hydroelectric options – Mutonga, Ruzizi III, Bujagali, Karuma, Ruhudji, Kabu 16 and Kakono – have a good performance with regards to Socio-economic and Environmental criteria and, except for Kabu 16 and Kakono, are among the least-cost options. However, results from the project risks assessment raise dilemmas concerning the following options:
  - Bujagali (at 3.98 ¢/kWh) in Uganda would affect scenery that is considered to be of exceptional beauty with high tourism potential. The cumulative impact of developing the option on aesthetics, natural heritage and tourism would be potentially significant though tourism impacts are expected to be mitigated by reorienting existing and initiating new activities at nearby sites.
  - Mutonga in Kenya has a good overall performance against risks as well as Socio-economic and Environmental criteria. However, it has the highest unit cost among all options at 8.68 ¢/kWh.
  - Ruzizi III is the second lowest unit cost option (at 2.86 ¢/kWh). However, it may involve risks with regards to the need to negotiate an agreement between Burundi, Rwanda and the D.R. of Congo prior to its development (note that such agreements are already in place for Ruzizi II but there are some unresolved issues associated with that agreement which could impact any negotiations regarding Ruzizi III).
- Hydroelectric options with seasonal regulation provide more power benefits than run-of-river options but they also raise the following dilemmas:
  - Songwe, at the border of Tanzania and Malawi, also has a relatively low unit cost (3.43 ¢/kWh) and flood control and irrigation benefits. However, it has significant resettlement and land requirements and it involves risks related to the need to negotiate an agreement between Tanzania and Malawi.
  - Rusumo Falls, at the border of Rwanda and Tanzania near Burundi, with a unit cost of 4.14 ¢/kWh, is expected to have high land and resettlement requirements. It may also pose problems associated with the proliferation of water hyacinths, increased waterborne diseases and downstream impacts on the Akagera National Park. It may also involve risks related to the need to

negotiate power sharing agreements between Burundi, Rwanda and Tanzania.

- The geothermal options considered in Kenya are the second best ranked option against Environmental criteria and risks. Except for its limited contribution to rural electrification, it also scores high against Socio-economic criteria. However, this option has a relatively high unit cost of 5.05 ¢/kWh.
- The generic wind option has a very good performance against Socio-economic criteria and risks and has a fair performance against Environmental criteria. However, it also has a relatively high unit cost of 8.33 ¢/kWh.
- The Kivu methane engines option performs well against Socio-economic criteria but has a higher unit cost of 6.11 ¢/kWh, and a low energy payback ratio.

Existing information does not allow for scoring the Mpanga and Masigira hydropower options in Tanzania (which have low unit costs of 3.03 ¢/kWh and 4.06 ¢/kWh, respectively) against Socio-economic and Environmental criteria. However, conclusions of feasibility studies for hydropower projects (Tanesco, March 1997) indicate that these options have potentially low socio-economic and environmental impacts. The same studies also consider the Upper Kihansi hydropower option (at a higher unit cost of 8.67 ¢/kWh) as a low impact option. It has not been possible to confirm this evaluation in the context of the present SSEA due to insufficient data.

Figure 11-1 - Comparison of Options on the Basis of Cost, Socio-economic, Environmental and Risk Issues



11.3 Ranking of Options

On the basis of the above analysis of dilemmas, two groups of options to be considered in power development portfolios can be identified: 1) best evaluated options and 2) other options, as presented in Table 11-1. In each group, options are listed in order of increasing cost.

Table 11-1 - Options to be considered in Power Development Portfolios (listed in order of increasing unit cost)

Best Evaluated Options	Other Options
Ruzizi III Karuma Ruhudji Gas Turbine 60 MW gas - generic x 4 units Combined Cycle gas x 3 units Bujagali Rusumo Falls Rumakali Geothermal – Generic Kivu methane engines 30 MW x 4 units Mombasa – LNG Kabu 16 Kakono Generic wind Mutonga	Mpanga Songwe Masigira Mchuchuma – Coal steam Mombasa - Coal Upper Kihansi

The rationale for the allocation of each option to each group is presented below.

11.4 Best evaluated options

Rusumo Falls is strategically placed in the region to: a) strengthen, electrically, the backbone transmission system required for the benefits of regional power planning to be enjoyed by all parties and b) meet the new loads from the mines in the Kagera District that are being implemented. However, Rusumo Falls has a relatively high risk score of 4.1. Environmental impact studies are required to better assess its environmental issues, especially with regards to potential downstream effects and the impacts of the creation of a reservoir that include some 250 km^2 of wetlands. In particular, its project design could be re-evaluated so as to minimize reservoir impacts on natural habitats; operation rules could be determined so as not to alter riverine habitats in the Akagera National Park; a mitigation plan should be developed to control risks of increase of malaria and bilharzia. A resettlement and rehabilitation plan is also required. Finally, a power sharing agreement between Burundi, Rwanda and Tanzania will also have to be negotiated, possibly within the framework of the Kagera River Basin Integrated Water Resources Management Project[1].

Bujagali, Karuma, Ruhudji and Rumakali do not raise significant dilemmas and can be considered among the best evaluated options.

[1] WSP and International Sweden AB in association with BCEOM and ERM. August 2003. *Kagera River Basin Integrated Water Resources Management Project*.

The following options have a relatively overall good score (better than 3.6) against risks as well as Socio-economic and Environmental criteria. Since their cost is less than the threshold value of 10 ¢/kWh, they can be considered among the best evaluated options, assuming that the dilemmas they raise can be resolved satisfactorily:

- **Ruzizi III:** an agreement between Burundi, Rwanda and the D.R. of Congo for the development of this option could be reached on the basis of the SINELAC experience.
- **Kabu 16** and **Kakono**: both options have a higher unit cost but they have a very good performance against Socio-economic and Environmental criteria. Besides, Kakono could incorporate an irrigation component.
- **Mutonga**: this option has the highest unit cost among screened options. It can be considered in the longer term but would require additional studies with regards to sediment trapping and downstream effects and the definition of reservoir operation rules taking into account power generation and controlled release of downstream floods.
- **Gas fired thermal stations** (including Kivu methane engines): despite their lower rank against Environmental criteria, these options are the best ranked options among fossil-fuelled options and they have a good performance against project risks.
- **Geothermal** and **wind** options: despite a higher unit cost, these options can be considered among the best evaluated options because of their good performance with regards to project risks, Environmental criteria and Socio-economic criteria (except for their limited contribution to rural electrification).

11.5 Other options

Other options include:

- **Songwe**: the irrigation and flood control benefits of Songwe could justify the development of this option provided it incorporates a well designed resettlement and rehabilitation plan and an agreement can be reached between Tanzania and Malawi.
- **Coal-fired thermal options**: with unit costs of more than 6 ¢/kWh, these options have the highest greenhouse gas and air pollutant emissions among the considered options. Besides, the Mombasa - Coal steam option in Kenya could have significant impacts in relation to increased risks of pulmonary diseases.
- **Mpanga, Masigira and Upper Kihansi**: these hydropower options have been included under other options as existing information does not allow to properly assess their socio-economic and environmental impacts and related project risks.

12 POTENTIAL IMPACT OF CLIMATE CHANGE ON RUNOFF

12.1 Introduction

The power development options, that have been retained from the database of all those identified, have certain characteristics whose values have been estimated based on historic information. This applies particularly to the energy output from hydroelectric options. This output is a direct function of the amount of water that flows through their turbines for conversion to electricity. There is strong evidence indicating that the climate is changing and that these changes can be significant over time. It is therefore appropriate to assess what these changes are likely to be in the region and to estimate their impact on the output of the options retained for use in this strategic assessment of power development options.

This chapter provides an assessment of the potential impacts on hydroelectric generation that could result from climate change, and consequently whether any such impacts could affect the selection and scheduling of new power options in the portfolios being evaluated in the SSEA study. The objective was not to define whether global warming will take place, but rather to use the results of existing analyses and predictions in a risk analysis to define whether the selection and timing of new power options in the preferred portfolios would be affected, if any such plausible changes from climate change were to be accepted for planning purposes.

This risk analysis may be described in terms of two components:

- Identification of plausible predictions of potential climate change in the region, based on analysis of results from existing climate change models;
- Conclusions on possible impacts of climate change on net water yield (runoff), and thus generation, on the new hydro options in the NELSAP region, that make up the preferred portfolios.

An indicative expansion plan (see the next chapter) includes the hydroelectric sites shown in Table 12-1:

Table 12-1 - New hydro options in the indicative plan

Year	Project	River	Country	MW
2012	Bujagali 1-4	Nile	Uganda	200
	Rusumo Falls	Kagera	Burundi/Rwanda/Tanzania	62
2013	Kabu 16	Kaburantwa	Burundi	20
2014	Bujagali 5	Nile	Uganda	50
	Ruzizi III	Ruzizi	Rwanda/DRC	82
2015	Ruhudji	Ruhudji	Tanzania	358
2017	Karuma	Nile	Uganda	200
2020	Rumakali	Rumakali	Tanzania	222

Figure 12-1 shows the general location of the above projects. (Note these areas cover sites of the above projects, and not their river basins).

12.2 Methodology Outline

The approach taken in the climate change analysis consists of two parts – climate change analysis to propose potential values for temperature and precipitation change (this section 12.2) and runoff analysis to provide corresponding estimates of changes in net water yield or runoff (section 12.4). This work was undertaken by the Stratus Consulting team of Joel Smith and Prof. Kenneth Strzepel (University of Colorado). The complete report on this study[1] is provided in Appendix J.

12.2.1 Time Frame and Emission Scenarios

The proposed time frame of the assessment is from 2000, i.e., current conditions, to 2100 (beyond the economic life of existing and planned projects). Predictions for temperature, precipitation, and consequent runoff changes were made for the years 2050 and 2100.

Models generally link potential temperature change (and thus precipitation and evaporation change) to anthropogenic (CO_2) emissions. The Intergovernmental Panel on Climate Change (IPCC) has proposed a number of economic development scenarios, with corresponding emission levels, which have been used as the basis for climate change predictions[2] [3]. Global values for the most commonly used scenarios are shown in Table 12-2:

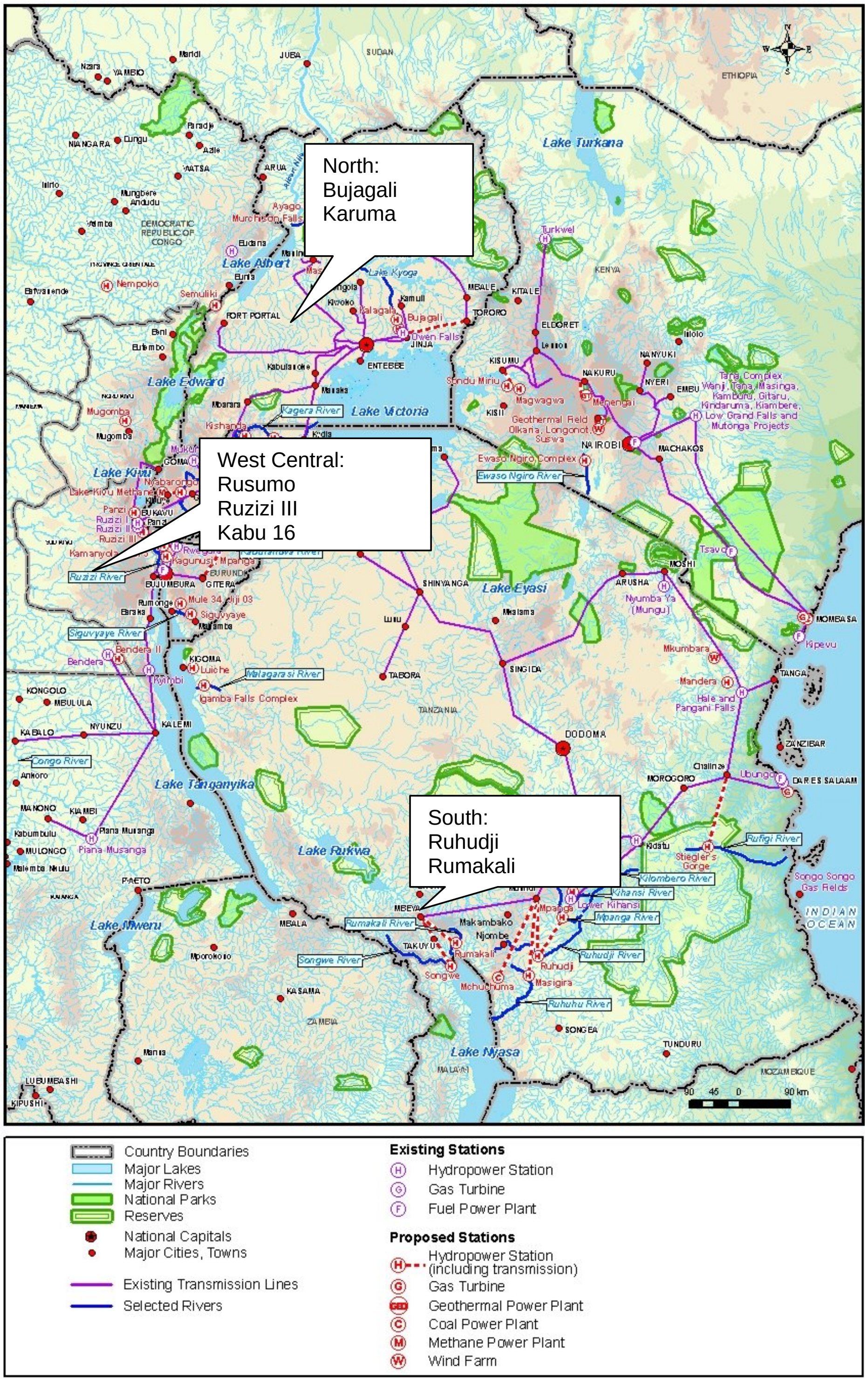
Table 12-2 - IPCC emission scenarios[3]

Name	Economic change 1990 to 2100 from GNP increase Trillion US$	Population by 2100 (million)	Cumulative emissions between 1990 and 2100 CO_2 (GtC[4])
A1F1	**505**	**7140**	**2190**
A2	225	15070	1860
A1B	**510**	**7060**	**1500**
B2	215	10410	1160
B1	310	7050	980

The A1B and A1FI emission scenarios have been selected for use in this analysis for assessing climate and corresponding runoff changes. They represent a relatively high economic growth worldwide and a relatively low growth in population. The first represents a medium level of emissions from the scenarios examined and the other a relatively high level of emissions[5].

[1] Stratus Consulting Inc. Climate change and impacts on runoff, August 2006
[2] Hadley Centre – Climate change, observations and predictions, recent research of climate change science from the Hadley Centre, December 2003
[3] IPCC Special Report on Emission Scenarios
[4] GtC = Gigatonnes of carbon emissions per year
[5] The selection of A1B and A1F1 was arbitrary, however the use of A1B as a median prediction seems to be general practice. A1F1 was selected as the high case, because it provided the highest predicted values of cumulative emissions. A2 would have provided results somewhere between A1B and A1F1. As noted previously the objective was to do a risk analysis, hence selection of a median and the maximum impact scenario. A2 may have a higher probability of occurrence, however use of its lower emission value would not have added to the "robustness" of the risk analysis.

Figure 12-1 - NEL Region - Options in plan and hydrologic areas of interest



12.2.2 Climate Change Analysis

The goal of the climate change analysis was to use the best available general circulation model (GCM) output to assess the potential changes in temperature and precipitation in 2050 and 2100 relative to 2000 in the selected sites in East Africa. Outputs from various climate models were examined to determine the degree to which models agree or disagree on the sign (increase or decrease) and magnitude of change in temperature and precipitation in the region.

The study used the NCAR[6] model MAGICC/SCENGEN[7], which readily enables users to specify greenhouse gas emissions scenarios and climate sensitivities, and to evaluate how well models simulate current patterns of climate, to select specific models, and determine degree of model agreement or disagreement on regional climate change projections.

The NCAR model is loaded with simulations from some 16 global models (General circulation models), and thus can be used to determine which models best simulate the climate of East Africa, by assessing how well they matched the observed patterns and values for temperature and precipitation. From this analysis the models that best simulate East African climate were selected.

The baseline climate data for the model was the 100 year monthly climate database, TS 2.1, produced by the Climate Research Unit of the University of East Anglia, United Kingdom. The historic sequence from 1961-1990 was used to establish baselines.

The model projections of changes in temperature and precipitation for 2050 and 2100 relative to 2000 were examined for the A1B and A1FI scenarios[8] [9] [10]. The A1B scenario projects a CO_2 concentration of 700 ppm by 2100. A1FI has the highest greenhouse gas emissions and projects a CO_2 concentration of about 940 ppm by 2100.

One estimate of climate was developed to cover the north and west central regions, i.e. the Nile River at Bujagali and Karuma and the Ruzizi and Kagera rivers for the Rusumo, Ruzizi and Kabu projects. A separate estimate of climate change was made for the southern site grouping in Tanzania, i.e., for the Ruhudji and Rumakali rivers.

12.2.3 Evaporation and Runoff Analysis

The primary analysis was made as part for the Stratus study using the regional one dimensional monthly water balance model (WATBAL), developed for a ½ degree by ½ degree grid of Africa, was used to calculate potential evapotranspiration, actual evapotranspiration, runoff and relative soil moisture. The model was calibrated at the ½ degree level against the GRDC[11] Global Gridded Runoff Database.

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[6] NCAR - US National Center for Atmospheric Research

[7] Wigley, T. M. L. 2004. "MAGICC/SCENGEN." Boulder, Colorado: National Center for Atmospheric Research. http://www.cgd.ucar.edu/cas/wigley/magicc/

[8] For definitions and further information on the IPCC scenarios see web site www.grida.no/climate/ipcc/emission

[9] See also Nebojsa Nakicenovic et al, Special Report on Emission Scenarios, Cambridge University Press, 2000, and IPCC web site

[10] See also Met Office Hadley Centre, Recent research on climate change science from the Hadley Centre, December 2003

[11] Global Runoff Data Centre - the digital world-wide repository of discharge data - www.bafg.de/**grdc**.htm

This model took the predicted temperature and precipitation values and calculated the corresponding evaporation losses, and thus net basin yields. All estimates are relative to present conditions.

12.3 Estimates of Climate Change for the Nile Equatorial Lakes Region

12.3.1 Selection of General Circulation Models

Given the current rates of greenhouse gas (GHG) emissions, global climate is expected to continue to change and global temperatures are projected to continue rising. However, changes in climate, particularly at the regional and local scale, are uncertain. Therefore, a number of general circulation models (GCMs) specifically focused on the Nile Equatorial Lakes region were examined to estimate potential changes in temperature and precipitation in these regions.

The sixteen GCM in the NCAR model were examined and the following seven were selected as they provided the most representative results (there was no one single model that was deemed appropriate for use by itself)

- CERG – The European Centre for Research and Advanced Training in Scientific Computation (CERFACS), France;
- CCSR – National Institute for Environmental Studies, Japan;
- CSIRO – Commonwealth Scientific Industrial and Research Organization, Australia;
- ECHAM3 – Max Planck Institute for Meteorology, Germany;
- ECHAM4 – Max Planck Institute for Meteorology, Germany;
- HadCM2 – Hadley Model, United Kingdom Meteorological Office;
- HadCM3 – Hadley Model, United Kingdom Meteorological Office[12].

12.3.2 Results for Uganda and Rwanda

The projections for the A1B scenario for the Rwanda and Uganda project areas are presented in Table 12-3. The area covered is 5°N to 5°S by 25°E to 35°E. Changes are relative to the year 2000.

[12] See McAveney et al. (2001) for model descriptions and citations. McAveney, B. J., C. Covey, S. Joussaume, V. Kattsov, A. Kitoh, W. Ogana, A.J. Pitman, A.J. Weaver, R.A. Wood, and Z.-C. Zhao. 2001. Model Evaluation. In *Climate Change 2001: The Scientific Basis,* Houghton, J. T., Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden, D. Xiaosu, and K. Maskell (eds.). Cambridge University Press, New York.

Table 12-3 - Projections for Uganda and Rwanda for the A1B scenarios

	Wet		Average		Dry	
	CCSR (Japan)		Model average		ECHAM (German)	
	Temp. (°C)	Precip. (%)	Temp. (C)	Precip. (%)	Temp. (°C)	Precip. (%)
2050 projections using the A1B scenario						
DJF	0.8	85.5	1.4	16.6	1.3	4.5
MMA	1.8	4.8	1.7	8.3	2.1	10.8
JJA	2.5	-13.6	2.0	16.3	2.4	147.8
SON	1.8	-0.9	1.6	3.7	1.7	1.6
Annual	**1.7**	**14.2**	**1.7**	**7.4**	**1.9**	**4.3**
2100 projections using the A1B scenario						
DJF	1.6	212.0	2.5	28.0	2.4	4.8
MMA	3.3	10.0	3.1	16.4	3.6	21.7
JJA	4.3	-10.4	3.5	41.3	4.1	518.3
SON	3.1	1.0	2.8	8.5	3.0	4.8
Annual	**3.0**	**27.3**	**3.0**	**13.8**	**3.3**	**8.3**

On average, the models project increased temperature, with some variation across the wet and dry models. Note however, that the wettest and driest models were selected, not the hottest and coolest. The difference between the model with the most warming (ECHAM3) and the model with the least warming (CERF) is less than 30%.

The precipitation results present an interesting pattern.[13] On average, the models project an increase in precipitation, both annually and for each season. The largest percentage increase is projected for the dry months of June through August. Since there is little precipitation in those months, even a large increase will have a relatively small absolute effect on precipitation.

The average model projections for the A1FI scenario showed a temperature increase in 2050 almost the same as in the A1B scenario, but with a much larger increase in precipitation. By 2100, under the A1FI scenario, there is substantially more warming and precipitation than in the A1B scenario. The dry and wet models under the A1FI scenario range from an annual increase of 11-23% by 2050 to 15-50% by 2100.

12.3.3 Results for Tanzania

The projections from MAGICC/SCENGEN for the A1B scenario for Tanzania are presented in Table 12-4. Area covered is 5°S to 15°S by 30°E to 40°E. Changes are relative to the year 2000.

[13] Annual precipitation in the sites being studied is about 1,300 mm/year.

Table 12-4 - Projections for Tanzania for the A1B Scenarios

	Wet		Average		Dry	
	CSIRO		Model average		CCSR-D2	
	Temp. (°C)	Precip. (%)	Temp. (°C)	Precip. (%)	Temp. (°C)	Precip. (%)
2050 projections using the A1B scenario						
DJF	0.9	25.7	1.7	5.5	3.3	-27.2
MMA	0.9	19.7	1.9	1.4	3.1	-17.1
JJA	1.2	5.3	2.1	-9.7	2.0	2.3
SON	1.1	37.5	1.8	-4.8	1.5	-29.6
Annual	**1.0**	**23.3**	**1.8**	**2.2**	**2.5**	**-25.4**
2100 projections using the A1B scenario						
DJF	2.8	47.0	3.0	8.1	5.8	-43.4
MMA	3.0	36.6	3.4	2.2	5.5	-27.6
JJA	3.3	12.7	3.7	-15.6	3.6	4.8
SON	4.1	85.7	3.1	-0.4	2.5	-38.7
Annual	**1.8**	**44.0**	**3.3**	**3.8**	**4.3**	**-39.7**

Here too, all the models project an increase in temperature. In this case, the wet and dry models give a wider range of change in temperature because the wettest and driest models in this region are also the coolest (least warming) and warmest (most warming).

The A1FI scenario for Tanzania projects more warming than A1B, particularly by 2100. Like A1B, the model average shows a slight increase in precipitation. However Since MAGICC/SCENGEN uses an extrapolation method to calculate the changes, these results lack credibility.

12.3.4 Other Results for the Region

It is relevant to note some results from other models and studies applicable to the study region. These include:

University of East Anglia, UK. Its School of Environmental Sciences, which includes the Tyndall Centre for Climate Change Research. Its program is headed by Professor Mike Hulme, and the centre provides technical support to the Hadley centre. Of interest is a study done by Hulme/UEA in association with the Zimbabwe climate research centre, on African climate change for the period 1900 to 2100. This study indicated a 0.0 to 1.0 degree temperature change in the SSEA study area over the century and a 0 to 20 % increase in precipitation (depending on location). Another researcher at the UEA, Dr. Declan Conway has also been heavily involved in modelling for the African region.[14] It is understood that the UEA use results from other models, primarily Hadley, for their climate studies.

Hadley Centre – UK Meterological Office. The Hadley Centre for Climate Prediction and Research provide public access to long term modelling results, for the period 2070 to 2100. Results are issued for temperature, precipitation and soil moisture on a quarterly and annual basis. Again of interest are forecasts of temperature and precipitation increases in the study

[14] www.cru.uea.ac.uk

region. [15] It is noted that many predictions of climate change are using development scenarios and results from the Hadley Centre.

University of Capetown – Africa Earth Observatory Network. Maarten de Wit and Jacek Stankiewicz have just issued the results of their study on changes in surface water supply across Africa.[16] This study also concludes that rainfall in the project area should increase. The model specifically includes the Rufiji and Ganane river basins. The results reported for this study seem to indicate potential precipitation increases in the region of from 0-10 % or 10-20 % depending on the location.

12.4 Potential Climate Change Impacts on Runoff

12.4.1 Methodology and Model Description

The objective was to apply a hydrological model to three sub-regions of the Nile Equatorial Lakes Region rather than to any particular catchment or water resource system. The model inputs were the climate variables of the 1961-1990 climatology and physiological parameters (e.g., soil properties) derived from global datasets and averaged over the 0.5^o latitude/longitude cells in the region. The primary model output comprised a time series (monthly time step) of simulated runoff for each of the three sub-regions of the Nile Equatorial Lakes region.

