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

Stage II

Preliminary Evaluation of New Power Options in Eastern Democratic Republic of Congo

March 2005

THE WORLD BANK

Canadian International Development Agency

Agence canadienne de développement international

SNC·LAVALIN International

In collaboration with Hydro Québec International

016223-004-00

PREFACE

On September 17th 2003, SNC-Lavalin International Inc. signed a contract with the International Bank for Reconstruction and Development to provide, in collaboration with Hydro-Quebec International, the consultancy services to conduct Stage I of a Strategic/Sectoral Social and Environmental Assessment of Power Development Options in Burundi, Rwanda and Western Tanzania. In September 2004 this mandate was widened to include Stage II which covers the countries of Kenya, Tanzania (all of it), Uganda and the eastern provinces of the Democratic Republic of Congo (DRC), as well as the areas covered by Stage I.

The starting point in the process is the identification of all practical new power options, and then provide a long list of projects, both thermal and hydroelectric, that would be candidates to meet the forecast loads in the region.

This report provides a preliminary assessment and screening of possible new power options in the eastern part of the DRC. For the purpose of this preliminary assessment and screening, the area in the eastern part of the DRC covered by this study includes the following provinces:

- Province Orientale
- Kivu Nord
- Kivu Sud
- Katanga Nord

TABLE OF CONTENTS

TABLE OF CONTENTS (cont')

PAGE

LIST OF TABLES

LIST OF FIGURES

SUMMARY

1 INTRODUCTION

The objectives set out in the Terms of Reference of the present SSEA II study includes the evaluation power generation options in Burundi, Kenya, Democratic Republic of Congo (DRC), Rwanda, Tanzania and Uganda (Burundi, Rwanda and Western Tanzania have already been studied as part of Stage I).

In the Stage I program new power options were evaluated in terms of environmental, social, economic and other factors, in addition to generation cost, before becoming candidates for alternative generation plans or portfolios. The options in Uganda, Kenya and Tanzania have already been identified in the East Africa Community Master Plan. The only area requiring analysis is the Eastern DRC. This report provides a preliminary assessment and screening of possible new power options in the eastern part of the DRC.

The identification of options in the DRC in this Stage II program is limited to the following provinces, each of which includes the watershed area in the DRC that is within the Nile Basin:

- Oriental
- Kivu North
- Maniema (eastern part)
- Kivu South
- Katanga

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 Congon 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. In reality the candidate resources from western DRC would be additional generation that would result from the rehabilitation of the existing Inga 1 and 2 plants.

2. THE POWER SECTOR IN THE DRC

Energy policy is managed by the Ministry of Electricity and Water Affairs. The state electricity company, Société National d´Électricité (SNEL), is the national authority under the direction of the Ministry, and they operate some 16 hydroelectric projects which provide about 90% of the total country production, including generation from Inga I and II.

SINELAC (Societé International des Pays des Grands Lacs) was established by Burindi, Rwanda and the DRC to develop international electricity projects. One project is the Ruzizi II - 28 MW project in Burundi, that is operated by the DRC. A key future issue is whether SINELAC would operate any other developments on the Ruzizi river (Ruzizi III, Sisi or other sites), with power being shared between the three countries.

The DRC has some 60 000 MW of hydroelectric potential (including 44 000 MW from further development at Inga Falls), however only 7% of the population have access to electricity.

2.1 Demand Forecast – Eastern DRC

Peak demands[1] for 2010 for the eastern provinces in the DRC are estimated at:

Oriental	11 MW
Kivu North	28 MW
Maniema (eastern part)	Negligible
Kivu South	29 MW
Katanga (Part)	25 MW

Total energy demands for the Eastern DRC were estimated as:

2005	289 GWh
2010	425
2015	629
2020	954

2.2 Existing and Future Generation – Eastern DRC

Total existing hydroelectric generation capacity is therefore as follows:

	Capacity – MW	**Energy - GWh**
Installed capacity	635	5536
Less Ruzizi II export	20	165
Less private production	75	651
Net capacity	**538**	**4720**

Most of this capacity (466 MW) is located in southern Katanga province which is outside the region being studied (N'Seke at 248.0 MW, N'zilo at 108.0 MW, Mwandingusha at 68.0 MW and Koni at 42.0 MW)

This leave a net hydro generation in the region being considered of about 72 MW.

Total thermal generation is 39 MW. Assuming an average generation of 3000 hours per year (34% average plant factor), total energy generation would be in the order of 117 GWh. Most of this generation is from very small units and a number of plants are privately owned.

It is assumed that only the Tshopo at 13 MW plant would be connected to the grid.

[1] Regional Power Needs Assessment, March 2005, SNC-Lavalin in association with Hydro-Québec International

2.3 Transmission – Eastern DRC

It is planned to connect Goma with Beni, on the border between the Kivu North and Oriental provinces, if one of the proposed hydroelectric projects along the route goes ahead. (Mugombo- 40mW, or the Ruzizi III project - 82 MW. It is assumed that Uvira will be connected to Kalemie in north Katanga, and thus to the Katanga grid.

The 110 kV transmission line from Bukavu to Katana and then to Goma is presently operating at 70 KV, and would have to be operated at 110 kV if the Goma - Rwanda proposed interconnection is to be constructed.

The interconnection between DRC and Rwanda is presently a 70 kV link from Bujumbura in Rwanda to Bukavu in DRC . This will be upgraded to 110 kV.

3 IDENTIFIED NEW HYDROELECTRIC SITES

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. The most important past studies include the following:

1972 Reconnaissance of hydroelectric resources in the North-east, by SICAI-Tractionel

1972 Energy study of Kivu Province, by Energoprojekt, in collaboration with the Office National de la Recherche et du Development of Zaire (ONRD)

1982 Inventory study of hydroelectric sites for mini or micro hydroelectric development, SEEE and OCCR-Inter G

1994 - Hydroelectric Resources of Zaire – Male Cifarha

Kiymbi rehabilitation project – SNEL, 1992

Based on the current study objective of evaluating new power options that would have a regional impact, the sites of most interest to the current study would be those with a potential of more than 30 MW. These sites are (installations are from the Cifarha report. Other options are commented on):

Oriental Province

Babeda I	50 MW or
Babeda II	50 MW
Wagenia Falls	20-50 MW
Wannie Rukula	690 MW

Kivu Province

Kamanyola	390 MW
Mugomba	40 MW
Panzi	36 MW
Ruzizi	270 MW
Sisi	110 MW

Katanga
Busanga 224 MW

4 GENERATION COSTS

4.1 Basis for Cost Estimates

For the purpose of the initial screening covered by this report, the capital costs from the **Hydroelectric Resources of Zaire – Male Cifarha,** which were expressed in US dollars at 1994 price levels are escalated to 2004 values, using the same procedure as was applied in the SSEA I study and allowances are included for interest during construction and for mitigation costs.

