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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

Executive Summary

February 2007

SNC•LAVALIN International

This work was carried out by:

SNC-Lavalin International

In association with:

- Hydro Quebec International
- Vincent Roquet et Associés Inc.
- Stratus Consulting Inc.
- Michael A. Stevens, Consultant
- WL Delft Hydraulics
- Experco International (Burundi, Eastern DRC and Rwanda)
- GIBB Africa Limited (Tanzania and Kenya)
- Sustainable Resources Network (Uganda)

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THE WORLD BANK

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Agence canadienne de développement international

SNC·LAVALIN International

SNC•LAVALIN International

SNC•LAVALIN
INTERNATIONAL Inc.
455 René-Lévesque Blvd. West
Montreal, Quebec
Canada H2Z 1Z3

Telephone: (514) 393-1000
Fax: (514) 876-9273

February 26, 2007

Mr. Jakob Granit
Sr. Water Resources Management Specialist
The World Bank, AFTNL
1818 H. Street, NW
Mailstop J11-1102
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.

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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.

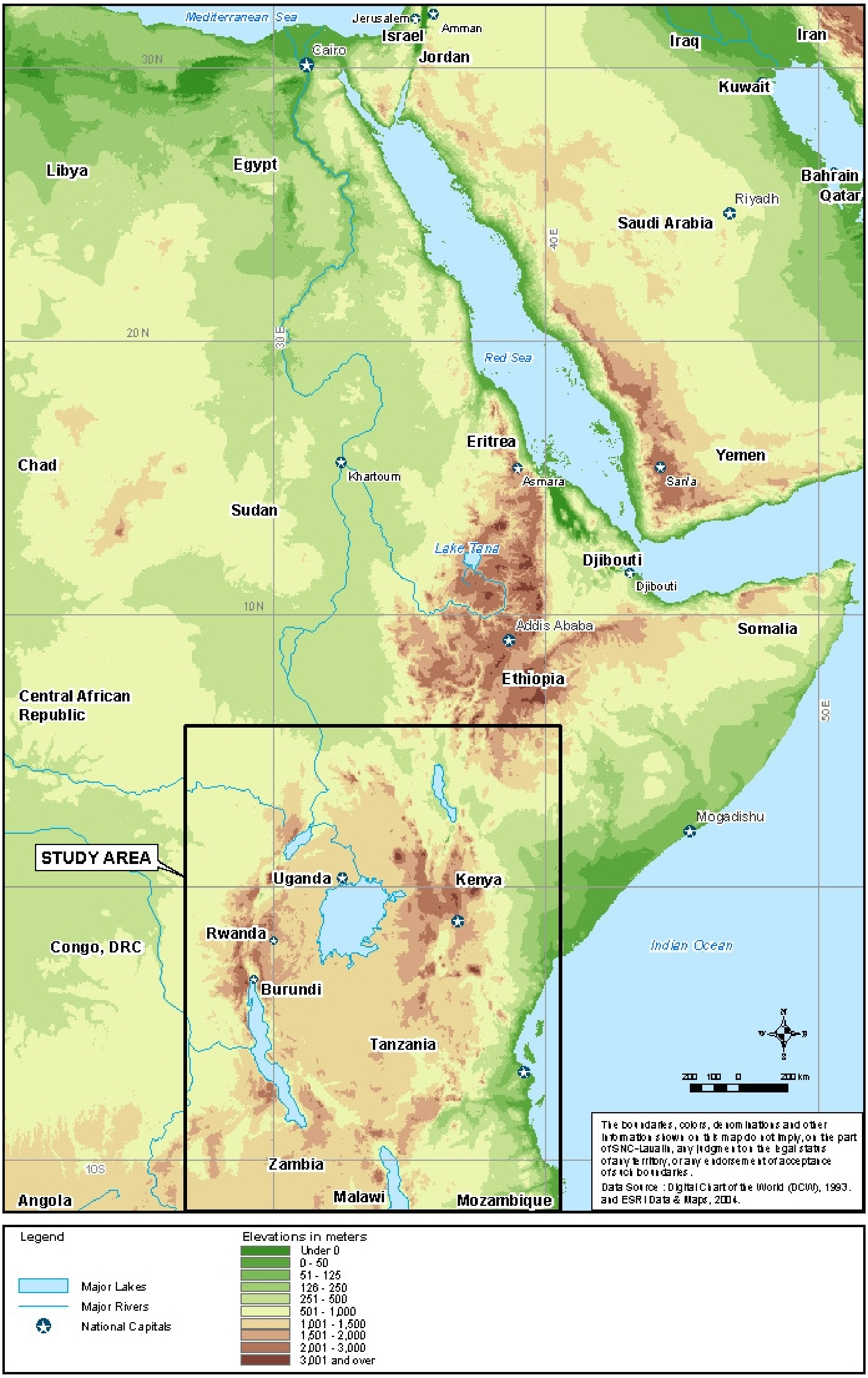
OUTLOOK

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.

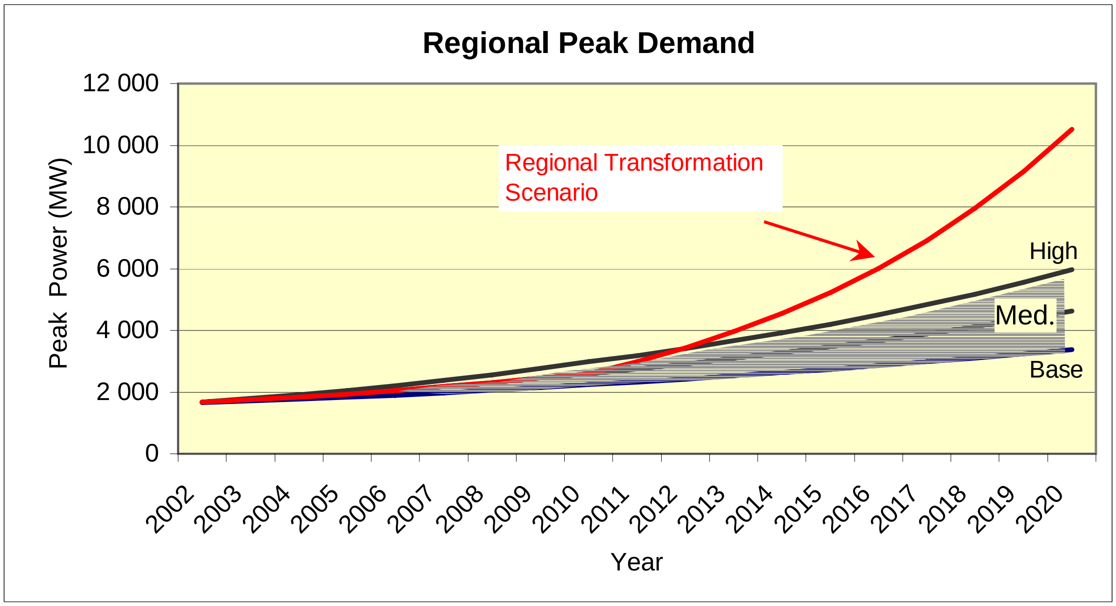
- Electric power demand forecasting methodologies are usually linked to historic trends, which implies a continuation of (or possibly a gradual improvement on) the current socioeconomic condition in the region.

[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.