The model used is a version of a conceptual rainfall-runoff model called WATBAL (Yates, 1997[17]), which can be applied to regionally averaged data. The model simulates changes in soil moisture and runoff. It is essentially an accounting scheme based on a conceptualized, one-dimensional bucket that lumps both the root and upper soil layer. The model comprises two elements. The first is a water balance component that describes water movement into and out of a conceptualized basin (Figure 12-2). The second is the calculation of potential evapotranspiration. The simplified representation of soil moisture dynamics has been shown to adequately represent runoff changes due to climate fluctuations (Yates and Strzepek, 1994[18]; Yates, 1997[19]).

12.4.2 Modeling Runoff

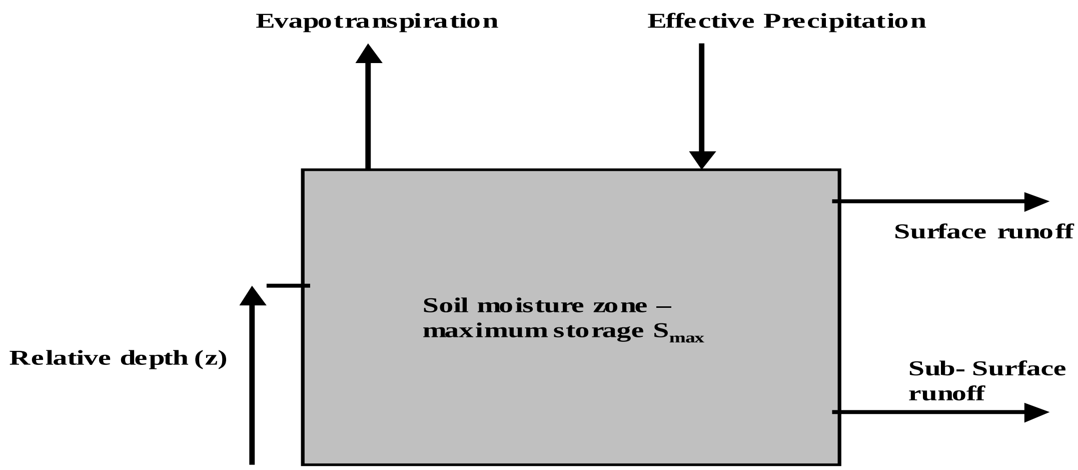
For this analysis, three areas of interest were identified as shown in Figure 12-1. The northernmost area is the Uganda project area, the central area covering the DRC and Rwanda/West Tanzania sites, and the southern Tanzania area.

In the WATBAL modeling, the regions are assumed to homogeneous hydroclimatic regions and all parameters are spatially averaged over the region.

Note that for the northern or Uganda region, the Nile flow or the flow out of Lake Victoria is not being modeled, rather the study is modeling the tributary flow to the Nile in the region, as indicative of the regional runoff.

[15] www.metoffice.gov.uk
[16] www.sciencexpress.org./ 2 march 2006
[17] Yates, D. 1996. WATBAL: An integrated water balance model for climate impact assessment of river basin runoff. *Int. J. of Water Resources Development* 12(2):121-139.
[18] Yates, D. and K. Strzepek. 1994. Comparison of models for climate change assessment of river basin runoff. WP-94-46, IIASA, Laxenburg, Austria.
[19] Yates, D. 1997. Approaches to continental scale runoff for integrated assessment models. *J. of Hydrology* 201:289-310.

Figure 12-2 - Simplified Version of the WATBAL Model that is used to Compute Gridded Runoff



12.4.3 Climate change runoff modeling approach

To ascertain the possible impacts of climate change within the regions being investigated in this study, the two region climate change scenarios developed by Stratus Consulting for the northern and southern regions were used. The northern scenario was used for the northern and central region, and the southern scenario was used for the south Tanzania region. Two time periods were studied: 2050 and 2100.

The quarterly seasonal changes in precipitation and temperature were applied to the appropriate monthly base climate conditions for the A1B model average runs only. For the A1B wet and dry scenarios and the A1FI model average scenarios, annual changes were added uniformly to each month.

The scenario changes were applied to the 1961 to 1990 base monthly temperature and precipitation record using the same climate change for each year of the record. Thus, the resulting 30 years of data are not a projected time series from 2051 to 2080 or 2101 to 2130 with progressively changing climate parameters, but a set of 30 possible years that might occur between 2050 and 2100 for the regions. So a 30-year Monte Carlo simulation of runoff for the years 2050 and 2100 was performed.

WATBAL was run with the 30 years of monthly-observed data for each scenario. The results for each region are provided in the following section.

12.4.4 Climate Change Runoff Results - Annual Results for all Scenarios

The analyses provided absolute and relative values of runoff change corresponding to the predicted precipitation and temperature changes described in Section 12.3 for all scenarios. The relative values are shown in Table 12-5. These are relative to base climate from 1961 to 1990. The values are changes in annual precipitation percent, annual average temperature, degrees Celsius, and aridity. A positive value in Precipitation/PET means it is getting wetter and a negative value means it is getting drier. Runoff is in percentage of the base year.

In general, the scenarios project an increase in runoff for the three regions. The exception is the dry scenario for the southern region, under which a decrease in runoff is projected. Furthermore, the model averages for the A1B and A1FI scenarios in the south (Tanzania) involve virtually no change in runoff.

12.4.5 Summary of Predicted Runoff Changes

The analysis of potential impacts of climate change on runoff in the three sub-regions in the Nile Equatorial Lakes Region shows that all three exhibit an asymmetric, non-linear relationship between precipitation and runoff. All the regions have a runoff multiplier of up to 3 times the precipitation change at +50% (e.g., a 25% increase in precipitation would lead to an approximate 75% increase in runoff) and 1.5 times the precipitation change at -50%.

The analysis of the climate change scenarios summarized in Table 12-5 contains the main message of this analysis. The model average climate change scenario for 2050 results in significant increases in runoff for the northern (Uganda) and western central (Rwanda) regions for both A1B and A1FI: 23 and 42% respectively. For 2100 there is a larger increase in runoff for the north and western central regions for both A1B and A1FI: 55 and 107% respectively. For the southern (south Tanzania) region, the model average changes in 2050 and 2100 result in no change in runoff for both A1B and A1FI: -1% and 0% respectively. These findings are driven primarily by the climate change scenarios, but also from the responsiveness of hydroclimatic system of each region.

Table 12-5 - Annual runoff changes relative to the Base (1961-1990)

	A1B Wet	A1B Avg.	A1B Dry	A1F1 Avg.
North (Uganda				
2050	137%	123%	104%	142%
2100	109%	155%	177%	207%
West Central				
2050	103%	119%	128%	141%
2100	107%	137%	158%	159%
South (southern Tanzania)				
2050	42%	100%	165%	100%
2100	23%	99%	234%	100%

12.5 Potential Impact on Generation Capability

12.5.1 General Conclusions

The general conclusions that may be drawn from the analyses described above include the following:

- The predictions of temperature and precipitation changes are consistent with other modelling results in that temperature is expected to increase with greenhouse gas emission increases;
- An increase in precipitation is the expected result from an increase in temperature, which will also increase evaporation and evapotranspiration losses;
- Changes will be more significant for the high emission scenario A1F1, than for the median emission scenario A1B, again because of the expected link between emission levels and temperature. (Note wet and dry scenarios were not tested for the A1F1 emission scenario);
- Net runoff will increase with increase in greenhouse gas emission levels;

- Increased emission levels (due to year or development scenario) will result in increased seasonal variability in runoff, as flood periods will provide most of the increased runoff, with dry periods being only marginally affected in terms of volume;
- Increased variability in runoff is most evident in the southern Tanzania region. It is relatively modest in the northern and central west regions;
- All annual runoff predictions (development scenario and wet/average/dry conditions) for the northern (Uganda-Victoria Nile) and central west (Rwanda-Burundi-West Tanzania) areas show increases in runoff. For the southern Tanzania area reduced annual run off would result only under dry condition scenarios, however this would apply anyway without climate change impacts.

12.5.2 Specific Results

Table 12-6 provides a summary of predicted runoff changes for each of the hydro options included in the reference indicative generation plan for the A1B (median emissions) and A1F1 (high emissions) scenarios, based on average model results.

These results show that for all cases, average runoff, **and thus generation**, would increase, based on average model results. This however does not take into account the possibility of increased flood discharges not used for power. However in turn one must recognize that a final optimization study for any given project, as part of the final design of the project, predicated on increased but more variable runoff, might justify higher capacity installations that would offset or eliminate this factor.

The only potential negative impact, as related to future generation, is the indication that minimum flows (dry season – see also monthly results in Appendix K) for the southern Tanzania projects (Ruhudji and Rumakali) could be reduced, based on average model results. However it has to be remembered that for this region, relatively little runoff volume occurs in the dry months August to November.

Furthermore reference to Table 12-5 suggests that the prediction from the “dry” model (the model that forecasts the least increase in precipitation) for southern Tanzania would be significantly reduced net runoff.

12.5.3 Overall Conclusions Related to Portfolio Development

The purpose of these analyses was to determine plausible changes to historic runoff for the new hydro options that were included in the reference indicative plan for the region that would be indicated from current climate change modelling. These potential changes could then be used to determine if the project selection and scheduling procedure would be valid if these changes would be accepted as the basis for planning studies.

The impact of changes in climate will tend to increase the output of most of the power development options being proposed. However, additional care is needed in the design of the flood evacuation structures in these options.

In considering whether to undertake any risk analyses, in the context of the results and conclusions that have been presented above, one should note that the immediate concern should be the validity of project selection for the first part of the plan period, as this could affect decisions being taken on the basis of studies already completed. Under this grouping one may include Bujagali, Rusumo and Ruzizi. These sites are in the northern and west central regions, for which the potential for runoff reduction, for any combination of emission scenario or model (average or dry) criterion, appears to be minimal (with all results showing runoff increases). The study results do not provide any basis for selecting a runoff reduction to be used in a risk analyses.

The longer term part of the preferred indicative plan includes Karuma in the northern region, and Ruhudji and Rumakali in the southern region. The results for the northern region are very positive in terms of long-term runoff trends, and thus there is no basis for assuming any negative impact for a risk analysis. For the Tanzanian projects there appears to be some potential for average annual runoff reduction.

The results of this climate change risk assessment are therefore defined as follows:

- There are few clearly identified hydrological risks to the hydro options included in the indicative plan, and overall for the Northern and Central West regions there is a high probability of increases in runoff, and thus generation, than presently identified from historic flow data. For the southern region there is a high likelihood of changes in seasonality of runoff, resulting in lower effectiveness for flow regulation in any smaller reservoir;
- Any further planning studies and assessment of new hydro options in southern Tanzania should address this risk in more detail;
- Results show that for all regions flood flows may increase significantly, thus designs for flood discharge during construction and over a permanent spillway should take this potential into account. Project costs would also be affected;
- Similarly the identified trend towards larger floods, suggests that project planning and environmental assessments for multipurpose specifically take into account this hydrologic risk in assessing project benefits from flood control.

The development of the portfolios of generation options was, therefore carried out with the hydrology data currently available and NO sensitivity analyses for climate change wee carried out, as any such sensitivity analysis would only present higher energy availability than current conditions indicate.

Table 12-6 - Impact of Climate Change on Runoff (Generation) for Preferred Hydro Options

ON POWER	PROJECT	MW	ENERGY AVERAGE GWH	ENERGY FIRM GWH	AVERAGE RIVER FLOW M3/S	MAX PLANT DISCHARGE M3/S Calculated	PLANT HEAD M	STORAGE	COUNTRY	CLIMATE REGION	A1B 2050 ADJUSTMENTS % MIN Q	MIN YIELD	AV Q	A1B 2100 ADJUSTMENTS % MIN Q	MIN YIELD	AV Q	A1F1 2050 ADJUSTMENTS % MIN Q	MIN YIELD	AV Q	A1F1 2100 ADJUSTMENTS % MIN Q	MIN YIELD	AV Q
2012	BUJAGALI 1-4	200	1703	1390	1165	993	23.5	L. VICTORIA	UGANDA	N	120	120	123	150	140	155	140	145	142	200	200	207
	RUSUMO	62	403	308	193	207	35	800 MCM *	B-R/T	CW	100	120	119	100	140	137	160	140	141	180	155	159
2013	KABU 16	20	112	67	10	12	191	PONDAGE	BURUNDI	CW	100	100	119	100	100	137	160	160	141	180	180	159
2014	BUJAGALI 5	50	222	14	1165	248	23.5	L. VICTORIA	UGANDA	N	120	120	123	150	140	155	140	145	142	200	200	207
	RUZIZI III	82	418	418	87	154	62	L. KIVU	R/DRC	CW	100	120	119	100	140	137	160	140	141	180	155	159
2015	RUHUDJI	358	1930	1476	35	55	765	269 MCM	TANZANIA	S	100	100	100	100	90	99	100	100	100	100	90	100
								ZANIBERI														
2017	KARUMA	200	1748	1619	1165	833	28	L. VICTORIA	UGANDA	N	120	120	123	150	140	155	140	145	142	200	200	207
2020	RUMAKALI	222	1141	1170	13	20	1295	265 MCM	TANZANIA	S	100	100	100	100	90	99	100	100	100	100	90	100

*Note Rusumo live storage remains to be confirmed

Nile flows based on records after 1961 - EAPMP

PLANT KW= 9.81 X 0.92 (EFF) X Hg X .95 (Head loss) x Q

8.57394 x Hg x Q

PLANT Q KW/8.57/Q

ZONE	NAME	DRY MONTH	A1B BASE %MIN RUNOFF CHANGE 2050	2100	A1B BASE % AV RUNOFF CHANGE 2050	2100	A1F1 HIGH %MIN RUNOFF CHANGE 2050	2100	A1F1 HIGH % AV RUNOFF CHANGE 2050	2100
N	L. Kyoga	January	120	150	123	155	140	200	142	207
CW	L. Tanganyika	August	100	100	119	137	160	180	141	159
S	L. Nyasa	October	100	100	100	99	100	100	100	100

% expressed as percentage of the base runoff

13 POWER DEVELOPMENT PORTFOLIOS

13.1 Objectives of Portfolio Development

The objective of the SSEA studies is to provide a strategic regional assessment of the different power options in the region, in the context of the long-term objectives of the NELSAP power development and trade sub-program. Consequently the individual systems of the six countries (Burundi, Eastern DRC, Rwanda, Kenya, Tanzania and Uganda) are treated as being electrically interconnected for mid and long term assessment of power development options for the Region. In fact there is already a degree of interconnection between these countries (Uganda and Kenya, and DRC-Rwanda-Burundi), and the comparison of alternative power options and portfolios has included the cost of additional transmission to provide sufficient interconnection for full sharing of benefits.

The assumption of electrical interconnection affects the selection and scheduling of power development options in several ways, and in turn this improves reliability and cost effectiveness, and may reduce environmental and social impacts:

- Preference is given in the ranking and selection of options to those options that will provide benefits to more than one country;
- The assumption of a large system means that larger and potentially more economic options may be included in the portfolios at an earlier date;
- System reserve may be shared, thus increasing reliability and/or reducing capital investment in new plant;
- Opportunities for renewable energy (hydroelectric) development are opened up;
- Opportunities to use new power options that are more environmentally and socially acceptable are improved.

The desire for development of a least cost and environmentally acceptable electrical system in the region is keyed to the conclusion of the NBI countries that regional electricity trade is an important component of their strategy to promote economic development[1]. Consequently it has to be remembered that there is an implicit interrelation between economic development, electricity demand and availability of low cost generation.

In order to properly assess the power development options for the region, two overall approaches were examined: an independent approach and a regional cooperation approach. This permits an assessment of the cumulative impacts of the regional approach.

Within these two approaches, four strategies were examined:

- Within the independent approach a strategy of using primarily national options;
- Within the regional cooperation approach, three strategies were followed:
  - Emphasis on best evaluated options
  - Emphasis on technological diversification; and
  - Emphasis on geographic diversification

In addition, sensitivity tests were carried out using different load growth scenarios and different assumptions regarding the mix of options. A series of portfolios were prepared that illustrate the selected strategies and sensitivity tests. Table 13-1 presents a summary of the portfolios examined.

[1] ESMAP – Opportunities for Power Trade in the Nile Basin – Final Scoping Study, January 2004

Table 13-1 - Nomenclature Used in Portfolio Development

<table>
<tr><th>Power Development Approaches</th><th>1. Independent</th><th colspan="3">2. Regional Cooperation</th></tr>
<tr><th>Strategies to Develop Power Option Portfolios</th><th>A) Primarily National Options</th><th>B) Best Evaluated Options</th><th>C) Technological Diversification</th><th>D) Geographic Diversification</th></tr>
<tr><td rowspan="12">Load Growth Scenarios</td><td colspan="4">a) Base (Growth in demand of 3.7% to 4.0%), one portfolio examined</td></tr>
<tr><td>Portfolio 1Aa</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">b) Medium (Growth in demand of 5.6% to 6.3%); three portfolios examined</td></tr>
<tr><td></td><td>Portfolio 2Bb</td><td>Portfolio 2Cb</td><td>Portfolio 2Db</td></tr>
<tr><td colspan="4">c) High (Growth in demand of 6.8% to 8.1%; two portfolios examined</td></tr>
<tr><td></td><td></td><td>Portfolio 2Cc</td><td>Portfolio 2Dc</td></tr>
<tr><td colspan="4">d) Transformation (Growth in demand of 5.1% to 15.0%; one portfolio examined</td></tr>
<tr><td></td><td colspan="3">Portfolio 2d*</td></tr>
<tr><td rowspan="6">Sensitivity Analyses</td><td colspan="4">Limited level of readiness (S1)</td></tr>
<tr><td></td><td></td><td>Portfolio 2Cb(S1)</td><td></td></tr>
<tr><td colspan="4">Allowing import options (S2)</td></tr>
<tr><td></td><td></td><td>Portfolio 2Cb(S2)</td><td></td></tr>
<tr><td colspan="4">No comparative analysis; only screening of options (S3)</td></tr>
<tr><td></td><td></td><td>Portfolio 2Cb(S3)</td><td></td></tr>
</table>

* Note: as the transformation scenario would require all the identified power options in the region it is not appropriate to give the portfolio an identifier for a specific strategy.

13.2 Definition of Portfolios

A portfolio is a proposal to install a group of power development options so as to meet a defined load growth scenario with a pre-selected level of reserve margin that illustrates a specific development strategy. There are four main development strategies that are defined below. To these are added an assessment of the impact of different load growth scenarios and of different implementation assumptions.

13.2.1 Main Portfolios Examined

Power development approach: Independent
Strategy to develop power option portfolios: Primarily national options
Load growth scenario: Base
Portfolio: **1Aa**

In order to better define the benefits from regional cooperation and the consequent implementation of larger, lower cost options, it is necessary to provide an assessment of the social and environmental consequences from failure to implement a regional integrated power supply system.

This reference strategy implies that regional projects will not go ahead, and that development throughout the region will be limited to national expansion plans, probably with limited access to financing. It follows from this assumption that the load growth scenario would be lower than under the situation of regional integration. Thus only one portfolio is examined and that uses the base load growth scenario.

Power development approach: Regional Cooperation
Strategy to develop power option portfolios: Best evaluated options
Load growth scenario: Medium
Portfolio: **2Bb**

This strategy minimizes the environmental and social impacts of power development in the region. Thus, under this strategy, all of the “best evaluated” options would be used first, followed by any additional options required to meet the load forecast with the selected level of reliability.

Power development approach: Regional Cooperation
Strategy to develop power option portfolios: Technological Diversification
Load growth scenario: Medium
Portfolio: **2Cb**

For this strategy, the criterion used to define the portfolio was that a balance is to be maintained between hydroelectric power development options and thermal options. Based on the availability of power development options by type, this constraint is defined numerically as having a target of 30% to 50% of the new power development options being hydro options. This implies that some of the best-evaluated options will be replaced by some of the other options.

In this context it has to be noted that new indigenous generation options in Uganda are primarily hydroelectric, while they are mostly thermal in Kenya. In addition, any major investment in coal or gas fired thermal plant would have to be on the coast in Kenya or Tanzania.

Power development approach: Regional Cooperation
Strategy to develop power option portfolios: Geographic Diversification
Load growth scenario: Medium
Portfolio: **2Db**

For this strategy, the criterion used to define the portfolio was that it needed to provide as much security of supply to each country as could be reasonably possible given the availability of resources even at the expense of using options with some environmental, social or risk concerns. For practical purposes, the selection of power development options was carried out using a target in 2020 of having the proportion of new power development options in each country similar to the share of the load in 2020 of each country. Thus, if 20% of the regional load in 2020 were in Uganda, the target installations of new power development options in Uganda from 2005 to 2020 would also be 20%. This target could not always be achieved because of the scarcity of attractive resources in some of the countries. In addition, this target was applied to the period as a whole only and not year-by-year.

13.2.2 Sensitivity to Load Growth

Power development approach: Regional Cooperation
Load growth scenario: High

Strategy to develop power option portfolios: Technological Diversification	**Strategy to develop power option portfolios:** Geographic Diversification
Portfolio: 2Cc	Portfolio: 2Dc

Because all of the "Best-evaluated" options would be used up under the medium load growth scenario, it would be redundant to derive a portfolio for the strategy of using best evaluated options under the high load growth scenario. Thus only technological and geographic diversification strategies are considered under the high load growth scenario.

Power development approach: Regional Cooperation
Load growth scenario: Transformation

Strategy to develop power option portfolios: Not Applicable
Portfolio: 2d

Because all of the identified resources in the region would need to be used (plus additional, as yet unidentified resources), to meet the load implied by the transformation scenario, it would be redundant to derive portfolios for the individual strategies being examined. Thus, only one portfolio of development is considered under the transformation load growth scenario.

13.2.3 Sensitivity Analysis

Many power development options have been dropped from the analysis because of lack of sufficient data to permit them to be analyzed on a consistent basis with other, more thoroughly studied options. This runs the risk that an option that would be attractive if studied further may have been discarded from the analysis. To assess the possible impact of this having occurred, a first sensitivity analysis was carried out using the condition that the **screening criterion for level of readiness of study was ignored** (thus all options only at the reconnaissance level and that met the other criteria are considered).

A second sensitivity test was carried out in which the **impact of imports** of power from outside the region was considered.

A third sensitivity analysis looks at the impact of taking account of the environmental, socio-economic and risk issues. In this sensitivity, the options were selected based on the results of the screening carried out in Chapter 7 but were **NOT subjected to the comparative analysis** based on environmental, social and risk aspects.

Power development approach: Regional Cooperation
Load growth scenario: Medium
Strategy to develop power option portfolios: Technological Diversification

Sensitivity to a limited level of readiness	Sensitivity to allowing imports	Sensitivity to eliminating the comparative analysis of options
Portfolio: 2Cb(S1)	Portfolio: 2Cb(S2)	Portfolio: 2Cb(S3)

As these are sensitivity analyses, it is expected that the impact would be the same regardless of which development strategy or which load growth scenario is selected. For this reason, only the medium load growth scenario applied to the technological diversification strategy is examined.

13.3 Summary of Information

13.3.1 Power Need Assessment

Chapter 5 presents four load growth scenarios: the base case growth scenario, the medium growth scenario, the high growth scenario and the transformation scenario. Each of these is presented in Table 13-2.

13.3.2 Power Development Options Retained

On the basis of the analyses in Chapter 11, two groups of options to be considered in power development portfolios can be identified: 1) best evaluated options and 2) other options, as presented in Table 13-3. In each group, options are listed in order of increasing cost.

13.3.3 Load-Resource Balance

The first step in the planning process is to determine if a sufficient amount of new generation options have been identified to meet the forecast load.

For this purpose, the medium load growth scenario (capacity and energy) for the region, as reported in Chapter 5, has been compared with the proposed installed capacities and firm energy capabilities of the identified new power options listed in Chapter 11, with capacity and energy availability being assumed based on the projected practical earliest on-power dates also provided in Chapter 7.

Table 13-2 - Selected Growth Scenarios

System Demand - MW				
Year	Base Case Scenario	Medium Growth Scenario	High Growth Scenario	Transformation Scenario
2004	1,802	1,878	1,946	1,878
2005	1,862	1,976	2,081	1,976
2006	1,940	2,097	2,246	2,097
2007	2,022	2,225	2,427	2,225
2008	2,108	2,362	2,620	2,362
2009	2,197	2,506	2,829	2,506
2010	2,290	2,650	3,056	2,650
2011	2,382	2,812	3,264	2,990
2012	2,477	2,974	3,488	3,439
2013	2,589	3,162	3,750	3,954
2014	2,693	3,348	4,012	4,547
2015	2,802	3,544	4,295	5,230
2016	2,919	3,752	4,599	6,014
2017	3,041	3,974	4,928	6,916
2018	3,169	4,211	5,284	7,953
2019	3,302	4,462	5,669	9,146
2020	3,441	4,731	6,086	10,518

Table 13-3 - Options to be considered in Power Development Portfolios (listed in order of increasing unit cost)

Best-evaluated Options		Other Options
• Ruzizi III (82 MW) • Karuma (200 MW) • Ruhudji (358 MW) • Gas turbine 60 MW gas – generic x 4 units (generic, capacity depends upon amount of gas to be imported) • Combined cycle gas x 3 units (generic, capacity depends upon amount of gas to be imported) • Rusumo Falls (61.5 MW) • Bujagali (250 MW) • Rumakali (222 MW) • Longonot geothermal (70 MW) • Suswa Geothermal (70 MW)	• Menengai geothermal (140 MW) • Generic geothermal (assumed at 140 MW) • Olkaria extension (35 MW) • Kivu methane engines 30 MW x 4 units (120 MW) • Mombasa – LNG (generic, capacity depends upon amount of gas to be imported) • Kabu 16 (20 MW) • Kakono (53 MW) • Generic wind (nominal capacity depends upon sites, 2 X 30 MW assumed) • Mutonga (60 MW) **Total: 1881.5 MW plus generic gas-fired thermal plants.**	• Mpanga (144 MW) • Songwe (330 MW) • Masigira (118 MW) • Mchuchuma – coal-fired steam (400 MW) • Mombasa – coal (generic, capacity depends upon amount of gas to be imported) • Upper Kihansi (no capacity, only energy) **Total: 992 MW plus generic coal-fired thermal plants.**

This comparison of load and available resources is shown in summary form in Table 13-4; the details are provided in Table L-2 of Appendix L. This covers the period 2005 to 2020. Resources are limited to the specific power development options that have been identified in previous studies, and that are listed in Chapter 8, as well are existing generation. Power development options are limited to those that have been retained after the screening, thus it does not take account of the results of the comparative analyses carried out in Chapter 9 nor the risks analyses carried out in Chapter 10. No generic power development options are included at this stage.