4.2 Planning Criteria

- Cost reference year: all costs are expressed in terms of mid 2004 costs;
- Future escalation: no further escalation is applied to capital costs or operating costs;
- Discount rate: A base case discount rate of 10%. (this discount rate excludes any allowance for inflation, and is therefore consistent with the estimates of future costs);
- The identification and assessment of new power options covers the period 2005 to 2020;
- Plant service life: hydroelectric projects will have an expected service life of 50 years, however for the purpose of calculating annual capital charges a 30 year period has been assumed;
- Operation and maintenance is assumed to cost 10 $US/kW/year;
- Interim replacement (major maintenance and equipment replacement) is assumed as equivalent to 0.25% of the capital cost per year;
- Insurance is assumed as equivalent to 0.10% of the capital cost per year;
- Project lead times for hydroelectric options vary from 6 to 8 years depending on project size.

4.3 Unit Generation Costs - Future Hydroelectric Projects

For the purpose of comparing alternative new generation options, unit capacity ($/KW) and energy costs have been estimated using a simplified economic analysis.

The capital cost includes interest during construction, which is a function of the scheduling of capital expenditures during construction, the length of the construction period, and the discount rate.

The table below shows the estimated unit costs of generation for the identified hydro projects in the Eastern DRC.

Unit Generation Costs of Hydroelectric Projects

Name	Total Cost $ Million	Instal. Cap. (MW)	Energy Unit Cost c/kWh	Cost per kW $/kW
HAUT-ZAIRE				
Babeba I	122.40	50	3.89	2448
Bangamisa	123.47	48	3.28	2572
Kisangani				
Tshopo II				
Wagenia I	411.46	50	11.33	8229
Wannie Rukula	1457.76	688	2.72	2119
KIVU NORD/SUD				
Kamanyola	517.79	390	3.12	1328
Kamimbi	131.51	14	14.20	9394
Kibongo				
Kiliba	39.06	15	6.70	2604
Kitete	200.52	21	14.43	9549
Mugomba	87.63	40	6.13	2191
Muhuma	71.69	25	7.98	2868
Mwana ngoye	403.65	46	13.23	8775
Panzi	136.72	36	8.66	3798
Rutshuru		10		
Ruzizi	318.64	270	2.79	1180
Semliki	95.59	28	8.85	3414
Sisi	405.93	174	5.14	2333
SHABA				
Bendera II				
Busanga	323.95	224	2.81	1446
Nzilo II	111.98	33	1.73	3393
Portes d´enfer	346.35	36	14.50	9621

4.4 Thermal Power Options

No information has been obtained to suggest that there are indigenous fuels in the eastern DRC for thermal power generation, apart from Lake Kava gas.

Thermal power options for the eastern DRC area assumed to be:

- Diesel engines – medium speed – 10 MW size range;
- Power supply from engines burning Lake Kivu methane.

Thermal power costs were developed for Rwanda for these two options, with the cost of diesel being based on an offshore crude oil cost of 40 USD/bbl. These would be applicable to the Bukavu area.

Thermal Generation Costs in US cents/kWh

	Diesel	Engines-Kivu gas
Variable cost	10.5	7.5
Total cost at 40% load factor	14.7	10.7
Total cost at 60% load factor	13.3	7.4

5 OPTIONS FOR SSEA PLANNING STUDIES

The objective of this component of the study is to provide an inventory of candidate new generation options to meet the forecast power needs for the six countries in the NELSAP region. The overall scope of the power options identification component includes two steps, First – a screening process of all the available technologies or new generation options, based on the identified project objectives, to be followed by a second screening that takes into account socio environmental and economic considerations.

The first level screening of options for new generation presented in this report covers three main components:

- **Cost** – in terms of unit average generation cost.
- **Technical factors** – including project size in terms of the interconnected load, level of preparation of the project, and earliest on-power date.
- **Social/environmental factors** – to introduce a first level screening of projects in terms of social and environmental acceptability.

Comments on specific projects are as follows:

5.1 Projects that Should be Excluded from the Candidate List

Busanga: Like N'zilo II, this is a potentially attractive site. It is not considered as a candidate for supply to the NELSAP region, due to its location.

Kamanyola: This is a variant on the Ruzizi scheme referred to above, and would not be a candidate for the same reasons.

Kiliba: Small size and lack of data for assessment.

Kitete: High generation costs.

Muhuma: Small size and lack of data for assessment.

Mwana ngoye: High generation costs

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 not considered as a candidate for supply to the NELSAP region, due to its size and location.

Portes d'enfer: High generation costs.

Ruzuzi: This project would involve the diversion of most of the Ruzizi river flows at the Sisi bend, to an adjacent river. This would preclude development of the Ruzizi III projects, and would presumably be unacceptable for environmental and social reasons.

Wangenia: High generation costs.

Wannie Rukulu: This would be a very large project, with an installation in the order of 700 MW. There is insufficient information for any assessment of the project, however it would be assumed to be a very long term option, and outside the time frame for this study.

5.2 Retained Hydroelectric Options

It is proposed that the following sites be retained as future candidates for DRC planning in the context of the regional power scheme. However these are all long term options and should not be considered as part of the current planning exercise, due to lack of specific information on technical feasibility, generation capability and cost.

Site	MW	Cost /kW	Cost/kWh
Mugomba	40	2191	6.1
Sisi	174	2191	5.1
Babeba I	50	2448	3.9
Bengamisa	48	2572	3.3
Semliki	*28*	*3414*	*8.8*
Panzi	*36*	*3798*	*8.7*

Semliki and Panzi are unlikely to be economic unless considered as a alternates to diesel.