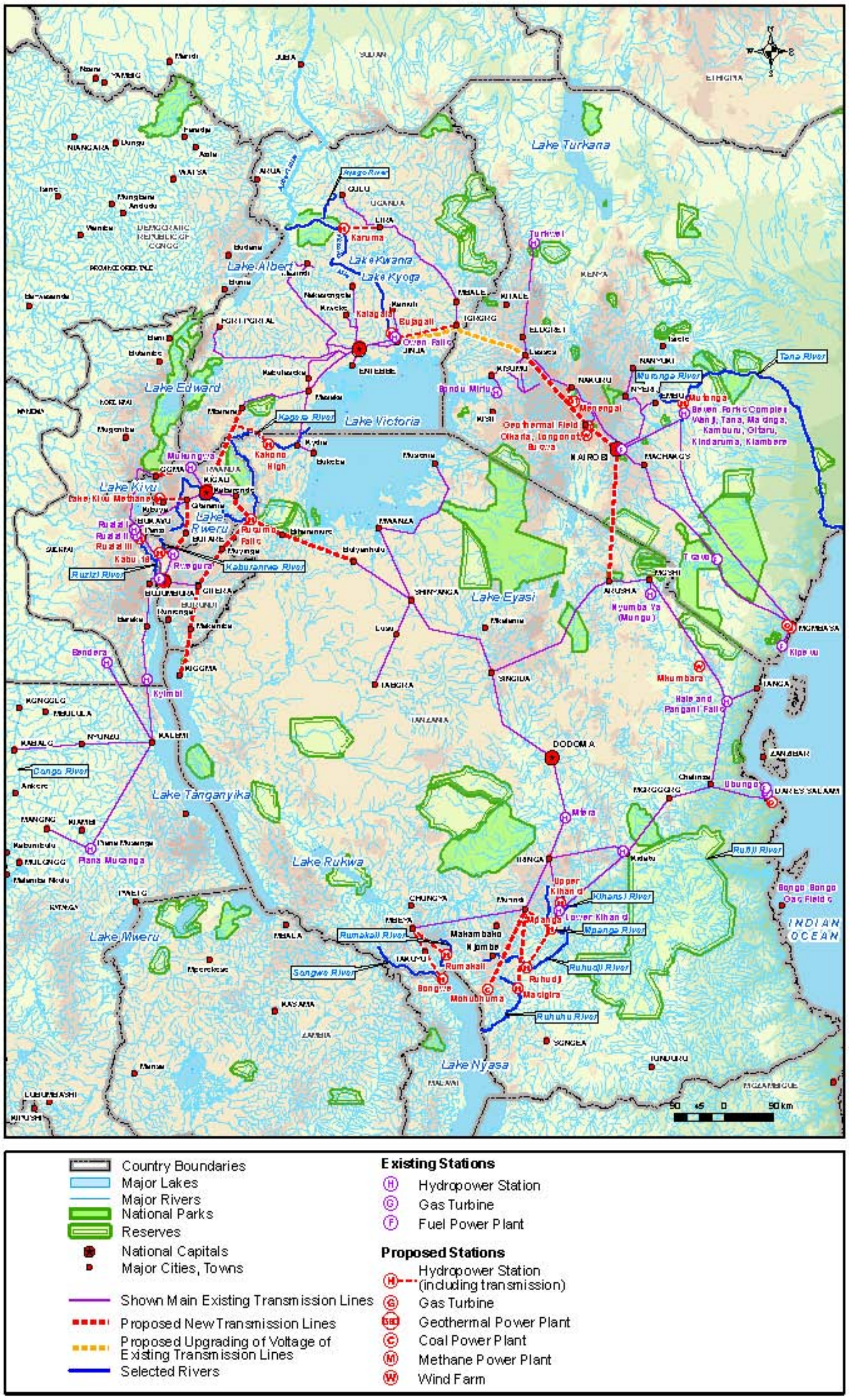
Table 1:
Power Development Options Retained for Comparative Analysis

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.

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

- 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:
  - 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)

Best-evaluated Options		Other Options
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)	**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.***	**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 .***

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 in electricity will require strengthening of transmission systems as well as close cooperation between the load dispatch centres.

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 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:

Load Growth:

- 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.

Resources:

- 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.

Cumulative Impacts of Power Development:

- 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

<u>Coordination and Integration:</u>

• 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)