Peak capacity capability is compared with peak demand plus a nominal 20% reserve.

This comparison shows that there are sufficient identified new generation resources in the region to meet the medium load growth scenario until 2020. The planning options are therefore to order power development options appropriately to meet the selected portfolio criteria, and to use generic generation as may be needed to improve portfolios and replace less desirable candidate power development options.

This in turn illustrates the importance of increasing the options base by:

- Providing more detailed studies on the 520 MW of options that could not be considered because of lack of information (sites not yet evaluated to at least the pre-feasibility level).
- Reassessing options presently considered to present possible environmental and social risk, to better evaluate the risks and to determine if such risks can be managed or mitigated, and at what cost.
- Considering in more detail the feasibility and cost of importing power into the region.

Similarly for the long term serious consideration should be given to developing energy efficiency, demand management and loss reduction programs to reduce the need for new generation and transmission.

There is also a potential for small hydro that has not been included in this assessment. For example the EAPMP notes that in Uganda some 100 MW of small hydro, mostly off-grid, may be developed in the next 10 years. It is expected that small hydro will be developed either as part of rural electrification programs (often isolated systems), or as private power projects. These may be important in the development of the electrical sector, however would not significantly affect the supply-demand balance.

The comparison also illustrates that the present situation in terms of both capacity and energy generation capability is critical and that this situation will continue for several years.

Table 13-4 - Load Resource Balance

	Load			Capacity		Energy		
	Peak Demand	Nominal Reserve	Total Demand	Total Available Capacity	Surplus Available	Energy Demand	Total Available Supply	Surplus Available
	MW	20%	MW	MW	MW	GWH	GWH	GWH
2005	1,900	380	2,280	2,327	47	11,100	11,512	412
2006	2,100	420	2,520	2,551	31	11,800	12,565	765
2007	2,200	440	2,640	2,642	2	12,500	12,951	451
2008	2,300	460	2,760	2,717	(43)	13,300	13,472	172
2009	2,500	500	3,000	3,197	197	14,100	16,831	2,731
2010	2,600	520	3,120	3,138	18	14,900	16,428	1,528
2011	2,800	560	3,360	3,138	(222)	15,800	16,428	628
2012	2,900	580	3,480	3,658	178	16,700	19,468	2,768
2013	3,100	620	3,720	4,146	426	17,600	21,600	4,000
2014	3,300	660	3,960	5,120	1,160	18,600	25,933	7,333
2015	3,500	700	4,200	6,080	1,880	19,700	31,216	11,516
2016	3,700	740	4,440	6,302	1,862	20,800	32,386	11,586
2017	3,900	780	4,680	6,302	1,622	22,000	32,386	10,386
2018	4,100	820	4,920	6,302	1,383	23,300	32,386	9,086
2019	4,400	880	5,280	6,302	1,022	24,700	32,386	7,686
2020	4,600	920	5,520	6,302	782	26,100	32,386	6,286

13.4 Independent Approach, Primarily National Options and Base Growth Scenario – Portfolio 1Aa

In order to identify potential environmental and social impacts of the regional integration approach, it was necessary to develop a representative portfolio, for each country, for the period to the year 2020.

The portfolio reflecting this reference strategy was developed under the following rules or criteria:

- Load growth in each country and collectively for the region would be expected to be lower than for the NELSAP plan based on medium load growth, because of electricity shortages (resulting in suppressed demand), and more expensive electricity (use of smaller less economic projects). For the purpose of developing a generation plan, the base load growth described in Chapter 5 was used.
- Transmission interconnections would be limited to present interchange capability. Thus potential transfers would be limited to those presently taking place between Uganda and Kenya, and for the sharing of the Ruzizi 1 and 2 generation.
- Rwanda, Eastern DRC and Burundi would be treated as a single load to reflect the relatively small size of these loads and the existing generation sharing between Rwanda and Eastern DRC. It was assumed that West Tanzania would remain separate from the main Tanzania grid. One third of the generation from Rusumo would be provided to West Tanzania.
- No power development options in excess of 150 MW (for any single stage of development) would be considered. It has to be recognized that any such project would have a total capital cost in the order of 300 million US$[2]. It is assumed for this strategy that investment conditions would not be adequate for larger projects. This approximates to the larger sizes of plant that have been commissioned in the past in the three larger load areas.
- Power development options would be scheduled to meet national loads only.

Table 13-5 presents the portfolios for each of the sub-regions considered. Some of the features of the portfolios are:

- In Kenya, all the known geothermal resources would be used, then medium speed diesels using fuel oil would be needed;
- In Uganda, medium speed diesel units would be used until Bujagali could be commissioned;
- In Tanzania the natural gas that is available offshore would be used in gas turbines as required;

[2] See unit costs in Appendix G.

Table 13-5 – Portfolios Reflecting an Independent Approach and the Base Load Growth Scenario

	Kenya			Uganda			Tanzania			Burundi, DRC, Rwanda		
Year	Name	Type/Fuel	Capacity	Name	Type/Fuel	Capacity	Name	Type/Fuel	Capacity	Name	Type/Fuel	Capacity
2005	Existing		1120	Existing		417	Existing		700	Existing		167
2006										Diesel	Fuel Oil	20
2007				Diesel	Fuel Oil	20				Diesel	Methane	30
2008	Olkaria 2	Geothermal	35	Diesel		20				Diesel	Methane	30
2009	Longonot	Geothermal	70	Diesel		20	Gas Turbine	Natural Gas	60	Kisala Ivugu	Hydro	13
	Gas Turbine	Natural Gas	60			20						
2010				Diesel								
2011	Gas Turbine	Natural Gas	60									
2012							Gas Turbine	Natural Gas	60	Rusumo 2/3	Hydro	41
2013	Suswa	Geothermal	70	Bujagali	Hydro	200[3]				Diesel	Methane	30
2014							Gas Turbine	Natural Gas	60	Diesel	Methane	30
2015	Menengai	Geothermal	140							Ruzizi III	Hydro	82
2016												
2017	Diesel	Fuel oil	20				Gas Turbine	Natural Gas	60	Diesel	Fuel Oil	40
2018	Diesel	Fuel oil	40							Diesel	Fuel Oil	40
2019	Diesel	Fuel oil	40				Gas Turbine	Natural Gas	60	Diesel	Fuel Oil	60
2020	Diesel	Fuel oil	40							Diesel	Fuel Oil	60

[3] Recent (December 2006) information indicates that Bujagali is to be developed to a total of 250 MW; however, only 200 MW would be required under the independent approach.

- For Burundi, Eastern DRC and Rwanda most of the additions would be medium speed diesels, some fuelled with fuel oil and others with methane from Lake Kivu. In addition, one hydro plant in Eastern DRC would be built: Kisala Ivugu. It is also assumed that Rusumo Falls would be built, even though it is a regional project. The rationale for this is that commitments have already been made for this project and it would be illogical to ignore this. Ruzizi III is also included.

13.5 Regional Approach, Best Evaluated Options and Medium Load Growth Scenario – Portfolio 2Bb

13.5.1 Definition of Portfolio

The objective of this portfolio is to use, to the extent practicable, the options with the least adverse environmental and social risks. Options for development in any year were, therefore, selected based on the following hierarchy of criteria:

- Options needed to be part of the best-evaluated group of options (until all such options had been included);
- Respect for the gestation period required for each option;
- Once the above two criteria were used, options were then selected on the basis of least unit cost of firm energy.

The proposed portfolio for this strategy would include:

- 2009: 120 MW of gas turbines, 60 MW of a combined cycle unit and one 10 MW diesel plant;
- 2010: a geothermal plant of 70 MW, the second methane-fuelled engine at Lake Kivu of 30 MW and a combined cycle unit of 60 MW;
- 2011: the third unit at Lake Kivu at 30 MW and a gas turbine of 60 MW;
- 2012: Bujagali (units 1 to 4)[4] and Rusumo Falls hydro plants;
- 2013: the geothermal plant at Suswa of 70 MW and the hydro plants at Kabu 16 and Kakono;
- 2014: the fifth unit at Bujagali[5], a gas turbine at 60MW and Ruzizi III hydro plant;
- 2015: the Ruhudji Hydro plant;
- 2016: the Karuma hydro plant;
- 2017: the Rumakali hydro plant;
- 2018: the Menengai geothermal plant, the fourth engine at Lake Kivu and two new geothermal plants whose locations has not yet been confirmed;
- 2019: the Songwe hydro plant;
- 2020: the Mutonga hydro plant, a wind farm, and a coal fired thermal unit at Mombasa (to be followed by other units).

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[4] Recent information (December 2006) indicates that the proponent for the Bujagali option intends to build the option in one stage of 5 x 50 MW units and that the option would be commissioned by the end of 2010. The impact of this information on all portfolios would be to advance Bujagali 1 to 4 by one full year and Bujagali 5 by three years but to delay the third unit at Lake Kivu at 30 MW and a gas turbine of 60 MW, both scheduled for 2011 to 2012.

[5] See previous note.

Of all these options, only Songwe and the Mombasa thermal unit are from the group of options that are less preferred. In practice, it is assumed that other hydro sites, such as some of those in the eastern DRC would have been further evaluated and thus be available at that time.

13.5.2 Transmission Requirements

The East African Community Master Plan[6] has proposed a substantial investment in lines within each of the EAC countries. In addition, the plan proposes two interconnectors;

- A 330 kV transmission line Arusha – Embakasi (Nairobi); and
- A double circuit 220 kV transmission line Tororo – Lessos.

During the Stage I of this assessment, the following transmission lines were proposed:

- 110 kV line from Kigoma, Rwanda to Rwegura, Burundi;
- 132 kV line from Kabarondo, Rwanda passing near Ngara to Biharamuro in the Kagera Province of Tanzania;
- 132 kV line from near Ngara, Rwanda to Gitega, Burundi; and
- 110 kV line from Gitega, Burundi through Bururi to Kigoma, Tanzania.

The DRC has also proposed a substantial investment in transmission lines, primarily to interconnect with neighboring countries and to evacuate power from power development options being considered as either new options or as rehabilitation of existing units. These lines include:

- 70 kV from Ruzizi, DRC to Bujumbura, Burundi to be upgraded to 110 kV
- 70 kV from Bukavu to Goma, both in the DRC to be upgraded to 110 kV
- 110 kV line between Goma nad Beni via Butembo
- 110 kV line between Mukungwa, Rwanda and Goma, DRC, then on to the proposed hydro plant of Mugomba in Uganda
- a line between Beni and Bunia to be connected to the exiting plant at Budana and the proposed plant at Semliki
- lines from the Mpiana Mwanga and Kiyimbi plants to the Ruzizi- Bujumbura line
- a submarine cable linking Kalemie, DRC to Kigoma, Tanzania

The location of some of these lines was based on the assumption that the Rusumo Hydro option would be built. As currently proposed, it includes transmission lines from the site to Gitega, Burundi; Kabarondo, Rwanda; and Biharamuro, Tanzania.

The transmission requirements being assessed in this report are those required to connect the EAC area (Kenya, Tanzania and Uganda) to the area that includes Burundi, Rwanda, Western Tanzania and Eastern DRC. It is assumed, for purposes of this assessment, that the proposals mentioned above will be implemented.

The generation/load balance in 2020 for this portfolio is shown in the table below.

[6] BKS Acres, East African Power Master Plan Study, Final Phase II Report, March 2005

Country	Generation (MW)	Peak Load (MW)	Surplus (MW)
Kenya	2045	2013	+32
Tanzania	2126	1249	+877
Uganda	877	902	-25
Burundi	74	141	-67
Eastern-DRC	166	209	-43
Rwanda	253	162	+91
Western Tanzania	82	71	+11
Total	5623	4747	+876

Note: Rwanda/DRC-East shared generation plants are allocated half to DRC and half to Rwanda.

The deficit for Eastern-DRC is seen to be relatively small and can easily be handled by the interconnection with Rwanda at Ruzizi-III. This sharing of Ruzizi-III also provides Eastern-DRC with access to the regional market. Although the load centres to the west of Lake Edward (Beni/Butembo) will need to be supplied from the Eastern-DRC system, this is not considered in this section since such connections are internal and not regional in nature. The small deficit of Eastern-DRC does not warrant additional regional interconnections.

The regional surplus of Uganda, Kenya and Tanzania (for purposes of this analysis defined as Group A) is seen to be close to 880 MW while the regional deficit of Burundi, Rwanda, DRC-East and Western Tanzania (again, for purposes of this analysis, defined as Group B) is 8 MW. Any interconnection to supply this deficit at peak load should also be capable of providing the reserve sharing requirements. For this study, it is considered appropriate that the interconnection capacity should be sufficient to cover the peak load deficit plus the loss of the largest generating unit within the importing region. Within the Group B region, the largest unit size is 82 MW, corresponding to the Ruzizi III plant, which would be shared by Rwanda and Eastern-DRC. The resulting interconnection capacity requirement is 90 MW.

Since the Group B region will require support to meet the peak load, it is considered necessary to have at least two interconnecting circuits with the Group A region in order to provide satisfactory reliability. The interconnection capacity of 90 MW is required to cover the outage of the largest generator in the Group B region. The outage of one tie line at the same time as the outage of the largest generator is considered to be a double contingency[7]. It is considered sufficient, therefore that with one interconnecting circuit out of service, the interconnection capacity requirement can be reduced to less than 10 MW to cover only the peak load deficit.

The maximum tie line loading for a range of line lengths and voltages is shown below.

[7] Transmission planning usually is based on the concept of single contingency, meaning that the load can still be met with one element (a generating unit or a transmission line) out of service.

Length (km)	Maximum Tie Line Loading (MW)		
	110 kV	132 kV	220 kV
100	80	115	315
150	65	95	260
200	55	80	225
250	50	70	200
300	45	65	180
350	40	60	165

Thus, for an interconnection capacity of 90 MW with two circuits (i.e. 45 MW per circuit) and 10 MW with one circuit, 110 kV would be suitable for up to a 300 km interconnection and132 kV and 220 kV would be suitable above 350 km. Since a 132 kV circuit and a 110 kV circuit would be similar in cost and the 132 kV provides a higher transfer capability, the 132 kV was selected for the interconnection voltage.

The selected alternative, as shown in Figure 13-1 would consist of:

- A 132 kV single-circuit line from Mbarara to Kigali (150 km). This project ha already been committed and will be funded by ADB;
- A 132 kV single-circuit line from Bulyanhulo to Biharamulo, connecting to the Biharamulo-Rusumo Falls 132 kV line (150 km).

It should be noted that there is existing generation in Burundi, Rwanda and Eastern DRC that uses expensive fossil fuels. In addition, as an emergency measure, some additional diesels are being installed in Rwanda. The carrying capability of the above lines would permit these plants to be displaced with power imported from other parts of the region (when it becomes available).

From an environmental impact standpoint, little impact is seen for the Bulyanhulu-Biharamulo corridor. The Mbarara-Kigali corridor would need to be routed around the protected area of Kagera, but this is not perceived as a major difficulty. The estimated cost of this interconnection scheme is:

- 132 kV single-circuit line (Bulyanhulu-Biharamulo), 150 km @US$ 115,000/km; cost = US$ 17 million;
- 132 kV single-circuit line (Mbarara-Kigali), 150 km @US$ 115,000/km; cost = US$ 17 million;
- Total Cost = US$ 34 million.

13.6 Regional Approach, Technological Diversification, Medium Load Growth Scenario – Portfolio 2Cb

A review of the portfolio for the regional approach using the best evaluated options and the medium load growth scenario indicates that 56% of the new generation is from hydroelectric options, which is a heavy reliance to be placed on a single technology. In this context, the concern is the risk of a regional extended drought condition that could reduce the energy availability from hydro options below historic minimums. The objective of this portfolio is to provide a generation portfolio that reduces such a reliance to not more than 50%.

13.6.1 Definition of the Portfolio

The proposed portfolio for this scenario would include the following:

- 2009: 120 MW of gas turbines, 60 MW of a combined cycle unit and one 10 MW diesel plant;
- 2010: a geothermal plant of 70 MW, the second methane-fuelled engine at Lake Kivu of 30 MW and a combined cycle unit of 60 MW;
- 2011: the third unit at Lake Kivu at 30 MW and a gas turbine of 60 MW;
- 2012: Bujagali (units 1 to 4) and Rusumo Falls hydro plants;
- 2013: the geothermal plant at Suswa of 70 MW and the hydro plants at Kabu 16 and Kakono;
- 2014: the fifth unit at Bujagali, Ruzizi III hydro plant and a gas turbine of 60 MW;
- 2015: the Ruhudji Hydro plant;
- 2016: the Menengai geothermal plant;
- 2017: the fourth engine at Lake Kivu and two new geothermal plants whose locations has not yet been confirmed and the Karuma hydro plant;
- 2018: a wind farm and one coal-fired unit at Mombasa;
- 2019: a second unit at the Mombasa coal-fired themal plant;
- 2020: the Rumakali hydro plant, the Mchuchuma coal-fired thermal plant and the third unit of the Mombasa coal fired plant.

Of all these plants only Mchuchuma and the Mombasa coal-fired thermal plants are from the group of options that are less preferred.

It may be noted that by 2020 there are no further qualified hydro options. However further project definition studies particularly for the eastern DRC could result in further hydro options by this date.

13.6.2 Transmission Requirements

The generation/load balance in 2020 for this portfolio is shown in the table below.

Country	Generation (MW)	Peak Load (MW)	Surplus (MW)
Kenya	2285	2013	+272
Tanzania	1996	1249	+747
Uganda	877	902	-25
Burundi	74	141	-67
Eastern-DRC	166	209	-43
Rwanda	253	162	+91
Western Tanzania	82	71	+11
Total	**5733**	**4747**	**+986**

Note: Rwanda/DRC-East shared generation plants are all allocated to Rwanda.

The regional surplus of Uganda, Kenya and Tanzania (Group A) is seen to be close to 990 MW while the regional deficit of Burundi, Rwanda, DRC-East and Western Tanzania

(Group B) is 8 MW. As the deficit is the same as in the conditions described for Strategy 1 the selected alternative is the same and, as shown in Figure 13-1, would consist of:

- A 132 kV single-circuit line from Mbarara to Kigali (150 km);
- A 132 kV single-circuit line from Bulyanhulo to Biharamulo, connecting to the Biharamulo-Rusumo Falls 132 kV line (150 km).

From an environmental impact standpoint, little impact is seen for the Bulyanhulu-Biharamulo corridor. The Mbarara-Kigali corridor would need to be routed around the protected area of Kagera, but this is not perceived as a major difficulty.

The estimated cost of this interconnection scheme is US$ 34 million.

13.7 Regional Approach, Geographical Diversification and Medium Load Growth Scenario – Portfolio 2Db

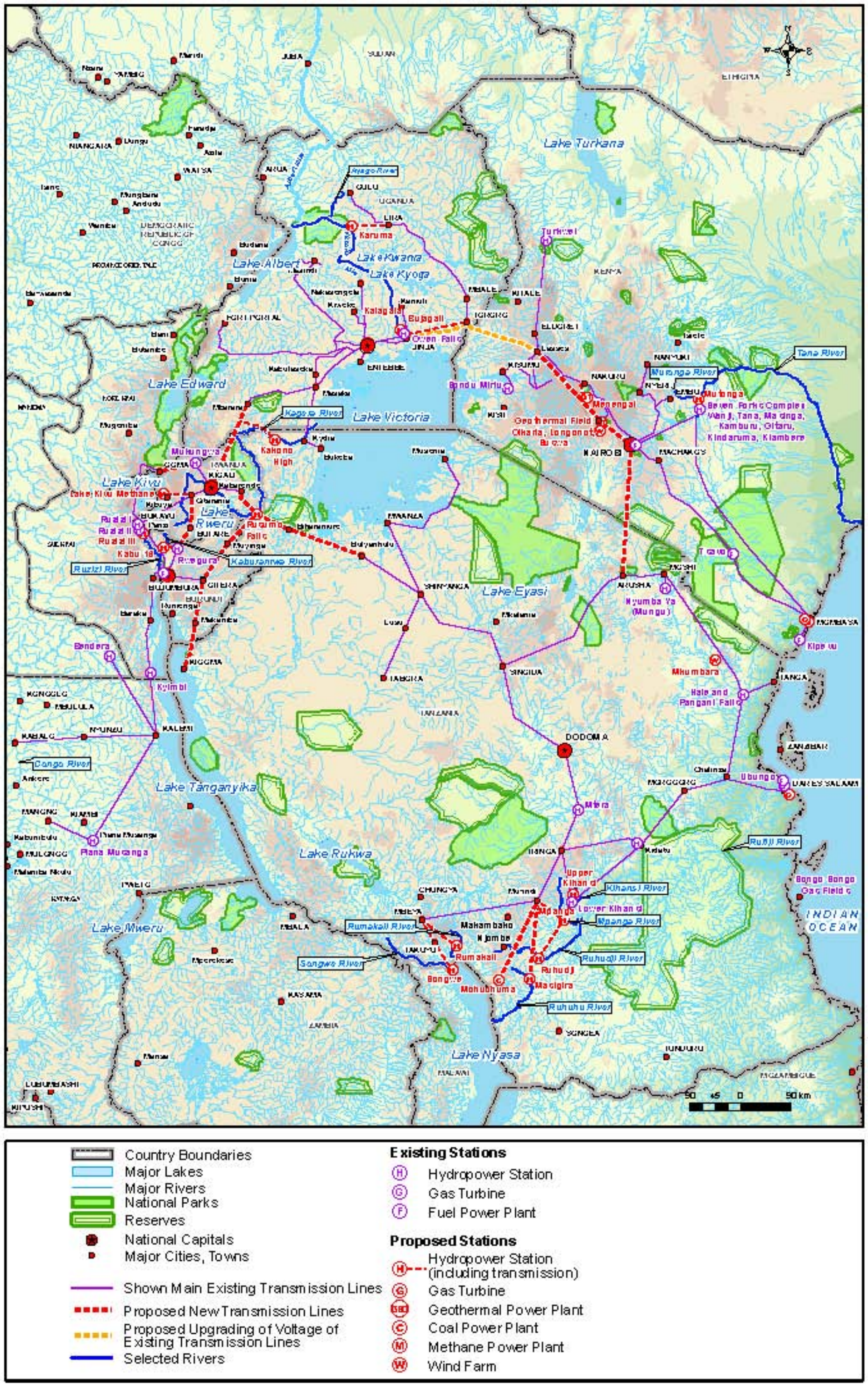
A review of the portfolio for the regional approach and technological diversification using the medium load growth scenario indicates that Kenya would provide 35% of the new generation while having 43% of the regional load. The same table shows the reverse for Tanzania: 40% of the new generation as compared to 29% of the load. The objective of this strategy is to provide a portfolio that provides a better balance geographically between new generation resources to be implemented in the region and the load.

13.7.1 Definition of the Portfolio

The proposed portfolio for this scenario would include the following:

- 2009: 120 MW of gas turbines, 60 MW of a combined cycle unit and one 10 MW diesel plant;
- 2010: a geothermal plant of 70 MW, the second methane-fuelled engine at Lake Kivu of 30 MW and a combined cycle unit of 60 MW;
- 2011: the geothermal plant at Suswa, a combined cycle unit and the third unit at Lake Kivu at 30 MW;
- 2012: Bujagali and Rusumo Falls hydro plants;
- 2013: the hydro plant at Kabu 16 and a combined cycle plant of 60 MW;
- 2014: the fifth unit at Bujagali and Ruzizi III hydro plant;
- 2015: the fourth engine at Lake Kivu and the Menengai geothermal plant;
- 2016: the Karuma and Kakono hydro plants and the first unit of a coal-fired thermal plant at Mombasa;
- 2017: the Mutonga hydro plant and two new geothermal plants whose locations have not yet been confirmed;
- 2018: the Ruhudji hydro plant
- 2019: the second and third coal fired units at Mombasa;
- 2020: the fourth and fifth units of the Mombasa coal fired plant, and a wind farm.

Figure 13-1 - Transmission Requirements



Of all these plants only the Mombasa coal-fired thermal plant is from the group of options that are less preferred.