It is recommended that DRC / SNEL seek funding for prefeasibiltiy studies for these potential sites.

1 INTRODUCTION

1.1 Objective and Scope

The objectives set out in the Terms of Reference of the present SSEA II study includes the evaluation power generation options in Burundi, Kenya, Democratic Republic of Congo (DRC), Rwanda, Tanzania and Uganda (Burundi, Rwanda and Western Tanzania have already been studied as part of Stage I).

For the Stage II program this process will include a review of previously identified new generation options in each of the four additional countries of the Nile Equatorial Lakes Region, i.e., DRC, Uganda, Kenya, and Tanzania. In effect the objective is to widen the candidate project database for the NEL region, by combining new power options from these countries with those already evaluated in Stage I for Rwanda, Burundi and Western Tanzania.

As defined in the TOR, the inventory of new power options will be based on existing information, to be obtained from previous studies in the covered countries, as well as information obtained by the consultant from similar projects (for generic options) and publicly available information from various literature sources. The identification and evaluation of new power options will respond to agreed development objectives identified in the needs assessment.

The objective of this component of the program is to identify all practical new power options, and then to provide a long list of projects, both thermal and hydroelectric, that would be candidates for development to meet the forecast loads in the region. In the Stage I program new power options were evaluated in terms of environmental, social, economic and other factors, in addition to generation cost, before becoming candidates for alternative generation plans or portfolios. For the Stage II program the same approach will be applied for new power options in all six countries.

The options in Uganda, Kenya and Tanzania have already been identified in the East Africa Community Master Plan. The only area requiring analysis is the Eastern DRC. This report provides a preliminary assessment and screening of possible new power options in the eastern part of the DRC.

The scope of the component for identification of new power options for the eastern DRC is primarily concerned with the following:

- Compilation of a list of previously identified new hydroelectric sites, including generation capability, capital cost and the level of preparation and project status that will to a large degree define earliest possible on-power dates;
- Estimating cost adjustments that should be made for any multipurpose hydroelectric projects;
- Identification of generic thermal alternatives, including diesel engines, and combined cycle plants. Thermal options would be limited to local diesel, or any options that could use local fuel resources;
- Preparing indicative capital costs to a common price level, e.g., 2004 prices;

- Estimating probable average generation costs for candidate hydroelectric sites (which are explicitly related to the plant capacity factor corresponding to the installed capacity proposed in the most recent study of the project), based on the updated capital costs;

- Estimating probable unit average generation costs for generic thermal projects for local power supply;

- Preparing a list of candidate projects, that potentially could be economic, and implemented within the time horizon of the study, i.e., before year 2020. For sites in the DRC the initial screening would also cover any identified major environmental risk or degree of unacceptability, as was done in Stage I;

- Preparing an indicative ranking of alternatives, with ranking based on estimated average generative cost.

1.2 Project Area in the Democratic Republic of the Congo

At the 6th PSC meeting in Uganda on December 1, 2004, it was suggested and agreed that the study area in Eastern DRC should be extended beyond Kivu South and Kivu North provinces to the Oriental province and the northern portion of the Katanga province, thus options in the DRC beyond this region should be dealt with as import options.

Consequently the identification of options in the DRC in this Stage II program is limited to parts of the following provinces, each of which includes some watershed area within the Nile Basin (see Figure 1-1).

- Oriental
- Kivu North
- Kivu South
- Maniema
- Katanga

It may be noted that the most important of the hydroelectric existing and potential resources in the DRC are in the western part of the country, on the lower reaches of the Congon 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. In reality the candidate resources from western DRC would be additional generation that would result from the rehabilitation of the existing Inga 1 and 2 plants.

Figure 1-1 - Eastern DRC

2 THE POWER SECTOR IN THE DRC

Energy policy is managed by the Ministry of Electricity and Water Affairs. The state electricity company, Société National d´Électricité (SNEL), is the national authority under the direction of the Ministry, and they operate some 16 hydroelectric projects which provide about 90% of the total country production, including generation from Inga I and II.

SINELAC (Societé International des Pays des Grands Lacs) was established by Burindi, Rwanda and the DRC to develop international electricity projects. One project is the Ruzizi II - 28 MW project in Burundi, that is operated by the DRC. A key future issue is whether SINELAC would operate any other developments on the Ruzizi river (Ruzizi III, Sisi or other sites), with power being shared between the three countries.

The DRC has some 60 000 MW of hydroelectric potential (including 44 000 MW from further development at Inga Falls), however only 7% of the population have access to electricity

2.1 Demand Forecast – Eastern DRC

Peak demands[2] for 2010 for the eastern provinces in the DRC are estimated at:

Oriental	11 MW
Kivu North	28 MW
Kivu South	29 MW
Katanga (Part)	25 MW

Total energy demands for the Eastern DRC are estimated as:

2005	289 GWh
2010	425
2015	629
2020	954

2.2 Existing and Future Generation – Eastern DRC

The 2003 Plan Directeur[3] does not refer to plans for new hydroelectric or thermal projects, apart from small diesel and micro hydro for remote centres.

A separate document listing potential hydroelectric sites[4] provides some information on existing and potential hydroelectric sites for the eastern provinces. A significant amount of hydroelectric potential is identified in this report in the Shaba or Katanga province. This report also provides some information on existing sites.

[2] Regional Power Needs Assessment, March 2005, SNC-Lavalin in association with Hydro-Québec International
[3] SNEL 2003 Plan Directeur National du Secteur de l'Électricité à l'Horizon 2015
[4] Les ressources hydro-électriques du Zaïre – Male Cifarha, février 1994

Some further information is provided in the ESMAP, 2004 report [5]. This report refers to a number of new and rehabilitation projects for the eastern provinces, that are included in the SNEL development plan. Total available new generation in the plan is shown as 259 MW, which includes the rehabilitation of Ruzizi I (some of which is not new generation), and construction of Ruzizi III.

This report lists, for the Eastern DRC, a total of 37 MW of existing interconnected hydro, plus a further 55 MW of generation in isolated networks (without specifying the hydro and thermal makeup of this total). It is understood that a significant part of this isolated generation is for mining loads. Connected and isolated generation in the Eastern DRC has a total capacity of 92 MW, and a corresponding output of 195 GWh.