The objective of this strategy, to match loads and supply in each country, is reasonably well met. In Kenya, generation would be 47% of the total versus 43% of the load, and in Tanzania the corresponding values are 27% and 29% respectively. In Uganda the supply is 16% of the total versus the 20% of the regional load. However Uganda generation could only be increase by another hydro project on the Victoria Nile, or large low speed diesel.

13.7.2 Transmission Requirements

The generation/load balance in 2020 for this portfolio is shown in the table below.

Country	Generation (MW)	Peak Load (MW)	Surplus (MW)
Kenya	2645	2013	+632
Tanzania	1574	1249	+325
Uganda	877	902	-25
Burundi	74	141	-67
Eastern-DRC	166	209	-43
Rwanda	253	162	91
Western Tanzania	82	71	11
Total	**5671**	**4747**	**924**

Note: Rwanda/DRC-East shared generation plants are all allocated to Rwanda.

The regional surplus of Uganda, Kenya and Tanzania (Group A) is seen to be close to 930 MW while the regional deficit of Burundi, Rwanda, DRC-East and Western Tanzania (Group B) is 8 MW. As the deficit is the same as in the other strategies, the selected alternative is the same and would consist of:

- A 132 kV single-circuit line from Mbarara to Kigali (150 km);
- A 132 kV single-circuit line from Bulyanhulo to Biharamulo, connecting to the Biharamulo-Rusumo Falls 132 kV line (150 km).

The estimated cost of this interconnection scheme is US$ 34 million.

13.8 Comparison of Strategies Using Medium Load Growth Scenario

Table 13-6 presents a comparison of the power development options included in the portfolios representing each of the three strategies examined for the regional integration approach. This table indicates that there is very little difference between the portfolios representing each of these strategies. The principal reason for this similarity is that the pool of power development options that are available to choose from is relatively small compared to the needs of the region.

Figure 13-2 and Table 13-7 present a comparison of the portfolios for the strategies examined in this report in terms of investment, present value of lifetime costs, diversification and geographic diversification as well as the use of power development options other than those that are best evaluated. The cost comparison is based on an analysis carried out using a software package that takes account of the items listed on the next page.

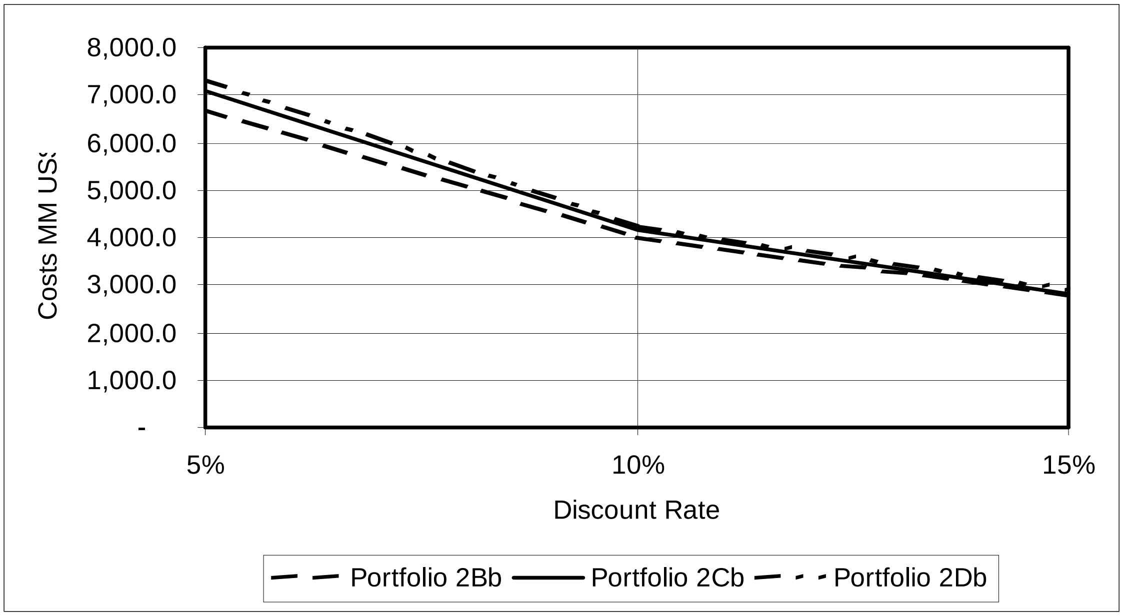
Table 13-6 - Comparison of Portfolios for Each Strategy of the Regional Cooperation Approach

POWER DEVELOPMENT OPTIONS			
YEAR	Portfolio 2Bb	Portfolio 2Cb	Portfolio 2Db
2004	All existing EAPMP + SSEA + DRC	All existing EAPMP + SSEA + DRC	All existing EAPMP + SSEA + DRC
2005	Kiira Units 14-15	Kiira Units 14-15	Kiira Units 14-15
	GT	GT	GT
2006	Kiambere extension	Kiambere extension	Kiambere extension
	GT	GT	GT
	Diesel 3 x 10	Diesel 3 x 10	Diesel 3 x 10
2007	GT	GT	GT
	Diesel 1 x 10	Diesel 1 x 10	Diesel 1 x 10
2008	Sondu Miriu	Sondu Miriu	Sondu Miriu
	Olkaria II	Olkaria II	Olkaria II
	GT	GT	GT
	Diesel 1 x 10	Diesel 1 x 10	Diesel 1 x 10
	Kivu engine No. 1	Kivu engine No. 1	Kivu engine No. 1
2009	GT	GT	GT
	GT	GT	GT
	Combined cycle unit	Combined cycle unit	GT
	Diesel 1 x 10	Diesel 1 x 10	Diesel 1 x 10
2010	Geothermal	Geothermal	Kivu engine No. 2
	Kivu engine No. 2	Kivu engine No. 2	GT
	Combined cycle unit	Combined cycle unit	Geothermal
2011	Kivu engine No. 3	Kivu engine No. 3	Geothermal Suswa
	GT	GT	Combined cycle unit
			Kivu engine No. 3
2012	Bujagali 1-4	Bujagali 1-4	Bujagali 1-4
	Rusumo	Rusumo	Rusumo
2013	Geothermal Suswa	Geothermal Suswa	
	Kabu 16	Kabu 16	Kabu 16
	Kakono	Kakono	Combined cycle unit
2014	Bujagali Unit 5	Bujagali Unit 5	Bujagali Unit 5
	GT	Ruzizi III	Ruzizi III
	Ruzizi III	GT	
2015	Ruhudji	Ruhudji	Kivu engine No. 4
			Menengai Geothermal
2016	Karuma	Menengai Geothermal	Karuma
			Mombasa 1
			Kakono
2017	Rumakali	Kivu engine No. 4	Mutonga
		Geothermal 2 x 70	Geothermal 2 x 70
		Karuma	
2018	Menengai Geothermal	Wind	Ruhudji
	Kivu engine No. 4	Mombasa 1	
	Geothermal 2 x 70		
2019	Songwe	Mombasa 2	Mombasa 2 and 3
2020	Mutonga	Rumakali	Mombasa 4
	Wind	Mchuchuma	Mombasa 5
	Mombasa 1	Mombasa 3	Wind

Options common to all three portofolios (yellow)

Options other than the Best Evaluated (orange)

Figure 13-2 - Present Worth of System Investment, Operating and Fuel Costs



1. Investment costs of all new power development options, which are converted into annuities using the expected useful life of each option and specific discount rates (5%, 10%, 12% and 15%);
2. Fixed operation and maintenance costs for all new power development options;
3. Variable operation and maintenance costs for all existing generation and for all new power development options;
4. Fuel costs for the systems as a whole;
5. The load forecast (energy and peak demand) from 2005 to 2020;
6. The monthly load patterns;
7. Maintenance schedules for each power development option (existing and new);
8. In order to assess the impact of options installed late in the period of analysis, the software takes the costs estimated in 2020 and extends them each year until 2054.

This software calculates the present value of the stream of costs for the entire period considered. This analysis indicates that:

- The portfolio representing technological diversification would cost[8] US$ 140 million (or 3.5%) more than the portfolio that ignores any diversification and concentrates on using only the best-evaluated options, regardless of where they are located.
- The portfolio representing geographic diversification would cost about 2.5% more than the technological diversification strategy.
- These results hold over a wide range of discount rates.
- The total investment over the period 2005 to 2020 in all three portfolios would be very similar: US $5.30 billion for the portfolio emphasizing the best evaluated options, US$

8 in terms of the present value at a discount rate of 10% of capital, operating and fuel costs over the period of analysis (2005 to 2054)

5.55 billion for the portfolio emphasizing technological diversification and US$ 5.41 billion for the portfolio emphasizing geographical diversification.

Table 13-7 - Comparison of Portfolios Using Medium Load Growth Scenario

	"Best Evaluated" Portfolio 2Bb	Technological Diversification Portfolio 2Cb	Geographical Diversification Portfolio 2Db
Present Value of annual costs at 10% discount rate – US $1,000 million[9]	4.01	4.15	4.25
Total Investment– US $1,000 million[10]	5.30	5.55	5.41
Technological Diversification - % of new plant using each technology			
♦ Hydro	56%	42%	38%
♦ Geothermal	14%	14%	14%
♦ Gas	14%	13%	14%
♦ Coal	-	20%	23%
♦ Other	16%	11%	11%
♦ Total	100%	100%	100%
Selection of Options - % of new plant			
♦ Best Evaluated	85%	80%	77%
♦ Other	15%	20%	23%
Geographical Diversification - % of new plant located in each country			
♦ Burundi (load = 3%)	1%	1%	1%
♦ Eastern DRC (load = 2%)	4%	4%	4%
♦ Kenya (load = 43%)	29%	35%	46%
♦ Rwanda (load = 3%)	5%	5%	5%
♦ Tanzania (load = 29%)	44%	39%	27%
♦ Uganda (load = 20%)	17%	16%	16%
♦ Total	100%	100%	100%

13.9 Comparison of Strategies under Different Load Growth Scenarios

Table 13-8 presents a comparison of the portfolios under the technological diversification strategy for the three load growth scenarios: medium, high and transformation. As can be seen, as the as higher growth rates are used, there are more and more resources required from the group of options that are less attractive. Table 13-9 compares the first three strategies for the different load growths in terms of investment, life-cycle cost, technologies used, geographical location and use of best evaluated options.

9 The impact of building Bujagali in one stage for the end of 2010 would be to increase the present value of all portfolios by about US$ 31.5 million, of 0.8%

10 The impact of revised Bujagali plan would not have any impact on investments for any of the portfolios.

13.9.1 High Load Growth Scenario

13.9.1.1 Regional Approach, Technological Diversification and High Load Forecast – Portfolio 2Cc

The impact of this development scenario is to advance the development of some of the power development options identified in Table 13-8 and to add another 1348 MW of new capacity.

The transmission requirements identified in Section 13.5.2 would be suitable for this portfolio up to at least the year 2017.

13.9.1.2 Regional Approach, Geographical Diversification and High Load Forecast – Portfolio 2Dc

The impact of this development scenario is to advance the development of some of the power development options identified in Table 13-9 and to add another 1660 MW of new capacity.

The transmission requirements identified in Section 13.5.2 would, again, be suitable for this portfolio up to at least the year 2017.

13.9.2 Regional Approach, Transformation Scenario – Portfolio 2d

The impact of this development scenario is to advance the development of some of the power development options identified under the medium load growth and to add another 6800 MW of new capacity (i.e., over double the needs shown in that table for the medium load growth scenario). This scenario will include several power options based on coal as a source of fuel.

The transmission requirements identified in Section 13.5.2 would be suitable for this portfolio up to at least the year 2015.

Table 13-8 - Comparison of Portfolios for Alternative Load Growth* Scenarios

YEAR	Portfolio 2Cc	Portfolio 2Dc	Portfolio 2d
2004	All existing EAPMP + SSEA + DRC	All existing EAPMP + SSEA + DRC	All existing EAPMP + SSEA + DRC
2005	Kiira Units 14-15 GT	Kiira Units 14-15 GT	Kiira Units 14-15 GT
2006	Kiambere extension GT Diesel 3 x 10	Kiambere extension GT Diesel 3 x 10	Kiambere extension GT Diesel 3 x 10
2007	GT Diesel 1 x 10	GT 3 GT Diesel 1 x 10 Sondu Miriu Olkaria II	GT Diesel 1 x 10
2008	Sondu Miriu Olkaria II GT Diesel 1 x 10 Kivu engine No. 1	Combined cycle unit Combined cycle unit Diesel 1 x 10 Kivu engine No. 1	Sondu Miriu Olkaria II GT Diesel 1 x 10 Kivu engine No. 1
2009	2 GT Combined cycle unit Diesel 1 x 10	2 GT Kivu engine No. 2 Diesel 1 x 10	2 GT Combined cycle unit Diesel 1 x 10
2010	Geothermal Kivu engine No. 2 Combined cycle unit	Geothermal Kivu engine No. 3 LSD	Geothermal Kivu engine No. 2 Combined cycle unit
2011	Kivu engine No. 3 GT	LSD Geothermal Suswa	Kivu engine No. 3 2 GT Geothermal Suswa
2012	Bujagali 1-4 Rusumo	Bujagali 1-4 Rusumo	Bujagali 1-4 Rusumo Kabu 16 Kakono Mutonga Kivu engine No. 4 Mchuchuma 1-2
2013	Geothermal Suswa Kabu 16 Kakono	Kabu 16 Kakono Mutongo Masigira	Mombasa 1,2 (150 MW units) Masigira Mchuchuma 3-4
2014	Bujagali Unit 5 Ruzizi III GT	Bujagali Unit 5 Ruzizi III Ruhudji	Ruzizi III Bujagali Unit 5 Ruhudji Karuma
2015	Ruhudji	Mchuchuma Menengai Geothermal	Mombasa 3 Mpanga Songwe Menengai Geothermal
2016	Menengai Geothermal	Mchuchuma Kivu engine No. 4	Rumakali Geothermal 2 x 70 Mombasa 4,5,6
2017	Kivu engine No. 4 Geothermal 2 x 70 Karuma	Geothermal 2 x 70 Karuma	Mombasa 7-10 Mombasa 300 - 1 Mombasa 300 - 2
2018	Wind Mombasa 1	Rumakali Songwe	Mombasa 1200 - 3, 4, 5, 6
2019	Mombasa 2	Mombasa 1, 2, 3	Mombasa 1200 - 7, 8, 9, 10
2020	Rumakali Mchuchuma Mombasa 3	Mombasa 4, 5,6	Mombasa 1 800 - 11, 12, 13, 14, 15,1(Wind

Options committed or under construction

Options other that the Best Evaluated

*** Note**: Based on Technological Diversification Strategy

Table 13-9 - Comparison of Strategies to various Load Growth Scenarios

	Technological Diversification		Geographical Diversification		Trans-formation Scenario
	Medium Scenario Portfolio 2Cb	High Scenario Portfolio 2Cc	Medium Scenario Portfolio 2Db	High Scenario Portfolio 2Dc	Portfolio 2Bd
Present Value of annual costs at 10% discount rate – US $1,000 million	4.15	6.03	4.25	5.92	9.85
Total Investment– US $1,000 million	5.55	7.96	5.41	7.08	15.82
Percentage of new plant using each technology					
♦ Hydro	42%	39%	38%	41%	21%
♦ Geothermal	14%	9%	14%	10%	5%
♦ Gas	13%	9%	14%	9%	4%
♦ Coal	20%	26%	23%	16%	67%
♦ Other	11%	17%	11%	24%	3%
♦ Total	100%	100%	100%	100%	100%
Selection of Options - % of new plant					
♦ Best Evaluated	80%	65%	77%	66%	30%
♦ Other	20%	35%	23%	34%	70%
Percentage of new plant located in each country					
♦ Burundi (load = 3%)	1%	1%	1%	1%	1%
♦ Eastern DRC (load = 2%)	4%	3%	4%	3%	1%
♦ Kenya (load = 43%)	35%	41%	46%	41%	71%
♦ Rwanda (load = 3%)	5%	3%	5%	3%	2%
♦ Tanzania (load = 29%)	39%	39%	27%	33%	21%
♦ Uganda (load = 20%)	16%	11%	16%	20%	5%
Total	100%	100%	100%	100%	100%

13.10 Sensitivity Analysis

13.10.1 Impact of Including Options with less than the Minimum Level of Data Available [Portfolio 2Cb (S1)]

The purpose of presenting this alternative is to give an indication of the likelihood that options that might be attractive with more information might have been eliminated from the analysis. It will also identify which of such options merit further study. This portfolio would include the following:

- 2009: 120 MW of gas turbines, 60 MW of a combined cycle unit and one 10 MW diesel plant;
- 2010: a geothermal plant of 70 MW, the second methane-fuelled engine at Lake Kivu of 30 MW and a combined cycle unit of 60 MW;
- 2011: a gas turbine plants and the third unit at Lake Kivu at 30 MW;
- 2012: Bujagali and Rusumo Falls hydro plants;
- 2013: the Hydro plants at Kyimbi, Budana, Piana Mwanga and Bangamisa;
- 2014: the fifth unit at Bujagali, the Ruzizi III and Babeda ! hydro plants and a gas turbine;
- 2015: the Suswa and Menengai geothermal plants;
- 2016: the Ruhudji hydro plant;
- 2017: the fourth engine at Lake Kivu and the Mchuchuma coal fired thermal plant;
- 2018: a unit of the Mombasa coal-fired thermal plant;
- 2019: the Karuma hydro plant;
- 2020: the second unit of the Mombasa coal fired plant and the Rumakali hydro plant.

Of all these plants, only the Mombasa and the Mchuchuma coal-fired thermal plants are from the group of options that are less preferred. The hydro plants at Kiymbi, Budana, Piana Mwanga, Bangamisa and Babeda need to be further studied before they can be included with confidence in the analyses.

13.10.2 Impact of Imports [Portfolio 2Cb (S2)]

An important generation supply option to meet the load growth is the importation of electricity from outside the NELSAP region. For the purpose of this study it is assumed that any such import would be from the Southern African Power Pool, based on delivery from Pensulo in Zambia to Mbeya in South West Tanzania. This delivery route would also apply to any large blocks of power from the Inga complex that would have to be wheeled through the SAPP system.

The EAPMP notes that power deliveries from the SAPP would require construction of 700 km of 330 kV single circuit line between Pensulo and Mbeya, presumably to be financed by a Zambian / SAPP entity, and which would entail a unit cost in the order of about 1.6 cents/kWh. Further costs would be associated with reinforcement of the Zambian system, and for transmission within the EAC region.

Other considerations include supply reliability and maximum imports as a function of the integrated system supply. Potentially this suggests that imports should be limited to about 10% of the system supply, e.g., 260 MW in 2010 or 460 MW in 2020.

For the purpose of this study it was considered important to establish an upper limit to the cost of any such import, based on comparison with indigenous supply to the system.

A scenario was developed that assumed three blocks of imports: 100 MW in each of 2009, 2010 and 2011. This portfolio would include the following plants:

- 2009: 60 MW of gas turbines, one 10 MW diesel plant and imports of 100 MW;
- 2010: an additional 100 MW of imports plus the second methane-fuelled engine at Lake Kivu of 30 MW and a gas turbine of 60 MW;

- 2011: a third block of imports of 100 MW, the third unit at Lake Kivu at 30 MW and a geothermal plant of 70 MW;
- 2012: Bujagali (units 1 to 4) and Rusumo Falls hydro plants;
- 2013: the geothermal plant at Suswa of 70 MW and the hydro plant at Kabu 16;
- 2014: the fifth unit at Bujagali and Ruzizi III hydro plant;
- 2015the Ruhudji Hydro plant;
- 2016: the Menengai geothermal plant;
- 2017: the fourth engine at Lake Kivu, two new geothermal plants whose locations has not yet been confirmed and the first part of Mchuchuma coal-fired thermal plant;
- 2018: the second part of Mchuchuma coal-fired thermal plant;
- 2019: the Karuma hydro plant;
- 2020: the Rumakali hydro plant and two units from the Mombasa coal-fired thermal plants and a wind farm.

Of all these plants, only Mchuchuma and the Mombasa coal-fired thermal plants are from the group of options that are less preferred.

This would exceed the 10% criteria suggested above for 2010 but would be under the limit for 2020, however, it would have a significant impact in reducing investment requirements in the region.

Such imports in the context of the medium load forecast would be similar to the cost of the portfolio representing technological diversification, if imports were priced at 3 cents/kWh, delivered to Mbeya. However this does not take into account the transmission reinforcement that would be required in the EAC regions. The corresponding results determined in the EAPMP were also 3 cents. After adding in the delivery costs it is concluded that supply to Pensulo would have to be in the order of 2 cents/kWh, which is considered to be probably uneconomic for SAPP.

The primary advantage of imports would be the reduction in capital investment required for new generation facilities. For example an equivalent 300 MW of new thermal plant would cost in the order of half a billion dollars.

13.10.3 Impact of Eliminating Comparative Analysis [Portfolio 2Cb(S3)]

It is, of course, essential to take into account the environmental and social impacts of power development options when planning the expansion of power facilities. In doing so, a planner needs to know the cost impact of such considerations. The purpose of presenting this alternative is to identify the cost impact of applying the results of the comparative analysis. This portfolio would include the following:

- 2009: 120 MW of gas turbines, 60 MW of a combined cycle unit and one 10 MW diesel plant;
- 2010: a geothermal plant of 70 MW, the second methane-fuelled engine at Lake Kivu of 30 MW and a combined cycle unit of 60 MW;
- 2011: the third unit at Lake Kivu at 30 MW and a gas turbine of 60 MW;
- 2012: Bujagali (units 1 to 4) and Rusumo Falls hydro options;
- 2013: the Masigira hydro plant, the Suswa geothermal option and a fourth methane-fuelled engine at Lake Kivu;

- 2014: the fifth unit at Bujagali and Ruzizi III hydro option;
- 2015: the geothermal plant at Menengai and the Karuma Hydro option;
- 2016: two new geothermal plants whose locations has not yet been confirmed and the Mpanga hydro option;
- 2017: the Mchuchuma coal-fired thermal plant;
- 2018: the Songwe hydro option;
- 2019: the Rumakali hydro option and a 60 MW gas turbine
- 2020: the second part of the Mchuchuma coal-fired thermal plant and the first unit of the Mombasa coal-fired thermal plant.

Of all these plants, Mpanga and Songwe hydro plants and the Mchuchuma and Mombasa coal-fired thermal plants are from the group of options that are less preferred.

13.10.4 Analysis of Results of Sensitivity Analyses

Table 13-10 presents a comparison of the sensitivity of the Technological Diversification portfolios to variations in key parameters in terms of investment, present value of lifetime costs, diversification and geographic diversification as well as the use of power development options other than those that are best evaluated.

This analysis indicates that:

- If the screening criteria were to be relaxed so that the level of information available was no longer a consideration, the overall cost of power development in the region could be reduced by about US$ 120 million or 2.9% (from $4.15 thousand million to 4.03 as shown on the first line under the headings of Table 13-10). This analysis includes the following power development options that have not yet been studied beyond the reconnaissance level:
  - Kiymbi, 43 MW;
  - Budana, 13 MW;
  - Piana Mwanga, 38 MW;
  - Bangamisa, 48 MW; and
  - Babeda 1, 50 MW.
- If the comparative analysis is not carried out and a portfolio is defined using cost and on-power dates as the only criteria, there could be a reduction in overall present value of costs of up to US $60 million (4.15 thousand million less 4.09) or about 1.5%.
- If power is available from outside the region for less than 3 US¢/kWh, it would be beneficial to the power development of the region (i.e. imports at 3 US¢/kWh would reduce the overall system costs by about US $210 million or about 5.0%).

13.11 Need for Flexibility

As shown in the previous sections, there are limited power development options available during the early years of the analysis, thus the options in all three strategies are the same. For the period beyond about 2015, there is sufficient time available to carry out the required studies to prepare options for implementation and therefore decisions need to be made as to the strategy that is to be followed. The key issues involved in such decisions are:

Table 13-10 - Comparison of Sensitivity Tests Using Medium Load Growth Scenario

	Portfolio 2Cb	Sensitivity Test to: Insufficient data Portfolio 2Cb (S1)	Imports @ $0.03/kWh Portfolio 2Cb(S2)	Environmental and Social Issues Portfolio 2Cb(S3)
Present Value of annual costs at 10% discount rate – US $1,000 million	4.15	4.03	3.94	4.09
Total Investment– US $1,000 million	5.55	5.42	5.05	5.52
Percentage of new plant using each technology				
♦ Hydro	42%	47%	41%	47%
♦ Geothermal	14%	10%	14%	14%
♦ Gas	13%	13%	10%	13%
♦ Coal	20%	21%	21%	17%
♦ Imports at US $0.03/kWh	-	-	9%	-
♦ Other	11%	9%	5%	9%
♦ Total	100%	100%	100%	100%
Selection of Options - % of new plant				
♦ Best Evaluated	80%	73%	79%	66%
♦ Other	20%	27%	21%	34%
Percentage of new plant located in each country				
♦ Burundi (load = 3%)	1%	1%	1%	1%
♦ Eastern DRC (load = 2%)	4%	10%	4%	4%
♦ Kenya (load = 43%)	35%	25%	25%	24%
♦ Rwanda (load = 3%)	5%	4%	5%	5%
♦ Tanzania (load = 29%)	39%	44%	40%	50%
♦ Uganda (load = 20%)	16%	16%	16%	16%
♦ Imports at US $0.03/kWh	-	-	9%	-
♦ Total	100%	100%	100%	100%

- The strategy of using the best-evaluated options results in a heavy reliance on hydro options with the attendant risk of drought. It also leads to a heavy reliance by some countries on those countries with abundant hydro resources
- The strategy of technological diversification reduces reliance on hydro options but includes more options that are less attractive. There remains, though the issue of perhaps a disproportionate reliance by some countries on others

- The strategy of geographical diversification addresses the issue of perhaps a disproportionate reliance by some countries on others but includes more options that are less attractive.