2.2.1 Hydroelectric Plants

The ESMAP report only refers to 37 MW of hydroelectric generation in the eastern DRC. It is presumed that this refers to the Ruzizi I and the DRC share of the Ruzizi II project.

The report by Male Cifarha provides information on a number of additional existing sites.

The report by ESMAP also provides a map with existing sites shown.

The available information from the report by Male Cifarha is summarized in Table 2-1 overleaf. It is assumed that the privately owned sites are for industrial/mining loads and are not connected to the grid.

Total existing hydroelectric generation capacity is therefore as follows:

	Capacity – MW	**Energy - GWh**
Installed capacity	635	5536
Less Ruzizi II export	20	165
Less private production	75	651
Net capacity	**538**	**4720**

Most of this capacity, as is shown in Table 2-1, is located in southern Katanga province.

Note this includes Ruzuzi I at its present nominal capacity of 28.2 MW. In fact Unit 4 is out of service, however after rehabilitation of the station, final output will be 31 MW.

2.2.2 Existing Thermal Generation

Existing thermal generation, based on the report by Male Cifarha, is listed in Table 2-2 overleaf.

Total thermal generation is 39 MW. Assuming an average generation of 3000 hours per year (34% average plant factor), total energy generation would be in the order of 117 GWh.

[5] Opportunities for Power Trade in the Nile Basin – final Scoping Study – January 2004 - ESMAP

Most of this generation is from very small units, and as is shown in the table, a number of plants are privately owned.

It is assumed that only the Tshopo 13 MW plant would be connected to the grid.

2.3 Transmission – Eastern DRC

The ESMAP report only refers to the 110 kV line connecting Goma, Mururu and Uvira, together with the connection between Mururu and Kibogoro in Rwanda. It is planned to connect Goma with Beni, on the border between the Kivu North and Oriental provinces, if one of the proposed hydroelectric projects along the route goes ahead. (Mugombo- 40mW, or the Ruzizi III project - 82 MW. It is assumed that Uvira will be connected to Kalemie in north Katanga, and thus to the Katanga grid.

The 110 kV transmission line from Bukavu to Katana and then to Goma is presently operating at 70 KV, and would have to be operated at 110 kV if the Goma - Rwanda proposed interconnection is to be constructed.

The interconnection between DRC and Rwanda is presently a 70 kV link from Bujumbura in Rwanda to Bukavu in DRC. This will be upgraded to 110 kV.

The ESMAP report notes the importance of improving the transmission interconnections between Eastern DRC, Rwanda and Burundi, and the Tanzania grid.

Table 2-1 - Existing Hydroelectric Projects in the Eastern DRC

REGION SITE	RIVER BASIN OR ZONE	RIVER	AV Q	PLANT Q	HEAD	MW	GWH	OWNER	STATUS
HAUT-ZAIRE	**(PROV. ORIENTAL)**								
Tshopo I	Kisangani	Tshopo		120	18	18,8	164	SNEL	
Budana	Bunia	Shari		37	50	10,3	90	Private	
Soleniama 1	*Bunia*	*Shari*		*12*	*11*	*1,1*	*10*	*Private*	*Out of service*
Soleniama 2	Bunia	Shari		12	11	1,1	10	Private	
OTHERS						1,5	12	Private	excl 1MW/9GWH out of service
S/T	(in service)					31,7	276,0		
KIVU NORD/SUD, MANIEMA									
Ruzizi 1	Bukavu	Ruzizi	62,3	159	24	28,2	247	SNEL	Act. 20.4 MW, 31.1 MW after rehab
Ruzizi II	Bukavu	Ruzizi	92	115	28,5	29,2	250	SINELEC	30% to DRC
Lutshuruku I -II	Kalima	Lutshuruku		10	80	6,9	60	Private	
Belia	Punia	Belia				2,2	19	Private	
Kailo	Kalima	Ambwe		23	12	2,2	19	Private	
Moga	Kalima	Lubiadja				1,3	11	Private	
Kampene	Kampene	Kunda		1	208	1,6	14	Private	
OTHERS						2,7	24	Private	
S/T						74,3	644		
SHABA	**(PROV. KATANGA)**								
N'seke	Nseke	Lualaba		162	179	248,0	2173	SNEL	
N'zilo	Nzilo	Lualaba		157	84	108,0	946	SNEL	
Mwadingusha	Mwadingusha	Lufira		69	116	68,0	595	SNEL	
Koni	Koni	Lufira		90	56	42,0	369	SNEL	
Kilubi	Kamina	Kilubi		15	66	9,0	70	Private	
Bendera	Kalemie	Kiyimbi		3	674	17,0	151	SNEL	
Piana-Muanga	Manonp	Luvua		136	22	29,0	254	Private	
Kalule	Lubudi	Kalue sud				4,0	35	Private	
OTHER						2,6	23	Private	
S/T						527,6	4616		
TOTAL						633,6	5536		

TOTAL AVAILABLE GENERATION		
Total private	75,5	651
Export from Ruzizi II	20,0	165
Net available generation	**538,1**	**4720**

Source - Report by Male Cifarha

Table 2-2 - Existing Thermal Projects in the Eastern DRC

REGION PROJECT	MW	GWH	OWNER	STATUS
HAUT-ZAIRE (ORIENTALE)				
Aketi	0,4	1,4	SNCZ	Cogeneration
Buta	0,6	1,9	SNEL	
Isiro	1,5	4,4	SNCZ	Cogeneration
Mungbere	0,1	0,3	SNCZ	Cogeneration
Tshopo	12,8	38,4	SNEL	
Ubungu	0,2	0,7	SNCZ	Cogeneration
S/T	**15,6**	**47,1**		
KIVU NORD/SUD				
Cogeneration		0,2	SNCZ	
Kasongo	0,4	1,1	SNEL	
Kindu	1,7	5,0	SNEL	
S/T	**2,1**	**6,3**		
SHABA (KATANGA)				
Dilolo	0,2	0,5	Private	Cogeneration
Gecamines	18,0	54,0	Private	Cogeneration
Kabalo	0,4	1,1	SNEL	
Kamina	0,6	1,9	SNEL	
Kamina	0,1	0,3	Private	Cogeneration
Kaniama	0,5	1,6	SNEL	
Kaniama	0,1	0,4	Private	Cogeneration
Kasenga	0,4	1,1	SNEL	
Kongolo	0,2	0,6	SNEL	
Sakania	0,9	2,5	Private	Cogeneration
S/T	**21,4**	**64,0**		
TOTAL	**39,1**	**117,4**		

Source - Report by Male Cifarha

3 IDENTIFIED NEW HYDROELECTRIC SITES

3.1 Master List of Identified Sites in the Eastern DRC

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.