Another key element is the rate of growth of demand in the region and the resources that are developed to meet this load. As mentioned in Chapter 5, the base medium and high load growth scenarios will not change appreciable the standard of living in the region; only the transformation scenario will do so. However, that scenario will use up all the resources identified in the region (all the best evaluated options, others and screened out options).

For the above reasons, it is essential that the power development strategy remain as flexible as possible to meet different economic growth and demand scenarios. For the purpose of this analysis, the portfolio of options selected for the NELSAP Indicative Power Development Plan is based on technological diversification, and the medium load forecast of 5.6% to 6.3% per year (2Cb).

13.12 Conclusions

The presentation and analysis of the various portfolios leads to the following conclusions:

- The independent approach to power development leads to lower power availability and the use of smaller, less cost-effective and less environmentally acceptable development options.
- There is very little difference in the early years of the period of analysis between portfolios representing the best-evaluated options, technological diversification and geographical diversification. This applies in terms of option selection, investments, present value of costs and transmission requirements.
- From a power sector planning perspective, security of supply is an important criterion and geographical diversification is preferred. On the other hand, the history of droughts in the region suggests that technological diversification should be emphasized. As mentioned above, there is little difference between these two strategies. Thus, for purposes of the NELSAP Indicative Power Development Strategy recommended in Chapter 15 of this report, the technological diversification strategy is used.
- The medium and high load growth scenarios can be met with power development options from the region but these growth scenarios will not materially improve the standard of living of the population in the region. As mentioned in Chapter 5, these growth rates will result in a unit consumption in the region of 44% to 56% of the current average for all of Africa (even excluding the wealthier countries) of 320 kWh/capita.
- To significantly improve the standard of living of the people in the region, the transformation scenario would be needed, which would lead to a unit consumption in the region equal to about the current average for all of Africa excluding the wealthier countries. This is still only about one third of the level reached by the developing countries of the world, even when the wealthier of them are excluded from the comparison. However, there are insufficient resources in the region to satisfy that demand.

14 ASSESSMENT OF CUMULATIVE IMPACTS

Cumulative impacts take into account the effects of multiple activities that add up incrementally to affect resources of regional or national significance associated with the implementation of a proposed option or set of options, regardless of who is responsible for the other identified activities. Cumulative impact assessment focuses on resources sustainability, within determined geographic and time boundaries.

Assessing the cumulative environmental and socio-economic consequences of an action requires delineating the cause-effects relationship, within these predetermined boundaries, between the multiple activities and the resources, ecosystems and human communities impacted.

The present assessment of power development portfolios identifies the main cumulative impacts of the proposed Regional Cooperation - Best Evaluated Options approach (Portfolio 2Bb) with maximized use of the most attractive resources with medium load growth compared to the Independent Development , with Primarily National Options (Portfolio 1Aa), and considers all the significant issues identified by the stakeholders; then it highlights the differences between the Portfolio of Technological Diversification and Medium Growth (2Cb) and Geographic Diversification also with Medium Growth (2Db).

14.1 Definition

Cumulative impacts refer to impacts that are additive or interactive in nature and result from multiple activities over time, including the option being assessed[1]:

- They are caused by the aggregate of past, present and reasonably foreseeable future actions;
- They are the total impact, including both direct and indirect impacts, on a given resource, ecosystem and human community of all actions taken, no matter who has taken the actions;
- They need to be analyzed in terms of the specific resource, ecosystem and human communities being affected;
- They cannot be practically analyzed beyond a reasonable boundary; the list of impacts must focus on those that are truly meaningful;
- They correspond to geographical or natural boundaries;
- They may result from the accumulation of similar impacts or the synergistic interaction of different impacts;
- They may last beyond the life of the project that caused the impacts;
- They should be assessed in terms of the capacity of the affected resource, ecosystem or human community to accommodate additional impacts.

The criteria for judging the significance of cumulative impacts are not different from those for other types of environmental assessment, but threshold effects and irreversible changes in the use of critical resources will generally be key concerns.

[1] Based on the US Council on Environmental Quality (CEQ)

14.2 Approach

The following Table 14-1 illustrates the approach used to determine the most significant cumulative impacts:

Table 14-1 - Steps in Cumulative Impact Analysis

Process Components	Cumulative Impact Analysis
Scoping	1. Establish the geographic scope for the analysis and the timeframe **(Section 14.3)**
Describing the Baseline Conditions	2. Identify the main/regional trends/issues **(Section 14.4)** 3. Analyse the "Independent development approach" strategy (1Aa) **(section 14.6)**
Determining the Magnitude and the Consequences	4. Estimate the significant cumulative impacts in terms of their magnitude, geographic scope, duration, frequency, reversibility and likelihood of occurrence for Portfolio 2Bb, and highlight differences with Portfolios 2Cb and 2Db, respectively with emphasis on technological diversification and geographical diversification. **(sections 14.7 and 14.8)** 5. Make recommendations to modify, or add measures to, investments making up to the development portfolio in order to avoid or minimize significant cumulative impacts **(sections 14.9 and 14.10)**

The main environmental issues that are identified for the SSEA hydroelectric options are related to:

- Change in flow regime;
- Sedimentation, erosion and water quality;
- Proliferation of invasive aquatic vegetation;
- Habitats and natural resources.
- Emissions of green house gases from the first year of the reservoir flooding

Two main cumulative impact issues are considered for conventional thermal options:

- Emissions of greenhouse gas emissions; and
- Effects of air pollutant emissions on habitats and human health.

Finally, no significant cumulative impact issues are identified with regards to geothermal options, wind power options and transmission lines.

A Cumulative Impact Assessment requires an Environmental Impact Assessment as a pre-requisite. The quantity and quality of data available is very limited for most projects. Only Bujagali, Mutonga and Karuma Falls have EIAs, albeit more or less complete, and have been subject to controversy; Ruhudji and Rumakali have only preliminary EIAs. Little information is available on environmental impacts of other options. In addition, no complete cumulative impact studies have been undertaken on any of the projects. However, the assessment could draw upon the information contained in the Nile River Transboundary Environmental Analysis, particularly with respect to the identification of environmentally sensitive areas and protected areas with transboundary significance.

At this stage, given the body of information available, the cumulative impact issues of the hydroelectric, thermal, geothermal, wind options and related power lines that are part of each portfolio, can be only be described on the basis of the steps defined above in Table 14-1. Thus the analysis of cumulative impacts in this report is not a quantitative Cumulative Impact Assessment per se but rather provides the basic qualitative information on cumulative impact issues to be taken into account into the analysis of the portfolios.

14.3 Defining the spatial boundaries and timeframe

The geographic scope for hydroelectric options is usually defined as the catchment area, the reservoir itself (or poundage area) and the river downstream from the dam. Cumulative impact issues for hydroelectric options will thus be linked with other hydroelectric developments in the same watershed, as well as to the presence of industries and agricultural processes impacting water quality, causing disappearance of wetlands and deforestation, all affecting resources, ecosystems and human communities. The exception to this would be the greenhouse gases emissions from large reservoirs, during the first few years, that would not necessarily be constrained to the catchment area. Notwithstanding this, the definition of the spatial boundaries for hydroelectric projects based on catchment area as been considered as the most appropriate basis for environmental impacts.

For thermal options, the geographic scope is more relevant on sub-regional for air pollutants emissions and on a regional basis for greenhouse gas emissions that tend to have an impact more on a global scale. They interact with other air pollutant emissions, and all of them are subjected to regional climatic factors such as winds, rain patterns and climatic changes.

Based on these considerations, and clustering of retained potential development options on the basis of logical zones of influence, cumulative impacts will be estimated for six main groups of options corresponding to watersheds where projects have been retained:

- Hydropower options in Victoria Nile watershed (outflow of Lake Victoria, downstream to Lake Albert);
- Hydropower options in the Lake Victoria watershed, including Sondu Miriu and Kagera Rivers discharging into Lake Victoria;
- Options in Lake Tanganyika basin, including hydropower options on the Ruzizi and Kaburantwa Rivers leading to Lake Tanganyika;
- Options in Lake Nyasa/Malawi basin, including hydropower options on the Rumakali and Songwe Rivers leading to Lake Nyasa;
- Options in Rufiji basin, including hydropower options on the Ruhudji River leading to Rufiji River;
- Hydropower options in Tana River basin (Mutonga).

In addition, three other types of options are not watershed bounded or are not precisely located. There are:

- Conventional thermal power options;
- Geothermal power options;
- Wind Farm power options.

To this, the transmissions lines must be added although they are not considered as specific projects.

To define the temporal scope for the proposed options, it is important to consider that the major environmental and social impacts will occur during the construction phase and the first five years of exploitation. Also, considering that all proposed options will likely be implemented before 2020, a 15-year time frame will therefore provide a sufficient period to allow all major cumulative environmental and social changes to occur in the area of interest.

14.4 Main Regional Trends and Issues

As highlighted in Chapter 4, the Africa Great Lakes region plays a major role in reducing poverty and securing food; each basin is a source of dietary proteins (fish and crops) and water, sustains livelihoods through fish harvesting, goods export, tourism and transportation. Irrigation, agriculture and hydropower are also water-related activities contributing to improve living conditions of the regional population.

These lakes and rivers which support subsistence livelihoods (agriculture and fisheries) have also experienced in the last decade or so a decline in fish resources, biodiversity, land fertility and overall deterioration in water quality via deforestation, over-exploitation and general poor management. This is in part due to rapid population growth in the areas bordering the watersheds, hence increasing pressure on natural resources, human habitat and economic and social infrastructures[2]:

> «The current population pressure on forests, wetlands, range lands and marginal agricultural lands, as well as inappropriate cultivation practices, forest removal and high grazing intensities, have led to unwanted sediment and stream flow changes that impact the downstream communities. This has led to unprecedented levels of soil erosion and siltation[3]».

This situation coupled with the increase of industrial pollution (lack of waste/effluents treatment) and urban growth have led to other environmental effects such as invasion of alien species (water hyacinth) and lowering of the water table (in Lake Victoria particularly).

These problems highlight the critical challenges facing economic growth and stability, and environmental protection and management. This diagram in Figure 14-1 on the next page shows the main trends occurring in the watersheds under study.

14.5 Definition of Strategies Followed

As mentioned in Chapter 13, four alternative strategies have been developed, each with its core concept:

A. Independent development approach, with primarily National options, and base load growth – Portfolio 1Aa

B. Regional cooperation approach with best evaluated options and medium load growth – Portfolio 2Bb

C. Regional cooperation approach with enhanced technological diversification with medium load growth - Portfolio 2Cb

D. Regional cooperation approach with enhanced geographical diversification and medium load growth – Portfolio 2Db

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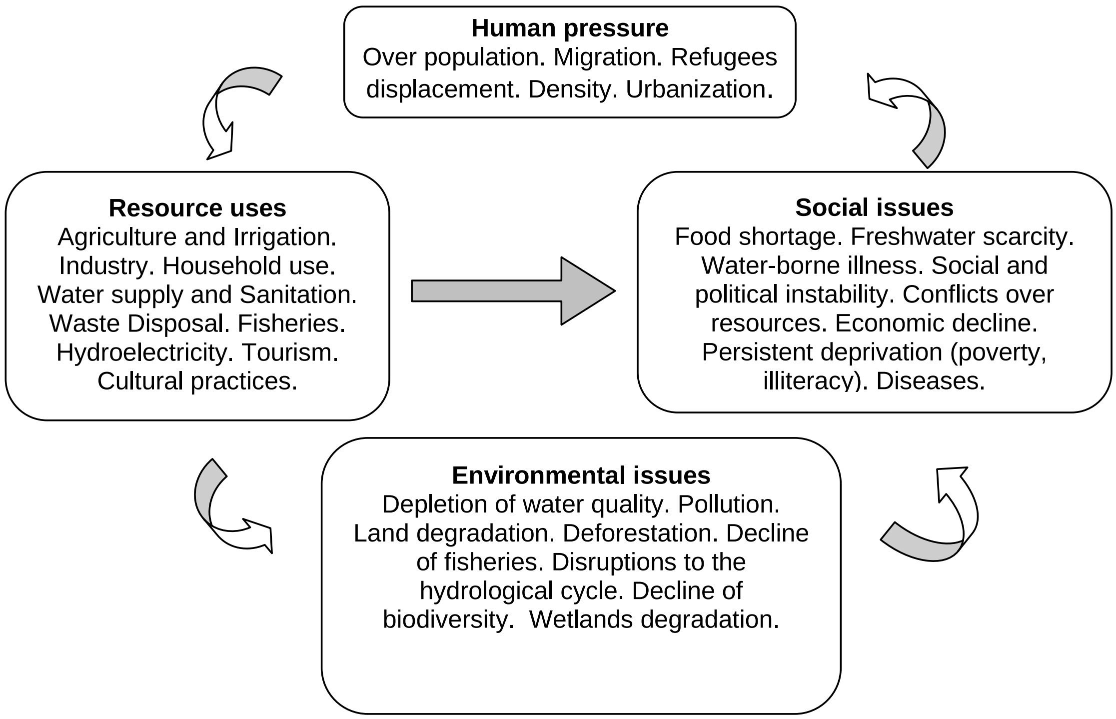
[2] UNEP, 2006
[3] AMCEN/UNEP, 2006

Figure 14-1 - Main regional trends



Sources: UNEP (2006)

14.6 Independent Development Strategy

14.6.1 Concept of the "Independent Development" Strategy

In practice there cannot be a future scenario with no new power or transmission development. Consequently this "independent development" strategy (Portfolio 1Aa) is defined to reflect a situation with the following elements:

- Lack of regional cooperation;
- Minimal inter-country power exchanges;
- Absence of international financing for major low cost options;
- Continuation of "emergency" or short term new generation installations;
- Poor reliability.

Development of this strategy can draw from previous experience in the region. Thus future generation would have a large "small plant and diesel" component, and power exchanges would be limited to Uganda / Kenya, and possibly Rwanda, Burundi, Eastern Congo, providing either, or both, the Rusumo hydro project on the border of Rwanda and West Tanzania or a project on the Ruzizi river could be implemented in the mid- term.

14.6.2 Criteria for the "Independent Development" Strategy

The “Independent Development " Strategy would be developed under the following rules or criteria:

- Load growth in each country and collectively for the region would be expected to be lower than for the NELSAP plan based on median load growth, because of electricity shortages (resulting in suppressed demand), and more expensive electricity (use of smaller less economic options).
- Transmission interconnections would be assumed to be limited to present interchange capability. Thus potential transfers would be limited to those presently taking place between Uganda and Kenya, and for the sharing of the Ruzizi 1 and 2 generation.
- Rwanda, Eastern DRC and Burundi would be treated as a single load to reflect the relatively small size of these loads and the existing generation sharing between Rwanda and Eastern DRC. It was assumed that West Tanzania would remain separate from the main Tanzania grid. One third of the generation from Rusumo would be provided to West Tanzania.
- No development options in excess of 150 MW (for any single stage of development) would be considered.
- Options would be scheduled to meet national loads only.
- Lower than usual reserve margins.

14.6.3 Portfolios at the country level for the Independent Development Strategy

New generation portfolios have been developed for each country, or area, based on the criteria outlined above. These are shown on Table 14-2.

14.6.4 Cumulative impacts of the “Independent Development” Strategy

This section, taking the current situation (Chapter 4) as starting point, describes the situation during the next 15 years if the power sectors of the region develop based on the assumptions presented above.

As the socio-economic development is estimated to be very low under the Independent Development Strategy (Portfolio 1Aa), the majors issues described previously in Chapter 4 will tend to worsen over time. The major driving factor will be demography, health, economy, culture, technology and politics.

14.6.4.1 Livelihoods and Urbanization

The ever-growing population will continue to put pressure on the environment, and these changes will have negative impacts on social development, weakening livelihood opportunities. Deforestation (for fuelwood, lightning and heating), intensification of agricultural activities and scarcity of lands will also exacerbate environmental pressure with consequences on lower land fertility by increasing erosion and decreasing moisture retention.

Confronted with this situation, a major part of the rural population will have to adopt new livelihood strategies in vital areas such as fisheries. Over fishing will therefore continue, and will further threaten the lakes productivity and biodiversity. The rural populations will be increasingly unable to sustain their livelihoods and this will fuel migration to urban areas, where rapid urbanization without sufficient energy supply will not be able to support industrial and manufacturing sectors, increasing unemployment and poverty among the new migrants.

Table 14-2 - Portfolio of Development Options for the Independent Development Strategy

	Kenya			Uganda			Tanzania			Burundi, DRC, Rwanda		
Year	Name	Type/Fuel	Capacity	Name	Type/Fuel	Capacity	Name	Type/Fuel	Capacity	Name	Type/Fuel	Capacity
2005	Existing		1120	Existing		417	Existing		700	Existing		167
2006										Diesel	Fuel Oil	20
2007				Diesel	Fuel Oil	20				Diesel	Methane	30
2008	Olkaria 2	Geothermal	35	Diesel		20				Diesel	Methane	30
2009	Longonot	Geothermal	70	Diesel		20	Gas Turbine	Natural Gas	60	Kisala Ivugu	Hydro	13
	Gas Turbine	Natural Gas	60			20						
2010				Diesel								
2011	Gas Turbine	Natural Gas	60									
2012							Gas Turbine	Natural Gas	60	Rusumo 2/3	Hydro	41
2013	Suswa	Geothermal	70	Bujagali	Hydro	200				Diesel	Methane	30
2014							Gas Turbine	Natural Gas	60	Diesel	Methane	30
2015	Menengai	Geothermal	140							Ruzizi III	Hydro	82
2016												
2017	Diesel	Fuel oil	20				Gas Turbine	Natural Gas	60	Diesel	Fuel Oil	40
2018	Diesel	Fuel oil	40							Diesel	Fuel Oil	40
2019	Diesel	Fuel oil	40				Gas Turbine	Natural Gas	60	Diesel	Fuel Oil	60
2020	Diesel	Fuel oil	40							Diesel	Fuel Oil	60

14.6.4.2 Deforestation, Soil Erosion and Sedimentation

As the energy needs will not be fully provided by the smaller scale national options and energy will be less accessible to poor rural populations, need for fuelwood, lighting and heating will continue to amplify the deforestation process and the degradation of forest areas. In Tanzania, UNEP estimates that 70% of the deforestation is due to fuelwood harvest. Moreover, this will continue to be exacerbated by the high demand for forest and pharmaceutical products in the global market and overexploitation of the forest resources in the region will continue. In some African countries, deforestation due to production of charcoal has increased eight to ten times more than the forest's production capacity

Table 14-3 presents a summary of the situation as of 2000. For example, Burundi has the highest rate of deforestation of Africa at 9% per year while it is at 3.9% in Rwanda, 2.5% in Tanzania and 0.2% in Uganda[4]. Roughly, this translates into an annual loss of 8460 ha for Burundi, as much as 838,421 ha for Uganda, and 11,970 ha for Rwanda, which had a total of only 307,000 ha of forest in 2000[5]. FAO also reports that the average rate of deforestation in Tanzania for the period 1990 to 2000 has increased from 2.5% to 3.32% for the period 2000 to 2005. It is likely that the situation is similar in all countries.

The rapid pace of deforestation will in turn contribute to natural hazards such as mudslides and flood run-off due to soil erosion., and it is anticipated that there will be an increase in erosion, release of sediment and consequently there will be a silting up of dams, undermining the generation of hydropower energy.

Table 14-3 – Deforestation in the Period 1990 - 2000

Country	Total Forest Area ('000 ha)	% of land area	Annual Rate of Change % (1990-2000)	Annual Change ('000 ha)
Burundi	94	3.7	-9.0	8460
DR Congo	135,207	-	-0.4	541
Kenya	17,096	30	-0.5	85
Rwanda	307	12.4	-3.9	12
Tanzania	35,257	39.9	-2.5	881
Uganda	4,190	21	-0.2	8

Source FAO 2005

14.6.4.3 Greenhouse Gases and Air Quality

To address the unsatisfied energy demand as soon as possible, the riparian countries will likely invest rapidly in energy options without thoroughly assessing the social and economic impacts, particularly in a regional or watershed context. They will therefore often opt for less environmentally and socially friendly project such as diesel, coal or fuel plants deteriorating even more the environmental and social conditions. In fact, countries are already expanding

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[4] FAO 2005.
[5] Idem

use of diesel generators to meet immediate subsistence needs, and this trend will continue in an independent approach.

These projects generally produce more greenhouse gases and hence will contribute further to climate change, a current global concern. Moreover, at a regional scale, emissions from the coal and/or fuel power plants will have a negative impact on air quality and acid rain affecting human, floral and faunal health. The following Table compares typical emissions of GHG per source. Reservoirs built for hydroelectric projects also emits greenhouse gases due to the decomposition of organic matter after flooding. There is still some debate over the extent of time that emissions would occur and the quantities emitted. It is however agreed that emissions would be larger and last longer in tropical countries compared to colder countries, and that large and shallow reservoirs would emit more than smaller and deeper reservoirs for an identical volume. Indeed, the quantity of and the nature of the vegetation submerged will also affect the emission rate.

Source	GHG Emissions (kg/MWh)
Wind farms	Less than 25
Natural gas	350 to 500
Diesel	455 to 650
Coal	900 - 1200
Reservoirs for hydroelectric projects	Emissions from large reservoirs would be roughly equivalent to emissions from a natural gas project

14.6.4.4 Water Related Conflicts

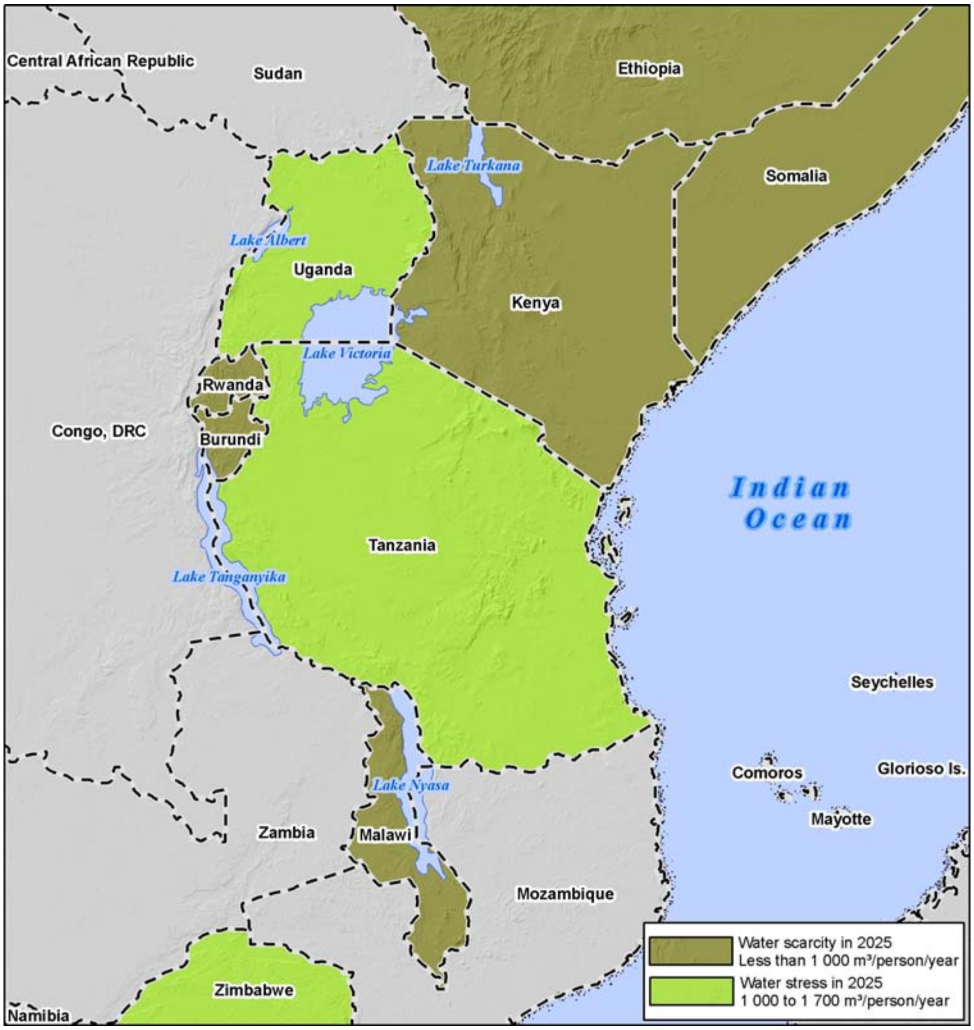
All of the riparian countries, except maybe DRC, are facing the situation where their water resources can be described as water-stressed or scarcity of water[6], which would lead to more conflicts over water-related activities such as navigation, transportation of goods, irrigation, hydroelectricity implementation and tourism. This is shown in Figure 14-2.

In this strategy, the situation would be compounded by a lack in regional cooperation in terms of energy supply, economic and environmental issues. Each government would attempt firstly to respond to its own needs with less concern for regional issues, such as the impacts of a dam construction on a watershed shared by other countries. This might therefore weaken the regional potential to alleviate poverty and would deepen the gap between countries: some countries would take advantages of the situation while others would be even more marginalized economically.

The resulting environmental degradation would lead to a decline in overall quality of life: conflicts over natural resources (land, water, forest) would increase, no major investment would be made in public services as the priority would be in energy sector, diseases and pests would spread, food insecurity and poverty would still be major issues.