The most important past studies include the following:

1972 Reconnaissance of hydroelectric resources in the North-east, by SICAI-Tractionel

This study covers two components – the Ruzizi river, including three sites:

Panzi	36 MW
Kitimba	34 MW
Kamaniola	240 MW

and the Lualaba river for the development of 38 m of head available between Kisangani and Ubundu. This study identified two sites, Kisangani and Wannie Rukula, for a total installation in the order of 1000 MW.

This study also considered smaller sites to supply Kisangani, such as the Tshopo site with 50-75 MW, possible extension to the existing Kiyimbi plant, and mini-hydro options.

These studies were at the reconnaissance level, however mostly used 1:5000 scale mapping, and resulted in relatively detailed quantity and cost estimates.

1972 Energy study of Kivu Province, by Energoprojekt, in collaboration with the Office National de la Recherche et du Development of Zaire (ONRD)

This study included demand forecasts, and alternative new generation sources, primarily hydroelectric generation. Generation from Lake Kivu gas, and from diesel was also evaluated.

Hydroelectric sites of more than 10 MW from this study are included in Table 3-1, from data from the report by Male Cifarha. The most important sites are:

Sisi on the Ruzizi river	110 MW
Ruzizi on the Ruzizi river	270 MW
Mugombo on the Lubero river	40 MW

These site evaluations are at the reconnaissance level. There are no detailed site descriptions, quantity or cost estimates in the report. Basic quantities are provided.

1982 Inventory study of hydroelectric sites for mini or micro hydroelectric development, SEEE and OCCR-Inter G

This report covers sites in four locations and, despite the title, includes mid-sized projects.

- **Kisangani** (Oriental Province) – this part of the study evaluated the sites of Wagenia, Bengamisa. and Wanie-Rukula. (This report also referred to a study of the Wagenia site by Sogreah in 1972)

- **Yamgambi** (Oriental Province) - to supply the town of Yamgambi on the Congo, 100 km downstream of Kisangani. This part of the study considered a site on the Lobilo of MW

- **Mbandaka** (Oriental Province) - to supply the town. A site of 5 MW was evaluated.

- **Tshimbubulu** (Kasai Province) – to evaluate alternative small sites for supply to the town.

These studies were all at the very preliminary or reconnaissance stage.

1994 - Hydroelectric Resources of Zaire – Male Cifarha

This report provides a compilation on information from the above and other previous studies, and provides an evaluation of the overall hydroelectric potential of the country. Information used in the current study is mostly taken from the Cifarha report.

A separate report reviewed in the current study is the **Kiymbi rehabilitation project – SNEL, 1992.** The present station includes two turbines, with a nominal output of 17 MW. There is a proposal to add a third unit to increase the plant capacity to 26 MW. The addition of the third unit was studied by Sicai-Tractionel in 1972.

Other reports relevant to this study, which were not available are:

- 1982 – Sicai-Tractionel on Ruzizi river sites
- 1977 – TEE-PDN on Lualaba sites in Kivu and Katanga provinces
- 1970 study by Tractionel of the Busanga sitge on the Lualaba river
- 1966 study by SOGEFOR of the Nzilo II site on the Lualaba river

Information on these sites was obtained from the Cifarha study.

Table 3-1 provides a listing of all identified sites with a potential of more than 10 MW. This table provides basic information on head, plant flow, capacity and energy. Also the latest known cost estimate, and the date of that estimate is shown. All costs referred to as 1990 costs, except those for the 1972 ONRD study, were adjusted to that date in the Cifarha report. The costs for the ONRD study have been converted from Zaires of 1972 to USD of 1990 by multiplying by a factor of 6. (i.e. 1 million Z = 6 million USD).

The only source reports reviewed for the current study are those referred to above. However based on these reports, and the Cifarha report, it is understood that no sites have been studied to a modern prefeasibility level, i.e., including a limited field investigation program of surveying and drilling.

Table 3-1 - Identified Hydroelectric Sites in the Eastern DRC

REGION	SITE	RIVER BASIN	RIVER	AV Q	PLANT Q	HEAD	MW	GWH	COST MUSD	COST YEAR	PREVIOUS STUDY YEAR	PREVIOUS STUDY REFERENCE
HAUT-ZAIRE		(PROV. ORIENTALE)										
	Babeba I		Tshopo	300	312	23	50	351	94	1990	1972	SICAI-TRACTIONEL
	Bangamisa	Zaire	Lindi	865	500	15	48	420	93	1990	1982	OCCR-SEEE
	Kisangani		Zaire		3395	17	460	30				
	Tshopo II		Tshopo		110	18	17	149				
	Wagenia I		Zaire	6700	2560	6,5	50	400	316	1990	1972	SICAI-TRACTIONEL
	Wannie Rukula		Lualaba	6700		20	688	6000	1098	1990	1976	SOGREAH
	Other sites	17 sites										
KIVU NORD/SUD												
	Kamanyola	Ruzizi	Ruzizi		69	450	390	1880	390	1990	1982	SICAI/TRACTIONEL
	Kiliba		Kiliba		3,3	545	15	65	30	1990	1972	ONRD
	Kitete		Lualaba	1880	520	6,5	21	153	154	1990	1977	TEE/PDN
	Mugomba		Luhola		35	140	40	160	66	1990	1972	ONRD
	Muhuma		Talya Sud		10,7	280	25	100	54	1990	1972	ONRD
	Mwana ngoye		Lualaba	1700	470	14	46	336	310	1990	1977	TEE/PDN
	Panzi	Ruzizi	Ruzizi	66	130	39	36	175	105	1990	1982	SICAI/TRACTIONEL
	Rutshuru		Rutshuru		21,5	56	10	55	0	1990	1972	ONRD
	Ruzizi	Ruzizi	Ruzizi		110	290	270	1300	240	1990	1972	ONRD
	Semliki		Semliki		170	20	28	120	72	1990	1972	ONRD
	Sisi	Ruzizi	Ruzizi		115,2	115	110	515		1990	1972	ONRD
	Sisi	Ruzizi	Ruzizi				174	888	307	1990	1992	Tractabel
	Other sites	17 sites										
SHABA		(PROV. KATANGA)										
	Bendera II		Kyimba		7,5	674	43	377				
	Busanga		Lualaba	135	200	135	224	1304	244	1990	1970	TRACTIONEL
	Nzilo II		Lualaba	100	100	98	33	720	86	1990	1966	SOGEFOR
	Portes d´enfer		Lualaba	1640	450	10	36	263	266	1990	1977	TEE/PDN
	Other sites	6 sites										