[6] UNEP, 2006

Figure 14-2 - Estimated Stress on Water Resources in 2025



14.7 Cumulative Impacts of the Portfolio for Portfolio 2Bb (Regional cooperation, Best evaluated options and medium growth)

Portfolio 2Bb is defined as the "regional cooperation approach with maximized use of the best evaluated options with medium load growth". This portfolio uses the most hydroelectric resources (as these were the best evaluated) and thus can be considered as putting the region at some risk of major droughts, although proper design and implementation of these options should reduce or eliminate this risk.

14.7.1 Cumulative Environmental Impacts

Table 14-4 below indicates the types of issues to be considered for each group of options and related activities as well as the expected duration of these impacts.

Table 14-4 – Types of Cumulative Impacts for Various Activities

Type of Equipment	Geographic Scope	Issues	Time Frame	Other Activities that Could Affect the Issues
Hydropower	Watershed	Change in flow regime Sedimentation, erosion and water quality Proliferation of invasive aquatic vegetation Aesthetics and tourism	Plant life (except for GHG in reservoir)	Deforestation in the watershed Changes in agricultural activities Urban and industrial activities Greenhouse gases from reservoirs
Coal-fired Thermal Power Options	Global	Greenhouse gas emissions Acid rain emissions Health issues related to air pollutant emissions	Long term, even after plant shutdown	Other human activities leading to greenhouse gas emissions and acid rain
Natural gas fired Thermal Power Options	Regional, mainly in prevailing wind direction	Similar to but significantly lower than for coal-fired thermal options	Plant life	Other human activities leading to greenhouse gas emissions and acid rain
Thermal Power Options fueled with Lake Kivu gas	Regional, mainly in prevailing wind direction	Similar to but significantly lower than for coal-fired thermal options BUT reduces methane emissions from lake	Plant life	Other human activities leading to greenhouse gas emissions and acid rain
Geothermal Power Options	Regional	None foreseen		Agricultural activities
Wind Farm Power Options	Regional	None foreseen		Agricultural activities
Transmission Lines	Regional	None foreseen		Agricultural activities

The water basins in the region are in general subject to pressure from changes in flow regime, sedimentation and erosion. Further deforestation and changes in agricultural, urban and industrial activities will contribute to the cumulative impacts on the basins particularly threatening water quality and biodiversity.

Compared to the Independent Development Strategy, the Portfolio 2Bb will favour rural electrification. Wood would still be used for cooking in many areas as stoves will not be readily available, but overall wood consumption should decrease as it will not be used as much as a source of light. Consumption for heating should also decrease. Overall, pressure on deforestation should decrease, particularly where pressure is already very high.

14.7.1.1 Hydropower

In addition to the impacts on deforestation, change in agricultural, urban and industrial activities, options favouring hydroelectricity will also have an impact in greenhouse gas emissions, particularly the options creating large reservoirs. It is generally recognized that large reservoirs will emit non negligible quantities of CO_2, CH_4, and also N_2O as the flooded organic material is degraded. To facilitate comparisons between options and portfolios, Table 14-5 presents the area that would be flooded by each hydropower option considered.

Table 14-5 – Area Flooded by Hydropower Options

Option	Type of Project	Flooded Area (ha)
Bujagali	Run of the River	125
Kabu	Run of the River	14
Kakono	Run of the River	1500
Kalagala	Run of the River	1900
Karuma	Run of the River	1.8
Kiambere Extension	Run of the River	?
Mutonga	Run of the River	1100
Ruhudji	Run of the River	1560
Rumakali	Run of the River	1320
Rusumo	Dam & Reservoir	40,000
Ruzizi III	Run of the River	10
Songwe	Dam & Reservoir	5600
Sondu Miriu	Run of the River	?
Upper Kihansi	Run of the River	?

14.7.1.2 Geothermal Power Plants and Wind Power Plants

Geothermal power plant emissions can vary according to the geothermal source, however the main pollutants will be CO_2 and H_2S emissions. The CO_2 emissions are usually low compared to a fossil fuelled thermal power plant and their contribution to global warming is less important; H_2S emissions can be considered as a local issue and unless many geothermal power plants are planned in the same area they will not lead to significant cumulative impacts. Globally, no cumulative impacts due to the addition of geothermal power options are expected.

The major issues related to wind farms are conflicts for land use, the possible negative visual aspect of having many wind turbines in one area, noise and infra sounds and the possible collision between the rotors and birds, migrating or not. Cumulative impacts are possible if many wind farms are located within the same area; considering that only one wind farm is proposed, no cumulative impact is expected.

14.7.1.3 Conventional Thermal Power Plants

The strategy that maximizes the use of “best evaluated options” shows a greater proportion of hydraulic options and less conventional thermal options than the technological or geographic diversification strategies.

Greenhouse Gas Emissions: Because Portfolio 2Bb has fewer thermal options than portfolios based on technological or geographical diversifications, it is also the one showing the lowest amounts of greenhouse gases and acids precipitation causing emissions.

The fossil fuel thermal projects proposed would generate emissions of 24 Mt CO_2 equivalent for the life cycle of the projects, taking into account the year the project is put in line. In year 2020 the total emissions would be about 2.6 Mt CO_2 equivalent. If the total population for the Nile Equatorial Lake Basin in 2020 (at an estimated growth rate of 2%) would be about 168 million, these emissions would then represent 0.14 t CO_2 equivalent per person for the six countries of the Nile Basin. By way of comparison, the table below shows the per capita emissions for Sub Saharan Africa, Europe or the World emissions[7]. South Africa is a major contributor to this figure having coal as a major source of energy to produce electricity.

Geographical Area	Per Capita Metric Tons
Sub Saharan Africa 2005	0.7
Europe 2005	6.7
World 2005	3.8

While the emissions for the new generating facilities for the SSEA region do not seem important, it is well established that all greenhouse gases emissions contribute to global climate changes. These emissions would add to the total world emissions and contribute to global climate changes. This phenomenon is a cumulative one.

Air Pollutant Emissions: The contribution to acid rain emissions for the region would be in the order of 57,000 t SO_2 equivalent over the horizon of the portfolio (15 years), and 5,000 t SO_2 equivalent for year 2020. The location for most of these fossil fuel thermal power plants is not yet defined, but would most likely be located relatively close to urban areas. These urban areas are likely to have other sources of SO_2 equivalent emission contributing to cumulative impacts for pollutant emissions on a local basis. This can contribute cumulatively to acid rain production and to an increase in pulmonary diseases.

14.7.1.4 Transmission Lines

The only environmental impact of the construction of transmission lines would be to clear some forest area and, perhaps, by improving access to some areas induce some deforestation in these new accessible areas. However, proper route selection for the lines would ensure that there are no protected forest areas affected, that areas prone to erosion are avoided, and induced impacts are minimized.

14.7.1.5 Victoria Nile Basin

Portfolio 2Bb suggests that Kiira units 14-15 (Owen Falls extension) be put into service in 2005, Bujagali 1-4 in 2012, Bujagali 5 in 2014 and Karuma Falls in 2016.

Watershed	Existing options	Proposed options
Victoria Nile	Owens Falls (H)	Bujagali (H) Karuma (H) Kiira (H) (C)[8]

Change in Flow Regime: The arm of the Victoria Nile where Kiira units 14-15 and the Bujagali options are located is separated by Lake Kyoga from the arm where the Karuma Falls option is located. Because of the distance separating these projects and the presence of Lake Kyoga between the two stretches of the river, the projects on the first stretch will not have a cumulative effect downstream on the second stretch as Lake Kyoga will act as a buffer zone. Lake Kyoga having a surface area of 4,700 km^2, it would take a difference in the daily flow caused by Bujagali and Kiira (Owens Falls) of at least 47,000,000 m^3, or 544

[7] World Bank's Facts and Figures from World Development Indicators 2005

[8] under construction in 2005; in operation as of October 2006.

m^3/s to affect the level of Lake Kyoga by 1 cm. Since Bujagali is a run of the river scheme with a 12 hour pondage, and a planned discharge of 280 m^3/s, it would not affect significantly Lake Kyoga level, even in the unrealistic situation where all discharge would be stopped for 12 hours.

Similarly, it would take a daily variation of 613 m^3/s at Karuma to affect Lake Albert's level by less than 1cm given its area of 5300 km^2. Karuma, another run of the river scheme, with only a one hour pondage, would have a maximum discharge at full output of 1000 m^3/s. The total quantity of water reflected by this pondage corresponds to 3,600,000 m^3, or only about 14% of what would be necessary to affect Lake Albert by less than 1 cm.

Compared to the natural variations in flow regime recorded during the last 50 years when flow almost doubled after 1961, to return to low flow conditions in the last three years, and the anticipated impact of climate changes that predicts a 20% increase by 2050, the cumulative impacts on the flow regime of the Victoria Nile River by the proposed Bujagali and Karuma projects are not significant. They are not expected to affect the hydrology of the Victoria Nile River, and the effect of daily peaking will not be noticeable further than 5 km downstream of the tailrace. No change in flow regime is expected downstream of Lake Albert.

The addition of these hydroelectric options on the Victoria Nile River in addition to the existing Owens Falls dam would also decrease the pressure to use more water to produce more power (by adding more capacity, more energy may be produced from the same quantity of water by reprocessing the same water further downstream). It is imperative that the options above be designed in a manner not to increase the water need to avoid adding more pressure on Lake Victoria's water levels.

Sedimentation, Erosion and Water Quality: No significant sediment load is present in the Victoria Nile River, most sediment having deposited in Lake Victoria. Changes in population densities and distribution along the Victoria Nile River as well as changes in agricultural practices could lead to soil erosion, a more important sediment load and a change in water quality in the Victoria Nile. A change in urban population densities and changes in agricultural practices in the Victoria Lake Basin could have an effect on the water quality flowing to the Victoria Nile. The dams of each of the proposed options would trap much of the sediment, in addition to lakes Kyoga and Albert, thereby attenuating these negative impacts.

Proliferation of Invasive Aquatic Vegetation: Water hyacinths are trapped upstream from Owen Falls Dam in Lake Victoria and will not create a cumulative impact downstream. There is already a reduction of 80 % of surface covered by water hyacinths on Lake Victoria[9] as compared to the 1997 figures. **Impact on Flora and Fauna:** The Bujagali and Karuma hydroelectric options will have a negative cumulative impact of the Victoria Nile, Lake Kyoga and Lake Albert 's flora and fauna due loss of habitats at Bujagali Falls, on riverbanks, the loss of islands, loss of terrestrial land for pondage, although they are fairly limited.

The Bujagali project is in close proximity to one of Uganda's thirty Important Bird Areas (IBA); the Mabira Forest Reserve. The IBAs of BirdLife International are selected because they shelter bird species threatened with extinction, have highly restricted distribution, are characteristic of particular biomes and/or hold exceptional large numbers of congregatory birds[10]. Change of land use and loss of riverbanks and islands could result in a loss of habitat for birds in the area. Although impacted areas are relatively small, 125 ha for

[9] Results from the Lake Victoria Management Plan (LVMP) completion studies 2005.
[10] BirdLife International, 2001

Bujagali and 1.8 ha for Karuma, further studies are required to determine if Owen Falls dam has an impact on bird habitats and if the addition of Bujagali would have a cumulative impact on birds in the region.

No important impact on migratory fish is theoretically expected on the Victoria Nile. The height of Karuma Falls (28 m) is a natural obstacle to fish migration near the Karuma project area. Upstream, the presence of Owen Falls dam is another obstacle for any fish migrating up or down the Victoria Nile from Lake Victoria and hence the Bujagali project would not have any further impact. The fish situation is however poorly documented and future sectorial studies will be necessary.

14.7.1.6 Lake Victoria Basin

The following table presents the Lake Victoria Basin with proposed and existing projects.

Watershed	Existing activities and power plants	Proposed options
Lake Victoria Basin	Small scale mining and alluvial gold planning	Rusomo Falls (H - 2012) Kakono High (H - 2013) Sondu Miriu (H - 2008)(C)

Change in Flow Regime: Lake Victoria is the second largest fresh water lake in the world with a surface area of 67,850 km^2. The total annual volume of water flowing at Rusumo Falls (6.9 x 10^9 m^3) represents a 10 cm layer of water over the total surface of the lake. Considering a reservoir of 400 km^2 upstream of Rusumo Falls, a depletion of 1 m over 3 dry months and subsequent replenishment over the next rainy period would amount to a total flow variation of 400 M m^3, or roughly at 4.4 M m^3/day (51 m^3/s). Such a variation on the flow regime would correspond at most to a 0.6 cm variation across Lake Victoria, and is negligible compared to natural variations experienced in the lake over the last few decades. Therefore, any modification of the hydraulic regime due to the combined presence of projects on the Sondu Miriu and the Kagera Rivers would have little incidence on the level variations of Lake Victoria.

The change in flow regime of Rusumo Falls combined to Kakono could have a cumulative impact on the wetlands along the Kagera River. It is estimated that Rusumo would flood 250 km^2 of wetlands, while the area affected by Kakono would be considerably smaller with a total flooded area of 1500 ha. Kakono would also flood riparian wetlands along the Kagera River upstream of the dam. Wetlands are quite abundant in the Lake Victoria basin, accounting for 31% of the total area (87,782 km^2), most being located around the northern portion of the lake. However, they are presently under considerable threat and are currently disappearing rapidly.

Habitats and Natural Resources: The modification of flow regime of Kakono, and particularly Rusumo Falls on the Kagera River could have effects the lower areas of the the Akagera National Park and on the Minziro Forest Reserve. The Akagera National Park has however been considerably degraded in the last 10 years due to human pressure. In addition to the civil war damages, the FAO estimates that between 650,000 to 2,000,000 cattle entered the park in the last decade for grazing while the army killed most of the predators to preserve the cattle.

The Sondu Miriu project is in close proximity to three of Kenya's sixty IBAs; Dunga swamp, Koguta swamp and Kusa swamp. A change in these wetlands could have a cumulative impact on birds in the area or migrating birds, but further study is required to fully asses the impact.

Rusumo Falls could have a potential impact on fish migrating and spawning in this section of the Kagera River. Fish presence and behavior will have to be further analysed during the realization of a specific EIA for this project. Rusumo Falls project is much less likely to have an impact on fish migration as they are not expected to migrate and spawn so far from Lake Victoria (300 to 400 km). More localized impacts on fish migration in the immediate vicinity of the project area are however possible and will need to be investigated in a future EIA.

Sedimentation, Erosion and Water Quality: Over the last 30 years, due to deforestation and erosion, a considerable quantity of sediment has found its way in the Kagera river. It is estimated that the total annual load of sediment carried by the river to Lake Victoria has increased from 400 kilotons/year in 1971 to 1400 in 2004, a 3.5 fold increase[11].

Sediment are constituted of an inorganic component including mostly soil particles such as clay or sand, and a second part constituted of organic matter often associated with nutrients. Both are found different proportions depending on the use of lands where they come from. Deforested areas will usually contain a higher proportion of inorganic matter while erosion from agricultural land would contain more organic matter and nutrients since fertilizers are often also used. Urban settlements will also greatly contribute to the organic load as domestic wastewater is discharged without treatment. Both have very different impact on the environment. Inorganic sediment, when depositing in calmer water will cover the existing habitats, and important loads due to change in the river basin may completely destroy them. Organic sediment will biodegrade with time and provide carbon source to sustain primary productivity, often leading to eutrophication and weed proliferation when in excess. In the Lake Victoria context, with its very high population density, and most of the Kagera basin is under crop, this has lead to a severe water hyacinth infestation and oxygen depletion. Any reduction of sediment/nutrients loading in the basin will therefore be positive.

If Rusumo Falls is built, it is estimated that the organic matter trapped in the reservoir would represent a reduction in the order of 15% to 20% of the organic nutrients that usually flow into Lake Victoria. If Kakono were added, most of the organic matter would be trapped in the behind the dams and would not enter into lake Victoria. The reduction of inorganic sediment flowing into Lake Victoria as a result of these options will compensate for the reduction of filtering capacity due to the decrease of wetlands area, upstream of the Rusumo Falls dam.

Proliferation of Invasive Aquatic Vegetation: The creation of the Rusumo Falls reservoir and Kakono pondage area could result in a proliferation of water hyacinths upstream of each dam due to the retention of organic sediment and nutrients present in the water because of the absence of wastewater treatment and other organic matter and fertilisers rich effluents discharged in the river. . At the same time, accumulation of water hyacinth upstream of the dams will allow removal of nutrients in the water, thus replacing to a certain extent the loss of wetlands and reducing the quantity of organic matter and nutrients reaching Lake Victoria. With the use of biological control, which seems to have a positive effect on reducing the water hyacinth footprint, it can be expected a further improvement in the fight against water hyacinth.

14.7.1.7 Lake Tanganyika River Basin

The Ruzizi River links Lake Kivu to Lake Tanganyika. Three power plants are already present on the Ruzizi watershed: Ruzizi I, Ruzizi II on the Ruzizi River and Rwegura on the Kitenge River. Two options are planned on this watershed: Ruzizi III on the Ruzizi River in 2014 and Kabu 16 on the Kaburantwa River in 2013.

[11] Nile Transboundary Environmental Action Project, November 2995

Watershed	Existing options	Proposed options
Tanganyika	Gisenyi (H)[12] Ntakura (H) Gihira (H) Ruzizi I and II (H)	Kabu 16 (H - 2013) Ruzizi III (H - 2014) Lake Kivu Methane (M – first unit in 2008)

Change in Flow Regime: The surface of Lake Tanganyika is roughly 30,000 km^2. The modification of the lake inflow regime due to the addition of the new hydroelectric power plants would have little incidence on the level variation of Lake Tanganyika. Taking into consideration that Kabu 16 would have a very small reservoir of 14ha, used mainly for minimum flow release during the dry season, and that Ruzizi III flow could vary daily from 50 to 175 m^3/s, this would have a negligible effect of 0.05 cm on the level of Lake Tanganyika.

Habitats and Natural Resources: Ruzizi III and Kabu 16 being run-of-river projects, no significant hydrological modification to the flow of the Ruzizi and Kaburantwa Rivers is anticipated. No effects are thus anticipated on the Ruzizi National Park[13] located on the lower reaches of the Ruzizi River and on its delta at the mouth of the entrance of Lake Tanganyika, which was retained recently as the only Ramsar Site in Burundi.

Kabu 16 is in close proximity to one of Burundi's five IBAs and Ruzizi III is in close proximity to one of Rwanda's seven IBAs; the Kibira National Park and Cyamudondo forest, respectively. The forests of these two IBAs are already under pressure from human activity but the small area and volume of these two projects isn't likely to have any impact on these IBAs.

Data on fish, particularly migratory fish, is very scarce and is many decades old. Taking into consideration that the Ruzizi I and II dams already constitute insurmountable obstacles for fish migration between Lake Kivu and Lake Tanganyika, and that the fish biomass has been characterized as quite low in the Kivu 16 area[14], no significant impact on fish is expected. However further studies in the field are necessary to validate these conclusions.

Sedimentation, Erosion and Water Quality: Sediment input from tributaries downstream of the proposed Ruzizi III such as the Kaburantwa and the Kagunuzi, both located in areas under intensive agricultural use contribute mainly to the sediment load of organic material and nutrients flowing into Lake Tanganyika. The reduction of organic load from the Kaburantwa because of the construction of Kabu 16 will be positive for Lake Tanganyika already under threat from eutrophication from the highly developed urban areas on the Burundi side. Ruzizi III is located quite far upstream on the Ruzizi River and in so close proximity to Ruzizi I and II that its construction would not alter significantly the sediment load already controlled by Ruzizi I and II.

Proliferation of Invasive Aquatic Vegetation: Water hyacinths are absent from this watershed and no cumulative impact is anticipated unless the plant is introduced.

12 Legend: H = hydroelectric option; M = Methane fuelled plant; F = producer of fertilizer (direct or indirect); G = geothermal option; I = Irrigation; C = under construction as of 2005

13 Some sources (maps, texts or websites) mention this National Park; others refer to it as a Natural Reserve and others do not mention a Park or Reserve at this location. For the purpose of this study it is assumed that there is a National Park at that location.

14 Sogreah, 1995

14.7.1.8 Lake Nyasa/Malawi Basin

The 30,040 km^2 Lake Nyasa (or Lake Malawi) is the third largest lake in Africa. Because of its important fish diversity, the lake has been identified by WWF as a priority freshwater area under its Ecoregion Conservation Programme[15]. The Rumakali project planned in 2017 and the Songwe project planned in 2019 both flow into Nyasa Lake.

Watershed	Existing options	Proposed options
Lake Nyasa/Malawi	Kapichira (H)	Rumakali (H) Songwe (H)

Change in Flow Regime: The hydrological conditions on the Rumakali River will be locally affected by the Rumakali project as the reservoir and discharge are relatively small. The effect would be slightly larger on the Songwe River because of a larger reservoir and larger discharge. Both project will have a negligible effect on Lake Nyasa given its large volume. For example, the total daily discharge of 19 m^3/s would affect Lake Nyasa by less than a millimetre. The creation of the dam and reservoir will however stabilize the river bed and reduce seasonal flooding.

Effects on Habitats and Natural Resources: The Songwe River is known to be very instable and its small gradient encourages flooding and high silt load deposition[16]. The creation of the reservoirs will have a positive impact by stabilizing the river and decreasing the quantity of silt entering the lake and destroying habitats. The lake has relatively low concentrations of nutrients, particularly phosphorus the limiting factor of primary productivity. Although concentrations appear to be increasing in the southern portion due to change in land use and human pressure, this trend has not been observed in the northern portion[17]. Lake Malawi is known to be one of the most species-rich lakes in the world and the Songwe and Rumakali projects will help preserving this biodiversity by controlling to a certain extent the loading of nutrients that would otherwise lead to eutrophication and decrease of biodiversity. However, other causes related to agricultural run-off in other parts of the basin, particularly in the south part, will contribute to its eutrophication.

The existing studies indicate that these projects could impact the wetlands at the mouth of both rivers. The decrease of both wetland areas will have a localized negative cumulative impact in their deltas at the entrance of Lake Nyasa by reducing productivity. However, the overall reduction of sediment/nutrients loading due to the dams and reservoirs will have a positive impact on the lake water quality and its biodiversity .

The Songwe project is likely to have an impact on fish migration and spawning as the project is located near to Lake Nyasa and the Songwe River is recognized as a spawning ground for a variety of fish. The Rumakali project is less of a concern due to its greater distance from the lake, but fish migration and behavior will have to be further assessed during the project's EIA.

Sedimentation, Erosion and Water Quality: The basin is heavily populated and agricultural practices contribute to soil erosion. The Songwe project, because of its impact in the stabilization of the river bed, will potentially affect the distribution of agricultural land along the river, thus possibly modifying the amount of sediments and nutrients flowing into Lake Nyasa, modifying locally the productivity of the lake in the vicinity of its delta. This

[15] http://www.ramsar.org/mtg_malawi_wwf_2003.htm
[16] Dukuduku 2002
[17] Bootsma and Jorgensen, 2006

issue will need further investigations as it is not clear where the river bed will stabilize and how it will affect agricultural practises downstream of the project.

14.7.1.9 Rufiji River Basin

This Ruhudji project is located on the Ruhudji River in the Rufiji Basin. This basin, of over 500 km long, already contains three other existing hydropower plants: the Lower Kihansi on the Kihansi River just upstream of the Kilombero flood plain (a Ramsar site); and the Mtera and Kidatu dams on the Great Ruaha River discharging into the Rufuji about 100 km downstream of the Kilambero floodplain.

Watershed	Existing options	Proposed options
Rufiji River basin	Lower Kihansi (H) Mufindi pulp mill Mtera (H) Kidatu (H)	Ruhudji (H)

Change in Flow Regime: The Ruhudji hydroelectric project has a 1560 ha reservoir and will change the hydrological conditions on the Ruhudji River by reducing the flood flows in a limited stretch of 15 km of river. The mean discharge at the dam is relatively small at 35 m^3/s and daily variations are expected to be in the range of natural variations[18] of the river.

The Kilombero floodplain is located almost 200 km downstream and is not expected to be affected by this project.

Sedimentation, Erosion and Water Quality: The sediment load on the Ruhudji River is not considered important and changes in agricultural practice do not seem to increase the sediment load in this area[19].

Natural Habitats: This change in flow regime will not affect the Kilombero site, an important wetland and Ramsar site, as well as an important bird sanctuary area located downstream of the Kilombero river discharging into the Rufiji River. The site is located some 200 km downstream of the Ruhudji project and any sediment variation of the relatively small sediment loading in the project area, will be damped before the water reaches the Kilombero site.

In the project area, fish population is very poor because of the steep gorge and rocky substratum and only eels seem to be using the area. Because of the very long distance between the project site and the Indian Ocean and the existence of various falls, no impact is expected on fish migrating to and from the Indian Ocean.

14.7.1.10 Tana River Basin

The Mutonga Project would be the sixth hydropower station of the Seven Forks Complex on the Tana River leading to the Indian Ocean; the other stations are: the Masinga Power Station and Reservoir, and the Kamburu, Gitaru, Kindaruma and Kiambere Power Stations.

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[18] SwedPower/Norconsult, 1998

[19] Makwetta J. Atwitye, Land Use and Physical Hydrology of the South Njombe Catchmant, Southern Highlands of Tanzania, Journal of Environmental Hydrology vol 7 paper 14, September 1999, http://www.hydroweb.com/jeh/jeh1999/makw.pdf

An extension of 20 MW to the Kiambere Power station will be completed in 2006 and the Mutonga project would be put into service in 2020.