Source **les ressources hydroélectriques du Zaïre - 1994 - Male Cifarha**
Sites previously studied > 10 MW

3.2 Information on Specific Sites

Based on the current study objective of evaluating new power options that would have a regional impact, the sites of most interest to the current study would be those with a potential of more than 30 MW. These sites are (installations are from the Cifarha report. Other options are commented on):

Oriental Province

Babeda I	50 MW or
Babeda II	50 MW
Wagenia Falls	20-50 MW
Wannie Rukula	690 MW

Kivu Province

Kamanyola	390 MW
Mugomba	40 MW
Panzi	36 MW
Ruzizi	270 MW
Sisi	110 MW

Katanga

Busanga	224 MW

Specific comments on some of these sites are provided below.

Babeda

The Babeda Falls are on the Tshopo river North-east of Kisangani. SICAI-Tractionel studied two sites, 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.

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 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 a 18 MW project, with a cost of 690 million Francs. This is approximately equivalent to 6000 $US/kW in 1982, which further confirms the scheme is not potentially viable.

Wannie 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. 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.

Busanga
This site was studied by Tractionel in 1970. 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.

Kamanyola
This option was studied by Tractabel, and is the same at Ruzizi in concept. Tractabel proposed a 390 MW installation. 90 MW.

The studies by Tractabel should be considered as preliminary or reconnaissance, as no field investigations were carried out. Note - Ruzizi III site was later studied in more detail by Tractabel, and thus is considered to be at a pre-feasibility level.

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

Panzi
This site, located between Ruzizi I and Ruzizi II was evaluated by SICAI in 1988, and then by Tractabel in 1992[6]. In the 1992 study two alternative baselines were evaluated and the downstream site selected. The unit generation cost would be significantly higher than for the Sisi bend sites or the Ruzizi III site. It is assumed this site would not be a candidate.

	MW	**GWh**	**COST MECU**
Panzi aval	42	210	1045

Ruzizi
The Ruzizi project assumes a diversion of flow from the Ruzizi River at a point just downstream of the Sisi bend, into the neighbouring Luvimui River, with a developed head of 300 meters. The diversion would take all the flow of the Ruzizi River up to the plant capacity of 110 m^3/s (which is twice the firm flow of the river). This project would eliminate Ruzizi III and any other downstream development. It is assumed to be unacceptable.

Sisi
Development on the Sisi bend of the upper Ruzizi was later studied by Tractabel (1992). Two sites with larger installations were evaluated.

	MW	**GWh**	**COST MECU**
Sisi 3	175	210	255.7
Sisi 5	205	1030	301.6

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

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

4 GENERATION COSTS

4.1 Basis for Cost Estimates

All the costs shown in Table 4-1 were taken from the original estimates and escalated and converted to USD of 1990, in the Cifarha report. No assessment has been made of the escalation procedure or currency conversion rates. However with all estimates adjusted to 1990 levels on a common basis, these will serve as a satisfactory base to rank new hydroelectric power options.

There is limited information on the makeup of the earlier estimates.

The ONRD estimates include a 20% provision for contingencies, and 15% for owners costs. Estimates are provided for various transmission alternatives, however these are not directly included in the capital cost estimates.

The Sicai-Tractionel study included 10% for contingencies, and a further 30% is added for "complementary " costs. No reference is given to transmission costs

The SEEE/Inter G estimates include transmission, however do not refer to overheads or contingencies.

It is assumed that none of the estimates include interest during construction, or an allowance for environmental or mitigation costs. With regard to mitigation costs, no specific major potential environmental risks were stated or indicated in the supporting reports.

For the purpose of the initial screening covered by this report, the capital costs shown in Table 4-3 have been retained. These were escalated to 2004 values, using the same procedure as was applied in the SSEA I study, as described below. The assumptions applied for the estimate of interest during construction are also provided. A 5% allowance for mitigation costs was added, for consistency with the SSEA I estimates.

4.2 Procedure for Escalating Costs from Earlier Estimates

The estimated costs provided in the original reference reports and listed in Table 4-3 have been escalated to present (2004) price levels using the following procedure, which reflects the fact that all prices are expressed in $US, and which therefore has to take into account exchange rate changes, as well as productivity, and increase in the extent to which labour, material and fabricated parts may be provided locally from the region.

All the original costs are expressed in terms of 1990 $US in Table 4-3.

It is recognized that there has been no escalation, or possibly even cost reduction in local costs, which may include skilled and unskilled construction labour, fabrication of certain equipment, especially gates and structural elements, construction materials, and transport of imported equipment and supplies.

Also there has been a general long term tendency to reduce costs of manufactured electromechanical equipment that may more than offset normal escalation.

It is also recognized that construction costs overall have been stable for some time.

Recognizing these factors, the procedure developed for SSEA I for the adjustment of costs using escalation indices has been to apply international escalation rates to only the foreign cost component of the civil works costs, and to assume that such escalation only applies up to the end of year 1999.

On a generalized or average basis it is assumed that the civil works comprise 65% of the overall project costs, and the foreign component of the civil works cost is 50%. Consequently the foreign component of the civil works makes up approximately 32.5% of the total project cost.

Thus the adjusted capital cost for a project is calculated as:

Original capital cost x 32.5% x inflation index, plus
Original capital cost x 67.5% x 1.00.