Watershed	Existing options	Proposed options
Tana River	Tana Complex (H) Hola Irrigation scheme (I) Nairobi (F) Bura Irrigation Project (I)	Mutonga (H) Kiambere extension (H) (C)

Change in Flow Regime and Natural Habitats: The hydrological conditions on the Tana River are already greatly disturbed by the existing hydroelectric complex of dams. Before the construction of these dams, the river used to flood its banks twice a year. These biannual floods would inundate the floodplain and delta area up to a depth of 3 m, supporting grasslands, lakes, seasonal streams, riverine forest and mangrove ecosystems. Since 1989, when the last dam was commissioned, flooding has decreased dramatically in volume and frequency. The proposed Mutonga-Grand Falls dam would be the last stage to complete control of the Tana's waters, as after construction there would be no appreciable addition to its flow except in extreme events occurring every 5 and 10 years. This would effectively end the regular bi-annual floods, cut off most of the floodplain from water, and significantly lower the local water table. Reservoir construction would reduce the sediment loads transported downriver, and stabilisation and regulation of waterflow would lead to deepening of the river channel and limit meander and oxbow formation[20].

Sedimentation, Erosion And Water Quality: The Seven Forks Complex has sedimentation problems due in part to agricultural practices in the watershed. The Mutonga project on the Mutonga River would also trap the sediment load of the river; being an important tributary of the Tana River, this would lead to cumulative impact on the Tana River by further reducing the amount of sediments and nutrients available downstream, on which a large part of the local agricultural practices depends .

The possible reduction of riverine forest could have a cumulative impact of two rare primate species already under pressure from the Kiambere hydroelectric dam and its extension

No fish migration and spawning is expected in this section of the river because of the project's great distance from the Indian Ocean and because of the existing falls and dams. The EIA carried in 1998 mentions the presence of eels as the only potential migratory fish, but does not draw any conclusion on the impact of the project[21]. It is not known if some fish living in the Tana River use the Mutonga River as a spawning ground, this will have to be further investigated during the eventual EIA of this project.

14.7.2 Cumulative Socio-Economic Impacts

Some socio-economic impacts of hydroelectric options (such as waterborne diseases or economic spin-offs during construction) are generally quite local and do not really generate cumulative effects with other activities elsewhere in the target area. On the other hand, geographical concentration of multiple options might affect the regional socio-economic dynamic and therefore will generate some impacts that may cumulate in time and space.

[20] IUCN, 2003
[21] Nippon KOEI Ltd., 1998

To assess these impacts, it is more appropriate to take into account the geographical proximity of the options rather than their presence in the same watershed as they are subjected to political, social, and economic factors that do not necessarily follow the same rules as environmental factors. For instance, even if the options Ruzizi III, Kabu 16 and Kakono High-Rusumo Falls are not in the same watershed, they are in close geographical proximity and likely to generate regional cumulative impacts. Thus, in this section, cumulative socio-economic impacts are analysed as much as possible per watershed, but are grouped together when appropriate.

Socio-economic impacts typically considered for the options included in this assessment can include economic development, resettlement; health, irrigation and agriculture, water supply, impact on tourism, impact on river navigation and cultural resources. Each of these themes is discussed below.

Economic development: all options should improve the local economy during construction and operation of the option in a few ways:

- The construction work force will be drawn partially from local residents;
- The presence of the construction work force will generate indirect job creation and will induce the creation of small businesses;
- The access roads for transporting material and equipment to the site will open up the area to additional development;
- The building of dams will facilitate local transport (making it easier for vehicles and people to cross the river).

In addition, the provision of electricity to the region will positively affect the economy of the region. options.

Rural electrification: the development of any power option promotes the electrification of communities immediately surrounding the option and also, by providing more power to the electrical grid, permits the electric utility to extend its system into other rural areas. This element is considered in the assessment of each option, and is not considered a cumulative impact.

Resettlement; all of the options will involve voluntary and temporary resettlement as workers will gravitate closer to the project sites during the construction and operation phases. Also, some options will affect negatively the local inhabitants either by flooding their agricultural land or their homes. This element is considered at the level of the assessment of each option. Where this issue is considered to have a cumulative impact (such as when the resettlement compounds an existing situation of refugees) it is highlighted in the discussions of the impacts of the options.

Health: the influx of workers during the construction phase of any option may have a negative impact on the health of the local residents by importing communicable diseases, including HIV/AIDS. Appropriate mitigation measures such as awareness raising can reduce these impacts. In addition, the development of these options usually entails the provision of health care facilities. The exception to this situation is when a reservoir is created which fosters diseases such malaria and bilharzia. This element is considered in the assessment of each option. It is not considered to be a cumulative impact.

Irrigation and agriculture: some options improve irrigation potential and some interfere with it. These aspects are also illustrated below.

Water supply: None of the options will affect any existing water supply system. The changes in flow regimes will not affect the quantity or quality of drinking water obtained from the rivers where the options would be located.

Impact on tourism: Most of the options are located in remote areas with virtually no tourism. Where this is not the case, it is indicated.

Impact on river navigation: river navigation at all sites is impeded naturally by the falls that make the site worthy of consideration. The construction of dams to divert most of the water around the falls and through turbines would therefore have no impact on river navigation. On the other hand, the use of the dam may improve transportation from one bank to the other.

Cultural resources: as most of the hydro options are run-of-river options with small reservoirs, there will be minimal flooding upstream of the dam and therefore no loss of cultural resources near those options. There are, however, four options with larger reservoirs; from the information available, it appears that the impounding of water at Rusumo Falls, Songwe, Ruhudji, and Mutonga would not flood any cultural resources.

14.7.2.1 Northern Part of Tanganyika Lake and Lake Victoria Watershed

Geographical scope	Existing options	Proposed options
Northern part of Tanganyika Lake and Kagera Watershed	Gisenyi (H) Ntakura (H) Gihira (H) Small scale mining and alluvial gold planning	Rusumo Falls (H) Kakono High (H) Kabu 16 (H) Ruzizi III (H) Lake Kivu Methane (M)

In this area, five options are proposed: Ruzizi III, Kabu 16, Lake Kivu Methane, Rusumo Falls and Kakono high.

Rusumo Falls is the only project with a reservoir. It would only slightly increase malaria incidences by offering more habitats for mosquitoes, but the impact is not as large as it may seems at first glance since the proposed 400 km^2 reservoir will include 375 km^2 of existing wetlands and lake. So the net increase area is only 25 km^2.

Irrigation infrastructure provided by Kakono High project will likely lead to an influx of farmers looking for irrigated lands. This agricultural boom might increase pesticides and fertilizers in drainage water and subsequently contribute further to contaminate water and accelerate the decline of biodiversity and fish populations, and fishery yields, particularly in Lake Victoria.

Human pressure due to resettlement in already over-populated areas will be one of the most significant social impacts. The construction of dams in the Kagera watershed (Rusumo Falls and Kakono high - both planned for the same years) accompanied with significant resettlement will increase instability and human pressure in an area characterized by high and medium rural population densities and by refugees movement. This will in turn add pressure on natural resources, such as lands and forests, and result in environmental degradation. In addition, the influx of people (resettled persons and foreign workers) may lead to a number of health impacts such as increase in the prevalence of HIV/AIDS and water-borne diseases. This situation can easily be worsened by poor management of resettlement plans that might lead to the loss of livelihoods.

Women are more likely to be negatively affected by displacement because men, in most instances, receive the financial compensation, and that would increase the financial dependence of women. Also, displacement coupled with natural resources degradation will increase many of the time-consuming tasks of searching for fuel wood and water, which are usually the responsibility of women. The availability of electricity should however have a positive effect on their workload by reducing time spent on household work and in the medium and long term attenuate the negative impact of displacement.

These cumulative impacts will benefit more directly households and communities that are already advantaged in terms of available resources, productive land and irrigation systems, access to markets and higher levels of education. This is partly because they are more able to take advantage of opportunities. Poor peasants and fishermen (even more if they are women) are usually more vulnerable than others groups to negative impacts affecting the environmental sustainability. For instance, an unfair redistribution of benefits related to options (such as electrification) can marginalize them even more, stressing social disparity.

14.7.2.2 Lake Nyasa/Malawi and Rufiji Watershed

Geographical scope	Existing options	Proposed options
Lake Nyasa/Malawi and Rufiji River basin	Lower Kihansi (H) Mufindi pulp mill Mtera (H) Kidatu (H) Kapichira (H)	Rumakali (H) Songwe (H) Ruhudji (H)

The northern area of Lake Nyasa/Malawi will host three hydroelectric options close to each other: Songwe, Rumakali and Ruhudji.

This region, not yet over-populated, will be impacted by the presence of these three dams. Agricultural activities (highly practiced particularly in the delta of the Songwe River) will be the most affected sector.

The Songwe project will also have a positive political impact by stabilizing the bed of the river, particularly the last 29 km, that constitutes the border between Tanzania and Malawi and ease local conflicts. However, to the farmers cultivating land close to the river, changes to the river channel may lead to sudden loss of some or all of their land during the flood season. Once the river is stabilized, if their land falls under the jurisdiction of the other country, they would loose their right to cultivate. These issues will have to be addressed during the EIA studies.

The Ruhudji project area is not densely populated and would not add to the existing water conflicts identified further downstream, particularly on the Great Ruaha River where are located the Mtera and Kidatu. The situation in this area is critical and power generation had to be stopped at Mtera because the 660 km^2 reservoir is about 10 m below its optimal level. Water losses from various causes including unplanned irrigation have been identified.

In addition, an increased supply in energy and improvement of access roads and infrastructure might lead to rapid socio-economic changes into this underdeveloped area, which implies many impacts such as:

- Economic diversification, employment opportunities and improved living conditions;
- Intensification of rural migration into urban communities and rapid urban growth;

- Less pressure on natural resources due to a diversified economy, not relying only on agriculture and fisheries;
- Increase in urban pollution.

14.7.2.3 Victoria Nile Watershed

Geographical scope	Existing options	Proposed options
Victoria Nile	Owens Falls (H)	Bujagali (H) Karuma (H) Kiira (H) (C)

The only significant negative cumulative socio-economic impact in this region (including Karuma and Bujagali options) will be on aesthetics and tourism concerns. Even more, this cumulative impact is irreversible. Indeed, the dam construction of Bujagali will destroy an aesthetically and culturally valuable part of a landscape (2.5 km of white river and falls). These impacts will lead in a loss of tourism revenues for the entire region. In contrast, it should be taken into account that a more reliable supply of energy will improve infrastructure and services, an essential factor to attract tourism and promote economic growth.

Even though the region is highly densely populated, it is not expected that the resettlement that will take place for Bujagali will deteriorate socio-economic conditions in the region. In the entire region, it is the only project with involuntary resettlement and thus the impact will not cumulate with other options proposed. Also, resettlement has already been carried out in affected area.

14.7.2.4 Eastern part of Lake Victoria (Kenya) and Tana Watershed

Geographical scope	Existing options	Proposed options
Eastern part of Lake Victoria	Seven Forks Complex (H) Hola Irrigation scheme (I) Nairobi (F) Bura Irrigation Project (I)	Mutonga (H) Kiambere extension (H) Sondu Miriu (H) (C) Geothermal Fields (G)

Four major options, Sondu Miriu (already under construction), Geothermal Fields (Olkaria, Longonot and Suswa), Mutonga, and Kiambere extension) are proposed in Kenya. No negative significant socio-economic cumulative impacts are expected and it is estimated that these options will contribute to a permanent enhancement of local economy.

There is a plan to locate geothermal power plants close to the capital, Nairobi. This geographic concentration near Nairobi and its industries might lead to slightly higher H_2S emissions, and contribute to acid rain and health problems.

The Mutonga hydroelectric project and the Kiambere extension (upstream) might affect considerably agricultural activities practiced in the region. The change in the flow of the river might interfere with an irrigation project located downstream (Bura), where traditional flood recession farming and flood plain grazing resources are used. This will lead to lost of irrigated lands and peasant will have to leave the region for more fertile areas, which are very scarce in this region.

14.7.3 Cumulative Impacts Downstream of the Nile Equatorial Lakes Region

The impacts identified for each of the river or lake basins were reviewed to assess the likely impact on the Nile River downstream of the Nile Equatorial Lakes Region.

First, the Lake Tanganyika, Lake Nyasa/Malawi, Rufiji River and Tana River do not discharge into the Nile; the former discharges into the Atlantic Ocean via the DRC and the others flow, directly or indirectly into the Indian Ocean. It is only options on rivers flowing into the Victoria Lake or the Victoria Nile that can have an impact on the Nile River downstream of the Region.

A second major consideration is that two of the options (Rusumo Falls and Kakono) are on rivers flowing into Lake Victoria. These two reservoirs, would trap sediment and nutrients, so there would be less entering in Lake Victoria. Moreover, the lake is so large (with a volume of almost 3,000 cubic kilometers) that any change in flow pattern (slight change from month to month with no change in annual flows from Rusumo Falls and no change from Kakono) will not be noticed in Lake Victoria.

Both options on the Victoria Nile (Bujagali and Karuma) are run-of-river schemes and, by definition will not have any changes in flow regime. They will not have any influence beyond Lake Albert, as explained in section 14.7.1.5. Both dams will also contribute in trapping sediment from Lake Victoria, and similarly no increase of sediment is expected downstream of Lake Albert.

At present, shortages of power are leading to the draining of Lake Victoria to levels much lower than intended when the Owen Falls plant was built. A rapid implementation of the Bujagali and Karuma options would lead to a decrease on the pressure to overuse the Victoria Lake storage. This may lead to a temporary reduction in flows downstream as some of the water flowing into the lake would be retained to rebuild the lake levels to historic levels.

Based on the above, it is concluded that the options proposed for the rivers leading to Lake Victoria and on the Victoria Nile would not have any significant impact on the Nile River downstream of the Region leading to Sudan and the Sudd Marshes.

14.7.4 Summary of Cumulative Impacts of the Portfolio 2Bb

The main cumulative impacts expected for Portfolio 2Bb are summarized in Table 14-6 and Table 14-7. These tables are in the form of a matrix that shows the types of impacts considered and each of the river basins identified. For ease of reference, the river basins flowing into the Indian Ocean, the Atlantic Ocean and the Nile are shown in different colours.

Although there are negative impacts associated with Portfolio 2Bb, they are less extensive in comparison to those associated with the “Independent Development Approach (Portfolio 1Aa)” as Portfolio 2Bb consists mainly of hydroelectric power which is a much cleaner means of power generation than coal and fuel, especially regarding air quality.

Furthermore, the positive impacts mentioned in the sections above are more pronounced in Portfolio 2Bb than in the “Independent Development Approach”. Mainly, more energy and greater economic growth will be generated in Portfolio 2Bb.

14.8 Cumulative Impacts of Other Portfolios

14.8.1 Portfolio 2Cb – Technological Diversification

Portfolio 2Cb is defined as regional cooperation approach with enhanced technological diversification with medium load growth. The difference between this strategy and the Portfolio 2Bb (regional cooperation approach with maximized use of the most attractive resources with medium load growth) is that Songwe and Mutonga hydroelectric options are replaced by four coal-fired steam plants (Mchuchuma, Mombasa I, II and III) located in Tanzania and Kenya.

14.8.1.1 Cumulative Impacts for Hydroelectric Options

Without the Songwe project, it can be expected that the conflicts between Tanzania and Malawi farmers because of the fluctuation of the river will continue and the river delta will remain in its current situation. There will be no direct and indirect socio-economic positive impact in the area due to job creations.

Rumakali will be the only project located on a river flowing into Lake Malawi/Nyasa. This will decrease the scope of environmental changes on the northern part of the lake, but will add the pressure of potential acid rain affecting the lake and its basin from Mchuchuma emissions. The “in service” dates also slightly change but this does not affect the conclusions reached for the other watersheds considered in Portfolio 2Bb.

There will thus be less environmental and social cumulative effects on the Tana River: The river will conserve its actual regime of seasonal flooding and farmers will continue their actual practices. The Mombasa projects in Kenya will contribute GHG and acid rain in the Mombasa area.

Cumulative Impacts for Geothermal Power Options, Transmission Lines and Wind Farm Power Options

The cumulative impacts for this strategy are the same as for the previous strategy**.** Globally, no cumulative impacts are expected from the addition of geothermal or wind farm power options.

14.8.1.2 Cumulative Impact of Transmission Lines

As with Portfolio 2Bb, there should be little to no cumulative impacts due to transmission lines.

14.8.1.3 Conventional Thermal Power Plants

Greenhouse gas emissions: The fossil fuel thermal options proposed for this Portfolio would generate emissions for a total of 35 Mt CO_2 equivalent, for the life cycle of the options, taking into account the year the project is put into service. In year 2020, the total emissions would be 7.4 Mt CO_2 equivalent (the total emissions represent 0.2 t CO_2 equivalent per person for SSEA region). These emissions would be significantly higher than those generated under Portfolio 2Bb. This is due to the presence of Mchuchuma and Mombassa coal fired power plants, which could have a cumulative impact on the region’s climate.

Air Pollutant Emissions: The contribution to SO_2 emissions of the region would be in the order of 68,000 t SO_2 equivalent for the 15 years and 14,000 t SO_2 equivalent for year 2020.

The contribution of this Portfolio to SO_2 equivalent emissions would be higher than those emitted under Portfolio 2Bb. The location for most of these fossil fuel thermal power plants is not yet defined, but they are likely to be located relatively close to the demand in urban areas, likely to have other sources of air pollutant emissions. Consequently, this strategy would contribute more to cumulative impacts on a regional basis. This will contribute cumulatively to acid rain and to an increase in pulmonary diseases. Coal fired power plants are important emitters of fine particles that travel deep into the pulmonary tissue. One exception to this is the Mchuchuma Coal Fired Power Plant, which will be located at the mouth of the coal mine; this mine is away from large urban areas and the emissions from that power plant would not add much to other urban acid rain emissions but its proximity to Lake Nyasa/Malawi would result in more acid rains that would affect the lake and its watershed, particularly downwind.

14.8.2 Portfolio 2Db – Geographical Diversification With Medium Load Growth

Portfolio 2Db represents a regional cooperation approach with enhanced geographical diversification with medium load growth. The difference between this strategy and the one for the best evaluated options is that Rumakali, and Songwe are not part of this geographical diversification strategy, and one option is added (Mombassa coal/steam plant).

14.8.2.1 Cumulative impact of Hydroelectric Options

There will be no change on Lake Nyasa/Malawi compared to the present situation relative to hydroelectric projects. The positive socio economic impacts anticipated from direct and indirect job creation will not materialize and the environmental situation of the Songwe and Rumakali rivers and their delta will remain the same as it is now.

14.8.2.2 Cumulative Impacts for Geothermal Power Options, Transmission Lines and Wind Farm Power Options

The cumulative impacts for this Portfolio are the same as for the best evaluated options Portfolio 2Bb. Globally, no cumulative impact are expected from the addition of the geothermal or wind farm power options.

14.8.2.3 Cumulative impact of Transmission Lines

As with Portfolio 2Bb, there should be little to no cumulative impacts due to transmission lines.

14.8.2.4 Fossil Fuel Thermal Power Plants

Greenhouse Gas Emissions: The fossil fuel thermal options proposed for this Portfolio would generate a total of 36 Mt CO_2 equivalent emissions, for the life cycle of the options, taking into account the year the project is put into service. In year 2020, the total emissions would be of 6 Mt CO_2 equivalent.

These emissions are almost the same as those that would be generated by the technological diversification Portfolio 2Cb and higher than those of Portfolio 2Bb and hence pose the same issue as the technological diversification Portfolio 2Cb of a possible cumulative impact on climate change. There again this is due to the presence of the 450 MW produced by the Mombasa coal fired power plant.

The total emissions would then represent 0.21 t CO_2 equivalent per person for the SSEA region.

Air Pollutant Emissions: The contribution to SO_2 equivalent emissions of the region would be in the order of 68,000 t SO_2 equivalent for the 15 years, and 11,000 t SO_2 equivalent for year 2020.

There again the contribution to SO_2 equivalent emission would be about the same as those emitted by the technological diversification Portfolio 2Cb and higher than those emitted by Portfolio 2Bb. The location for most of these fossil fuel thermal power plants is not yet defined, but they are likely to be located relatively close to the demand in urban areas. These urban areas are likely to have other sources of air pollutant emissions contributing to cumulative impact for pollutant emissions on a regional basis. This can contribute cumulatively to acid rain and to an increase in pulmonary diseases.

Globally, no significant cumulative impact is expected from the addition of the geothermal, wind farm power options and transmission lines.

14.9 Conclusions

Overall, there are not many differences between the Portfolio based on Best Evaluated Options, Medium Load - Portfolio 2Bb and the Technological and Geographical diversification portfolios, The differences are summarized below:

Portfolio 2Bb vs Portfolio 2Cb Best Evaluated vs Technological Diversification	Portfolio 2Bb vs Portfolio 2Db Best Evaluated vs Geographical Diversification
Removal of Songwe (H)	Removal of Songwe (H)
Removal of Mutonga (H)	Removal of Rumakali (H)
Addition of Mombasa (C)	Addition of Mombasa (C)
Addition of Mchuchuma (C)	

Because the portfolios differ so little, the difference in cumulative impacts between the Portfolio of Best Evaluated Options and the two diversification portfolios will not be very determinant. Moreover, since the two diversification portfolios share some of the same modifications from the portfolio of Best Evaluated Options, i.e. removal Songwe (hydroelectric option) and addition of Mombasa (coal option), the differences are even less determinant.

The main differences between the two diversification portfolios and the Best Evaluated Options portfolio, are that the two diversification portfolios (2Cb and 2Db) increase the air emissions, greenhouse gases and pollutants responsible for acid rains compared to 2Bb. This will translate into a cumulative impact that will be perceptible at the regional level. The other differences due to the removal of Songwe, Mutonga or Rumakali will be much more localized and will translate into less change or no change in the hydrology and aquatic environment of the rivers involved, and into less positive socio economic impacts because less direct and indirect jobs will be created since dams and power plants will not be built. Some of these jobs will be created where the coal projects will be located, but the construction activities are less important than for hydropower plants and dams, and overall economic benefits would be smaller.

Apart from the advantages derived from the diversification, whether technological or regional, the two portfolio do not offer environmental or social benefits compared to the Best Evaluated Options portfolio (2Bb).

The most significant differences between all portfolios lie between the Independent portfolio (1Aa) and any of the Regional Cooperation portfolios (2Bb, 2Cb, 2Db). Over the Independent portfolio, any of the regional portfolios will have the following advantages:

- Decrease pressure on deforestation
- Less greenhouse gases and other air pollutants
- Better regional integration more reliable electricity supply
- Less water related conflicts
- Better environmental planning and management with positives consequences on management of aquatic resources: fisheries and biodiversity
- Improvement of socio-economic conditions, including alleviation of daily chores such as wood gathering.

14.10 Mitigation Measures

The implementation of all these projects will also have some local and cumulative impacts, but most of them can be mitigated rather easily by implementing a number of measures that have proved themselves in other projects elsewhere. Some of the measures follows to attenuate the most significant cumulative impacts, and a more complete set of measures also applicable for individual project impacts may be found in Appendix G.

14.10.1 Hydropower Options

14.10.1.1 Greenhouse Gas Emissions

The removal of vegetation to be flooded will reduce the net greenhouse gas (GHG) emissions during the first five years of operation. Under normal conditions the decay of vegetation will produce mainly CO_2; when flooded, the production of methane (a GHG equivalent to 23 times CO_2) is anticipated as a result of decay in shallow tropical reservoirs. The presence of other organic material, difficult to remove, will add to net GHG emissions. This mitigation measure would be particularly relevant to the Rusumo Falls project and all the larger reservoirs.

14.10.1.2 Designated Habitats and Natural Sites

The mitigation plans for the impacts on designated habitats and natural sites have to be site-specific and often involve enhancement of remaining habitats and natural sites nearby. The most successful mitigation, compensation and enhancement plans to restore designated habitats and natural sites are:

1. Protection of land area at a level equivalent to or better in ecological value than the lost land; this measure is easy to apply in certain areas.
2. Conservation of valuable land adjoining the reservoir for ecological purpose and erosion prevention. A conservation management plan should be initiated as soon as a decision to build the project is taken.
3. Creation of ecological reserves with rigorous and effective protective measures.
4. Enhancement of reservoir islands for conservation such on purposes, to encourage their use by migratory birds and to support a wide range of flora.
5. Development or enhancement of nesting areas for birds.

6. Creation and protection of spawning and rearing habitats for fishes in reservoirs or in tributaries.
7. Diversification of aquatic habitats in bays of the reservoir and construction of weirs to maintain water level.
8. Replacement of flooded designated habitats by habitats of similar value.
9. Morphological adjustment of land in selected area around the reservoir and revegetation to create specific habitats.
10. Targeted management plans for endangered species conservation.

14.10.1.3 Sedimentation and Erosion within the Reservoir and Downstream

The most effective measures to prevent reservoir sedimentation are:

1. Adequate bank protection in the catchment area.
2. Reforestation of area showing acute erosion process in the catchment area.
3. Changes in agriculture practices on slopes susceptible to erosion.
4. Use of sediment trapping devices upstream.
5. Use of bypassing facilities to divert floodwaters (run-of-river).
6. Adding sluices to the dam.

This is particularly true for all reservoirs located on the Tana and Rufiji basins, respectively in Kenya and Tanzania.

14.10.1.4 Environmental Impacts on the Downstream Reaches

Changes to downstream hydrology and sediment release have a potential to reduce local biodiversity. The disappearance of natural floods alters the natural life cycle of ecosystems downstream. The change in water quality downstream from a reservoir can be adverse for aquatic wildlife. Daily variation could also have adverse effect on the downstream habitats and increase erosion process.