The foreign component of the civil works costs will be made up primarily from contractors supervisory staff, construction equipment, and fuel. In order to calculate the inflation index, the United States Bureau of Reclamation (USBR) been used. Values for this index from 1977 to 2004 are shown in Table 4-1 below.

Table 4-1 - Annual USBR Indices
(Construction Costs Trends - Composite trend Index for January of each year)

Year	Index	Year	Index	Year	Index
1977 (1)	100	1990	177	1997	213
1984	153	1991	183	1998	219
1985	156	1992	186	1999	220
1986	158	1993	189	2000	228
1987	160	1994	195	2001	234
1988	163	1995	201	2002	236
1989	169	1996	207	2003	244
				2004	252

For the adjustments applied in this study, the ceiling index was set at 220, corresponding to 1999 price levels. The formula for adjusting 1990 costs to 2004 levels is therefore:

Cost 2004 = 0.325 * Cost in 1990 * (220/177 Index in 1990) + 0.675*Cost in 1990.

4.3 Interest During Construction

Interest during construction was added to the direct project costs to provide a more realistic approximation of the total cost of the project, to be used in calculating unit generation costs.

Total interest was calculated using an interest rate of 10% and standardized schedules of expenditures during construction. Interest amounts were calculated for 3 and 4 year construction programs.

Table 4-2 - Interest During Construction

Interest for 3 year construction

3 year construction	Year	% of total cost
	1	30
	2	40
	3	30
Total IDC as% project cost		**15.68**

Interest for 4 year construction

4 year construction	Year	% of total cost
	1	10
	2	40
	3	30
	4	20
Total IDC as% project cost		**18.05**

For the purpose of calculating IDC, and thus generation costs, the project construction period was selected on the basis of project size. A four year construction period has been assumed for projects 70 MW or larger. Costs at 2004 price levels including IDC are shown in Table 4-3.

4.4 Planning Criteria

4.4.1 Cost Reference Year, Future Escalation and Discount Rate

All costs are expressed in terms of mid 2004 costs. No further escalation is applied to capital costs or operating costs.

The identification and assessment of new power options covers the period 2005 to 2020.

A base case discount rate of 10% was used in determining annual costs for interest and capital repayment (expressed as an uniform annual payment), and interest during construction. This discount rate excludes any allowance for inflation, it is therefore consistent with the estimates of future costs.

4.4.2 Plant Service Life

The hydroelectric project will have an expected service life of 50 years, however for the purpose of calculating annual capital charges a 30 year period has been assumed.

4.4.3 Operation and Maintenance and Other Costs

Unit generation costs will also include allowances for operation and maintenance, interim replacement, and insurance. For hydroelectric plant, all O and M cost is considered as fixed.

- Operation and maintenance is assumed to cost 10 $US/kW/year
- Interim replacement (major maintenance and equipment replacement) is assumed as equivalent to 0.25% of the capital cost per year

- Insurance is assumed as equivalent to 0.10% of the capital cost per year.

4.4.4 Project Lead Times for Hydroelectric Options

The review of the available study reports indicates that all projects have only been prepared to a reconnaissance level. While the various studies have developed different levels of detail, none have included field investigations, such as surveying, mapping at scales larger that 1:5000, detailed geological reconnaissance, searches for construction materials and foundation drilling.

Also most of the studies were carried out in the 1970-82 period, so values used to optimize the schemes, and the projected loads would have been quite different.

Overall lead times for hydroelectric projects will typically include the following minimum time frames:

Activity	*Time- months*
Prefeasibility study, following a reconnaissance level project identification	6-12
Feasibility study (including consultant selection)	12-24
Feasibility study update (where required)	6-12
Environmental study and approval	12
Preparation of IPP process and tendering (where applicable)	12
Project financing (IPP or public ownership)	12
Final design (including consultant selection)	12
Construction (depending of size and complexity – and including tendering)	36-60

This indicates that the total time to implement a project, following the reconnaissance stage assessment would vary from 6 to 8 years depending on project size. This suggests that any project with a projected installation of less than about 80-100 MW could not be brought into service before January 2011, and the corresponding earliest on-power date for a larger project would be after year 2013.

Actual times will vary considerably, depending on environmental approval process, private or public ownership, commitment of the host government, feasibility of financing, size and complexity of the project, and the extent to which activities may be fast tracked.

The lead times assume that funding would be available now for prefeasibility studies of selected projects.

4.5 Unit Generation Costs - Future Hydroelectric Projects

For the purpose of comparing alternative new generation options, unit capacity ($/KW) and energy costs have been estimated using a simplified economic analysis.

The capital cost includes interest during construction, which is a function of the scheduling of capital expenditures during construction, the length of the construction period, and the discount rate.

The unit cost of capacity is estimated from the capital cost, including interest during construction, and the nominal plant installed capacity. (Note that the firm capacity of the plant, especially for run of the river hydroelectric projects may be significantly lower).

Average annual costs over the life of the project are calculated for the capacity component, using the parameters outlined later in this section and assuming equal annual payment of capital and interest. Unit energy costs ($/kWh) are calculated from capital charges and operation and maintenance costs.

The total cost of energy generation is a function of plant capacity factor and combines the fixed annual capacity component ($/kW-year/hours of operation) with the variable energy component ($/kWh). In the case of the hydroelectric option the plant capacity factor, and thus average hours of operation, is defined.

This procedure does not take into account any future escalation in operating costs.

The above procedure is useful in comparing relative plant costs, however for hydroelectric projects this does not take into account different plant capacity factors - derived as:

CF% = energy capability(kWh)/(installation (kW) x 8760 hours) x 100

The derived unit generation costs are shown in Table 4-3 overleaf.

It should be noted that the following sites that appear in the table have been deleted for the following reasons:

- Tshopo - This is an extension to an existing project. No cost data was available
- Kisangani – No energy data was available, and the cost data in the original Sicai was not clear
- Rutshuru – Project is small (10 MW) and no cost data was available
- Kibongo – Project is small (13 MW) and no cost data was available
- Kamimbi – Project is small (14 MW) and no supporting information was available
- Bendera II – This is an extension to an existing project. No cost data was available.