In order to maintain the quality of the aquatic habitats downstream, various mitigation measures are proposed and vary in terms of environmental issues. They are:

1. Application of a minimum flow at all times;
2. Water release policies that take account of ecological issues;
3. Construction of bottom outlets;
4. Periodic releases of water to recreate annual flooding cycle;
5. Surface spillway;
6. Decrease residence time of water in reservoir to provide a quality of water downstream that is similar to the water flowing into the reservoir;
7. Fish ladder.

14.10.1.5 Socio-economic Mitigation, Compensation and Enhancement Measures

The hydropower options that are considered in the comparative analysis raise the following main socio-economic issues:

14.10.1.6 Involuntary Displacement

Except for the Ruzizi III, all hydroelectric options selected involve some involuntary displacement. For the Bujagali option, resettlement has already been carried out in the affected area. Preliminary resettlement plans exist for the Karuma and Mutonga options.

Comprehensive guidelines that define this process, based on lessons learned from projects the world over, now exist. They are based on the following principles (as described in the World Bank Resettlement Policy):

- Avoid or minimize involuntary displacement
- Improve livelihoods
- Develop the resettlement plan around a development strategy
- Promote participation
- Move people in groups
- Rebuild communities
- Consider host's needs
- Protect vulnerable groups

Successful resettlement also depends on an appropriate resettlement policy framework. Current legislation on land tenure and resettlement has been reviewed for all six countries in Chapter 3 of this report. This review indicates that none of the six countries have explicit laws regarding compensation for resettlement. Thus the principles indicated above provide the best guidance available. Special attention must be paid to eligibility criteria for defining various categories of displaced persons, entitlements and methods of valuing affected assets.

14.10.2 Fossil-Fuelled Thermal Power Options

Air emissions are one of the main issues regarding fossil-fuelled thermal generation; emissions levels for the design and operation of each project must be established through the environmental assessment process on the basis of country legislation and the World Bank Pollution Prevention and Abatement Handbook.

14.10.2.1 Socio-economic Mitigation, Compensation and Enhancement Measures

To a large extent, socio-economic impacts of fossil-fuelled thermal power options depend on determining an appropriate site for the project that takes into account socio-economic considerations. Such an approach can be considered as one of the most significant mitigation measures of thermal power plants impacts. As far as possible, sites in industrial areas, away from agricultural or residential areas, are preferred. The project layout must also take into account the increased demands on local infrastructure, such as roads, housing, medical facilities or schools that result from the influx of workers during construction and operation.

Table 14-6 - Summary of Environmental Cumulative Impacts on Portfolio 2Bb

	Lake Tanganyika Basin	Lake Nyasa/ Malawi Basin	Rufiji River Basin	Tana River Basin	Lake Victoria Basin	Victoria Nile Basin	Cumulative Impact on Downstream Nile
New options Included	Kabu 16 (2013), Ruzizi III (2014) and Lake Kivu Methane (2008, 2010, 2011, 2018)	Rumakali (2017), Songwe (2019)	Ruhudji (2015)	Mutonga (2020) Kiambere Extension (H, C)	Rusumo Falls (2012), Kakono (2012)	Bujagali (2012 and 2014), Karuma (2016)	
Outflow to:	South into the DRC then to the Atlantic Ocean	Indian Ocean	Indian Ocean	Indian Ocean	Victoria Nile	Nile River	
Flow Regime	No change; hydro options are run of river	Reservoir associated with Songwe option could reduce flood flows and stabilize river bed but increase dry season flows; increase in evaporation Rumakali is run-of-river; hence no impact	Reduction in flood flows; slight increase in flows during dry period. Increase in evaporation. Variations within natural range.	Would eliminate any residual seasonal flooding	Reduction in flood flows; slight increase in flows during dry period, absorbed by Lake Victoria. Virtually no change in evaporation/ evapotranspiration rates	No change; options are run-of-river and flow variation into Lake Kyoga and Lake Albert is damped by the volume of the lakes. No change in evaporation	Virtually no change
Water Quality and Quantity	Improved; reduction in sediment trapped by the dams. No change in quantity	Improved; reduction in sediment trapped by the dams	Improved; reduction in sediment trapped by the dam	Improved; reduction in sediment trapped by the dam	Improved; reduction in sediment trapped by the dam	Improved; reduction in sediment trapped by the dams	Slight improvement in quality of water; no change in quantity
Riparian and vegetative resources	Improved; reduction in nutrients flowing into Lake will reduce eutrophication	Reduction in nutrients and change in flow regime would have a negative impact on the wetlands in the delta area	Is not likely to affect important wetland and Ramsar site by reducing nutrients because of great distance from project	No impact	Reduction in size of wetlands	Slight reduction in nutrients	Reduction in nutrients would counterbalance pressure being exerted by population growth
Wildlife/ Biodiversity	Virtually no impact	Reduction of sediment and nutrients will preserve actual biodiversity of lake	Virtually no impact	Possible reduction in riverine forest could increase pressure on two rare primate species	Any impact would be localized. Reduction of wetlands could have impact on migratory birds, but more information needed	Slight loss in habitat (localized)	No impact
Fish and fisheries	No significant impact expected because of the Ruzizi. Potential presence of migratory fish (eel) in the Kaburantwa importance of impact on fish or fisheries to be determined with EIA	Presence of migratory fish; importance of impact on fish or fisheries to be determined with EIA	No migratory fish except maybe eels; no impact on fish or fisheries	Potential presence of migratory fish (eels); importance of impact on fish or fisheries to be determined with EIA	Potential presence of migratory fish; importance of impact on fish or fisheries to be determined with EIA	No migratory fish from lake to river no impact on fish or fisheries	No impact

Table 14-7 - Summary of Socio-Economic Cumulative Impacts on Portfolio 2Bb

	Northern part of Lake Tanganyika and Lake Victoria watershed	Lake Nyasa/Malawi and Rufiji River basin	Tana River	Eastern part of Lake Victoria (Kenya)	Victoria Nile Watershed	Cumulative Impact on Downstream Nile
New options Included	Rusumo Falls (H) Kakono High (H) Kabu 16 (H) Ruzizi III (H) Lake Kivu Methane (M)	Rumakali (H) Songwe (H) Ruhudji, run of the river (H)	Mutonga (H) Kiambere extension (H)(C)	Kiambere extension(H) Sondu Miriu (H) (C) Geothermal Fields (G)	Bujagali (H) Karuma (H) Kiira (H) (C)	
Agriculture	Potential agricultural boom due to increase in irrigated lands; might lead to increase in the use of pesticides and fertilizers	Possible loss of land along the Songwe river due to stabilization of river bed and of country boundaries Potential agricultural boom due to increase in irrigated lands; might lead to increase in pesticides and fertilizers	Loss in irrigated lands and possible outmigration of peasants for more fertile areas; changes of usual practices as seasonal floods are eliminated	No impact	No impact	No impact
Irrigation	Improved	Improved	Affected, might interfere with an irrigation project (Bura)	No impact	No impact	No impact
Water supply	Improved due to improvement in water quality	Improved due to improvement in water quality	Improved due to improvement in water quality	Improved due to improvement in water quality	Improved due to improvement in water quality	Improved due to improvement in water quality
Tourism	No impact	No impact	No impact	No impact	Irreversible impact, destruction of 2.5 km of white river and falls; a loss of tourism revenues; however, more reliable supply of energy will improve tourism infrastructure and services	No impact
River navigation	No impact	No impact	No impact	No impact	No impact	No impact
Cultural resources	No impact	No impact	No impact	No impact	No impact	No impact
Economic development and rural electrification	Improved locally and regionally	Improved locally and regionally	Improved locally and regionally	Improved locally and regionally	Improved locally and regionally	Not applicable
Health	Risk of increase in waterborne diseases and slight risk of increase in communicable diseases during construction; may be compensated by improved health care availability	Slight risk of increase in communicable diseases during construction; risk of increases in malaria and bilharzias due to reservoir; may be compensated by improved health care availability	Slight risk of increase in communicable diseases during construction; risk of increases in malaria and bilharzias due to reservoir; may be compensated by improved health care availability	Higher H_2S emissions leading in health problems; may be compensated by improved health care availability	Slight risk of increase in communicable diseases during construction; may be compensated by improved health care availability	Not applicable
Impact on population density	Increase in human pressure due to resettlement and refugee movement in an overpopulated areas	No impact	No impact	No impact	No impact	Not applicable

15 CONCLUSION, RECOMMENDATIONS AND NELSAP INDICATIVE POWER DEVELOPMENT STRATEGY

The Nile Equatorial Lakes Region of Africa is in need of a reliable, environmentally acceptable and low-cost source of electricity. The current situation of energy undersupply, suppressed demand and reliance on fossil fuels and locally harvested wood for energy is neither sustainable nor a sound basis for economic and social development in the region.

Decision-makers at the national, regional and international levels are cognizant of the seriousness of the situation and keenly aware of the need to increase power generation in the region. However, they are also aware that improperly designed and poorly constructed power generation facilities, both hydro and thermal, can have severe environmental and social consequences.

This assessment, which does not replace detailed environmental impact assessments or feasibility studies, is intended to provide information, analyses and recommendations that assess a number of power generation options and ranks them in terms of environmental, social, cost and risk criteria.

Although not limited to hydro options, the portfolios are heavily weighted toward that source of energy due to its relative abundance in the region.

The assessment suggests that several of the options merit further consideration and detailed study. Most of the hydro options, which are run-of-river configurations, would appear to have limited adverse environmental or social consequences.

This chapter provides, first, a set of conclusions related to the availability of electricity, power development options available in the near terms, environmental issues, social issues, impact of climate change and investments required. It then provides recommendations for a NELSAP strategy for power development. Within this strategy is a recommended NELSAP Indicative Power Development Plan. The recommendations also include specific actions required by decision-makers in the region to carry out the strategy proposed and to implement the NELSAP Indicative Power Development Plan. The chapter ends with a discussions of institutional issues that need to be addressed in order to foster electricity trade in the region.

15.1 Conclusions

Availability Electricity in the Region:

The level of availability and use of electricity in the region is very low:

- Current consumption is about 95 kWh/capita/year.
- At the end of the forecast period there can be some improvement depending upon the load growth scenario that is achieved.
  - Base forecast scenario: 103 kWh/capita/year, an increase of less than 10% over current levels of about 95 kWh/capita/year;
  - Medium forecast scenario: 141 kWh/capita/year, an increase of 53% over current levels but not even half of the current average for all of Africa (even excluding the wealthier countries) of 320 kWh/capita/year, as shown in Table 5-1;

- High forecast scenario: 181 kWh/capita/year, an increase to almost double the current level in the region but still well under the current average for all of Africa (even excluding the wealthier countries);
- Transformation scenario: 318 kWh/capita/year, an increase to over three times the current level in the region but just equal to the current average for all of Africa excluding the wealthier countries. This is still only about one third of the level reached by the developing countries of the world, even when the wealthier of them are excluded from the comparison.

<u>Power Development Options prior to 2009:</u>

- Because of the lead times required to select and implement power development options, there is very little choice of options prior to 2009 – the options available are options already committed and under construction or small plants that can be built rapidly such as gas turbines and diesel units. These plants include:
  - Gas turbines,
  - Kiambere extension
  - Diesels
  - Sondu Miriu
  - Olkaria Geothermal
  - The first engine at Lake Kivu, and
  - A combined cycle unit
- In order for the countries to be able to act in concert in the development of their power sectors, a backbone of transmission facilities needs to be built as soon as practicable. This backbone should ensure that power can flow from any of the proposed mid and long-term power development options to the load centres anywhere in the study region.

<u>Environmental Issues:</u>

- Even the most hydro-intensive portfolio (the one representing the strategy that maximizes the use of the best-evaluated options) would not have any significant effect on the Albert Nile leading to Sudan and the Sudd Marshes, whether in terms of flow regime, volume lost due to evaporation or sediment load, provided the operation of the Victoria Nile hydropower facilities does not deviate significantly from the natural flow as determined in an agreed curve based regulation (for Lakes Victoria, Kyoga and Albert).
- The cumulative impacts were considered using as a reference independent development of the region on an ad hoc basis with no regional integration. This base would include continued suppressed electricity demand and the installation of smaller and less attractive power development options than the regional integration would foster.
- The cumulative impacts on the environment from multiple hydro projects in a river basin or several thermal plants are relatively minor; the most significant would be emissions from thermal plants and potential impacts on wetlands in the Kagera River and the Rufiji River.

Social Issues:

- The most significant social issue is the resettlement of population due to the construction of options, particularly those with reservoirs. Effective mitigation measures need to be implemented as part of a resettlement action plan.

Impact of Climate Change

- For the Northern (which includes the Bujagali and Karuma options) and Central West regions (which include Rusumo, Ruzizi III and Kabu 16) there is a high probability of increases in runoff, and thus generation, than presently identified from historic flow data. For the southern region (which includes Ruhudji and Rumakali options) there is a high likelihood of changes in seasonality of runoff, resulting in lower effectiveness for flow regulation in any smaller reservoir;
- The overall impact of climate change on the power output of portfolios examined is expected to be positive over the period of the assessment.

Investments Required:

- The total capital investment required over the period 2005 to 2020 to meet the medium load growth scenario for the portfolios representing all three strategies considered are very similar (these include US $ 0.7 billion up to 2009 inclusive):
    - Portfolio maximizing the use of best evaluated options regardless of technology used or geographic location – US$ 5.83 billion
    - Portfolio emphasizing technological diversification – US$ 5.75 billion
    - Portfolio emphasizing geographic diversification – US$ 5.67 billion

  The higher investment for the first portfolio reflects the greater hydroelectric content, which is more than offset by the variable (primarily fuel) operating expenses.

- The high load growth scenario would require over 50% more investment – US$ 8.25 billion.
- The transformation scenario would require over three times more investment – US$ 16 billion.
- Imports from Inga in the DRC or from other sources would be attractive if power can be delivered into the region for under approximately U$ 0.03/kWh.

15.2 Recommendations and NELSAP Indicative Power Development Strategy

The following are specific recommendations for a NELSAP Indicative Power Development Strategy based on the medium load growth scenario.

Priority Options for Power Development:

- Because of the long lead times required for the construction of power development options, there is little that can be done to improve the power supply situation other than:
    - To implement options already committed or under construction and
    - To install units that can be built quickly such as diesel and gas turbine units as well as combined cycle plants, all of which, unfortunately, use expensive fuels

- Again, because of lead times required, each of the following options would have to be designed and built as soon as possible
    - Bujagali 1 to 5 (250 MW) in Uganda;
    - Kabu 16 (20 MW) in Burundi;
    - Kakono (53 MW) in Tanzania;
    - Geothermal plants in Kenya (2 by 70 MW plants);
    - The second and third phases of the Lake Kivu gas engines (30 MW) in Rwanda/DRC;
    - Ruhudji (358 MW) in Tanzania;
    - Rusumo Falls (62 MW) between Rwanda and Western Tanzania; and
    - Ruzizi III (82 MW) between Rwanda and DRC.

  All of these options are required during the period 2009 to 2015. The order of installation of these options would depend upon the speed with which the additional studies required for each can be completed. These options are needed regardless of the development strategy selected.

- During the same period 2009 and 2015 additional gas turbines, diesels and some combined cycle plants (and other hydro options if they can be implemented during this period) will be needed to fill an expected shortfall.

- Planning should begin now for the installations required after 2015. Such planning should take account of the strategy for development that the governments of the region opt for (best evaluated options, technological diversification or geographic diversification). Planning should be based on the medium load growth scenario but should be flexible enough to advance new power development options if the growth is higher than the medium load growth scenario.

  For the purpose of this analysis, the portfolio of options selected for the NELSAP Indicative Power Development Plan is based on technological diversification, and the medium load forecast of 5.6% to 6.3% per year (2Cb). This plan is presented in Table 15-1. As noted above, there is a need for flexibility. Options not listed in Table 15-1 but included in the portfolios outlining the three strategies (best evaluated and others) will be needed to implement under the high and transformation growth scenarios. These options are shown in Table 15-2. They could be used if the load grows at a rate greater than the medium load growth scenario or if different development strategies are accepted.

Table 15-1 – NELSAP Indicative Power Development Plan

Year	Addition	Country	Capacity Addition (MW)
2009	Gas Turbines	Tanzania	120
	Combined Cycle	Tanzania	60
	Diesel	Tanzania	10
2010	Geothermal	Kenya	70
	Kivu engine #2	R/DRC	30
	Combined cycle unit	Tanzania	60
2011	Kivu engine #3	R/DRC	30
	Gas turbine	Tanzania	60
2012	Bujagali 1 – 4	Uganda	200
	Fusumo Falls	B/R/T	61.5
2013	Geothermal (Suswa)	Kenya	70
	Kabu 16	Burundi	20
	Kakono	Tanzania	53
2014	Bujagali 5	Uganda	50
	Ruzizi III	R/DRC*	82
	Gas Turbine	Kenya	60
2015	Ruhudji	Tanzania	358
2016	Geothermal (Menengai)	Kenya	140
2017	Kivu engine #4	R/DRC	30
	Geothermal (non-specified)	Kenya	140
	Karuma	Uganda	200
2018	Wind (two plants)	Kenya	60
	Mombasa 1	Kenya	150
2019	Mombasa 2	Kenya	150
2020	Rumakali	Tanzania	222
	Mchuchuma (Units 1 and 2)	Tanzania	200
	Mombasa 3	Kenya	150

Table 15-2 - Power Development Options Not Used in Indicative Power Development Plan

Power Development Option	Country	Capacity Addition (MW)
Mpanga Hydro (MW)	Tanzania	144
Mutonga Hydro ((60 MW)	Kenya	60
Songwe (330 MW)	Tanzania	330
Upper Kihansi (energy only)	Tanzania	N/A
Additional combined cycle plants (generic)	Tanzania	As required
Thermal plants fuelled with LNG, assumed located at Mombasa and assumed in the number and sizes needed	Kenya	As required
Additional coal-fired units at Mchuchuma	Tanzania	Up to 400 MW
Thermal plants fuelled with coal imported from South Africa or elsewhere, assumed located at Mombasa and assumed in the number and sizes needed	Kenya	As required

Priority Studies:

- Carry out studies on several of the power development options that have only been identified and studied to the reconnaissance level. These include:
  - Kiymbi, 43 MW (rehabilitation);
  - Budana, 13 MW (rehabilitation);
  - Piana Mwanga, 38 MW (rehabilitation);
  - Bangamisa, 48 MW;
  - Babeda 1, 50 MW;
  - Sisi 3/5, 174-205 MW.
- Carry out further studies of the Malagarasi Cascade (including Igamba Fall) from the point of view of development for the region (current information is for options that use only a small fraction of the potential of the cascade).

Imports:

- Replace local plants with imports from outside the region IF such imports cost less than US 3¢/kWh (levelized unit cost over the life of the purchases).

Transmission Requirements to Promote Regional Cooperation

- The transmission backbone components from Burundi, Rwanda and Western Tanzania recommended in the SSEA Stage I report are noted:
  - A 110 kV line from Kigoma, Rwanda to Rwegura, Burundi;
  - A 132 kV line from Kabarondo, Rwanda passing near Ngara to Biharamuro in Kagera province of Tanzania;
  - A 132 kV line from Ngara, Tanzania to Gitega, Burundi;
  - A 110 kV line from Gitega, Burundi to to Kigoma, Tanzania.

- The transmission lines recommended in the EAPMP covering Kenya, Tanzania and Uganda for the integrated case (as defined in the EAPMP and is the equivalent of the regional approach used herein) are noted:
  - A new 220 kV line from Arusha, Tanzania to Nairobi, Kenya;
  - A upgrade of the existing 132 kV line from Lessos, Kenya to Jinja, Uganda to 220 kV.
- The transmission lines proposed by the DRc for the eastern regions of the country are noted:
  - 70 kV from Ruzizi, DRC to Bujumbura, Burundi to be upgraded to 110 kV
  - 70 kV from Bukavu to Goma, both in the DRC to be upgraded to 110 kV
  - 110 kV line between Goma nad Beni via Butembo
  - 110 kV line between Mukungwa, Rwanda and Goma, DRC, then on to the proposed hydro plant of Mugomba in Uganda
  - a line between Beni and Bunia to be connected to the exiting plant at Budana and the proposed plant at Semliki
  - lines from the Mpiana Mwanga and Kiyimbi plants to the Ruzizi- Bujumbura line
  - a submarine cable linking Kalemie, DRC to Kigoma, Tanzania
- Add two new lines to connect the isolated load in Burundi, Western Tanzania, Rwanda and Eastern DRC to the EAC area:
  - A 132 kV line from Mbarara to Kigali; and
  - A 132 kV line from Bulyanhulo to Biharamulo, Tanzania;
- Some of these transmission lines are part of the proposed Regional Rusumo Falls Project: Rusumo to Gitega, Burundi; to Kabarondo, Rwanda; and to Biharamuro, Tanzania;

<u>Next steps:</u>

Table 15-3 presents in summary form the decisions and work required to implement the proposed power development options. In addition to these actions related to specific development options, the following actions need to be taken urgently from a regional and sectoral point of view:

- The governments of the six countries should select a development strategy (maximize the use of the best evaluated power development options regardless of the technology involved or security of supply; technological diversification; geographical diversification or security of supply; or other) to be followed by the region so as to be able to plan and implement power development options in a coherent manner.
- The governments of the six countries should decide on the level of coordination and integration of their power sectors and then carry out the appropriate actions described in Chapter 3 on changes to the legal and regulatory framework to facilitate, to the level desired, power trading between the countries of the region.

Table 15-1 together present an indicative expansion plan based on technological diversification, and the medium load growth scenario. Figure 15-1 presents a map of the region that includes:

- New power development options recommended for installation between now and 2015;
- The backbone transmission system.

Note that this map does NOT include:

- Power development options already under construction (and therefore not part of the process being reported on in this document);
- Power development options beyond 2015 as the selection of options for that period will depend upon the decisions of the various countries as to the development strategy they wish to follow;
- Local transmission requirements, as these are national matters as opposed to regional ones.

DRC needs to further evaluate a number of potentially attractive sites, and particularly seek financing for the three rehabilitation projects referred to above.

15.3 Institutional Issues

The discussion in Chapter 3 on legal and regulatory matters indicates that there does not seem to be any legal or regulatory impediment to regional cooperation. Indeed, there is currently cross-border trade in electric power. There are however, some issues that would need to be resolved before some of the options identified above can be implemented. These include:

- Ruzizi III and Rusumo Falls are located on international boundaries; before they can be financed, lenders will insist that agreements between the countries on the joint use of the water will need to be concluded;
- Some of the options may be installed in one country for the immediate benefit of another country. This will require power purchase agreements as well as transmission access agreements.

Significant cross-border trade may require strengthening of transmission systems as well as close cooperation between the load dispatch centres of each affected country. In this context, for the efficient functioning of a regional electricity market (at some point in the future) the member countries need to articulate a minimum platform for cross-border power trade that embraces the following:

- Each member country should decide on the degree of security of power that is appropriate to it, given the availability and cost of resources and the level of reliance it is willing to place on the power systems of neighboring countries;
- Imports/exports need not be regulated per se or, if they are, as little as possible, ensuring only that (a) such trading is not more costly than native generation when such supply is available; and (b) operational security of the network and quality of supply are not compromised.

If the country opts for a multi-buyer system to facilitate and foster regional trade, then it is important to have:

- Open access to transmission network is transparent and non-discriminatory (existing generators and IPPs) rules for pricing and volume of trade;
- Functional unbundling, at least in the initial stages, be limited to transmission and generation coupled with the creation of an independent transmission system operator

at the national level that would provide transmission services and open access same-time information;

- Transparent pricing arrangements for transmission services (also called wheeling charges or transit fees) and ancillary services.

It is also essential that the countries where options are located have institutional capacities to ensure full implementation of national laws, standards and regulations with regard to environmental impact assessments, community impacts, mitigation and monitoring.

Table 15-3 – Urgent Actions Required to Achieve On-Power Dates

Regional Actions to be taken	Action by
Commitment to design update for Rusumo Falls	B/R/T
Rusumo - complete studies and approval	B/R/T
Start design update and EIA for Rusumo	B/R/T
Rusumo final approval and construction contract	B/R/T
Design, procurement and installation of Kivu gas engines	R/DRC
Procure and install required diesels	B/R/T
Bujagali - final studies/approval/design	Uganda
Bujagali 1-4 start construction	Uganda
Ruzizi III studies and approval	R/DRC
Ruzizi III design	R/DRC
Study, commit, design and implement backbone transmission - SSEA 1	B/R/T
Study, commit, design and implement EAC transmssion additions	K/T/U
Study, commit, design and implementinterconnections EAC - SSEA-1	B/K/R/T/U
Complete transmission construction	K/T/U
Longonot geothermal final studies/EIA and approval	Kenya
Longonot geothermal - start design	Kenya
Longonot geothermal construction	Kenya
Procure and install required gas turbines	Tanzania
Procure and install 60 MW steam cycle CC unit	Tanzania
Kakona final study and approval	Tanzania
Kakono - design start	Tanzania
Kabu 16 final study and approval	Burundi
Kabu 16 - design start	Burundi
Start procurement of Kivu gas engine No. 2 group	R/DRC
Suswa geothermal investigations and approval	Kenya

Figure 15-1 - Map Showing Regional Development of Power and Transmission Requirements to 2015 (Regional Approach, Technological Diversification Strategy and Medium Load Growth Scenario)