Table 4-3 - Hydroelectric Projects - Unit Generation Costs

CAPITAL COST ESTIMATE														ANNUAL COSTS (US million)				Unit prices	
Name	Original cost	Purpose Factor	Adjusted price	Price Yr.	Escalated to 2004 **	- STRUCT.	IDC %	COST WITH IDC	ENV. MITIGA-TION	TOTAL COST	INSTAL CAP	AVERAGE ENERGY	FIRM CAP	AMORT IZATION	O & M	INS+INT REPL	TOTAL	Energy unit cost	Cost per kW
	$ MILLION		$ MILLION		$ MILLION			$ MILLION	$ MILLION	$ MILLION	(MW)	(GWh)	(MW)	$/YR	$/YR	$/YR	$/YR	c/kWh	$/kW
HAUT-ZAIRE																			
Tshopo II	N/A																		
Babeba I	94	1,00	94,00	1990	101,42	3	15,68	117,32	5,07	122,40	50	351	45,00	12983651	250000	428385	13662036	3,89	2448
Wagenia I	316	1,00	316,00	1990	340,95	3	15,68	394,41	17,05	411,46	50	400	45,00	43647168	250000	1440103	45337271	11,33	8229
Wannie Rukula	1098	1,00	1098,00	1990	1184,69	4	18,05	1398,53	59,23	1457,76	688	6000	619,20	154638506	3440000	5102174	163180679	2,72	2119
Kisangani	N/A																		
Bangamisa	93	1,00	93,00	1990	100,34	4	18,05	118,45	5,02	123,47	48	420	43,20	13097797	240000	432151	13769948	3,28	2572
KIVU NORD/SUD																			
Sisi	305	1,00	307,00	1990	329,89	4	18,05	389,43	16,49	405,93	174	883	156,60	43060597	870000	1420750	45351347	5,14	2333
Ruzizi	240	1,00	240,00	1990	258,95	4	18,05	305,69	12,95	318,64	270	1300	243,00	33800766	1350000	1115229	36265995	2,79	1180
Kiliba	30	1,00	30,00	1990	32,37	3	15,68	37,44	1,62	39,06	15	65	13,50	4143718	75000	136719	4355437	6,70	2604
Semliki	72	1,00	72,00	1990	77,68	4	18,05	91,71	3,88	95,59	28	120	25,20	10140230	140000	334569	10614799	8,85	3414
Mugomba	66	1,00	66,00	1990	71,21	4	18,05	84,06	3,56	87,63	40	160	36,00	9295211	200000	306688	9801899	6,13	2191
Muhuma	54	1,00	54,00	1990	58,26	4	18,05	68,78	2,91	71,69	25	100	22,50	7605172	125000	250927	7981099	7,98	2868
Panzi	105	1,00	105,00	1990	113,29	3	15,68	131,05	5,66	136,72	36	175	32,40	14503015	180000	478515	15161530	8,66	3798
Kamanyola	390	1,00	390,00	1990	420,79	4	18,05	496,75	21,04	517,79	390	1880	351,00	54926245	1950000	1812248	58688493	3,12	1328
Kamimbi	N/A																		
Kibongo	N/A																		
Kitete	154	1,00	154,00	1990	166,16	3	15,68	192,21	8,31	200,52	21	153	18,90	21271088	105000	701823	22077911	14,43	9549
Mwana ngoye	310	1,00	310,00	1990	334,48	3	15,68	386,92	16,72	403,65	46	336	41,40	42818424	230000	1412760	44461184	13,23	8775
Rutshuru	N/A																		
SHABA																			
Busanga	244	1,00	244,00	1990	263,26	4	18,05	310,78	13,16	323,95	224	1304	201,60	34364112	1120000	1133816	36617929	2,81	1446
Bendera II	N/A																		
Nzilo II	86	1,00	86,00	1990	92,79	3	15,68	107,34	4,64	111,98	33	720	29,70	11878660	165000	391927	12435587	1,73	3393
Portes d´enfer	266	1,00	266,00	1990	287,00	3	15,68	332,00	14,35	346,35	36	263	32,40	36740970	180000	1212239	38133209	14,50	9621

4.6 Thermal Power Options

No information has been obtained to suggest that there are indigenous fuels in the eastern DRC for thermal power generation, apart from Lake Kava gas.

Thermal power options for the eastern DRC area assumed to be:

- Diesel engines – medium speed – 10 MW size range;
- Power supply from engines burning Lake Kivu methane.

Thermal power costs were developed for Rwanda for these two options, with the cost of diesel being based on an offshore crude oil cost of 40 USD/bbl. These would be applicable to the Bukavu area.

Table 4-4 - Thermal Generation Costs in US cents/kWh

	Diesel	Engines-Kivu gas
Variable cost	10.5	7.5
Total cost at 40% load factor	14.7	10.7
Total cost at 60% load factor	13.3	7.4

5 OPTIONS FOR SSEA PLANNING STUDIES

5.1 Ranking of New Hydroelectric Options

The new hydroelectric options have been ranked in terms of unit energy cost (Cents US/kWh) and unit capacity cost (total investment cost/installed capacity in $US/kW). These are shown in Table 5-1.

These two rankings show different results. This is due to different plant capacity factors and probably lack of consistency in the energy values. For example the stated energy value for the Wannie Rukula site corresponds to a 100% plant factor, and thus must be overstated.

It is also important to note that firm energy values were not available for most sites, however until there is a major level of integration between hydro dominant systems such as DRC or Uganda, and thermal dominant systems such as Kenya, the cost of firm energy is a much better indicator of value than the average cost of average annual energy generation.

5.2 First Level Screening of New Power Options

The objective of this component of the study, as presented in this section is to provide an inventory of candidate new generation options to meet the forecast power needs for the six countries in the NELSAP region. The overall scope of the power options identification component includes two steps, First – a screening process of all the available technologies or new generation options, based on the identified project objectives, to be followed by a second screening that takes into account socio environmental and economic considerations.

The first level screening of options for new generation presented in this report covers three main components:

Cost – compassion of generation costs, between alternative hydro sources, and with thermal alternatives. This comparison is made in terms of unit average generation cost.

Technical factors – including project size in terms of the interconnected load, level of preparation of the project, and earliest on-power date.

Social/environmental factors – to introduce a first level screening of projects in terms of social and environmental acceptability.

The calculation of unit generation costs is shown in Table 4-3. Project ranking based on unit costs is shown in Table 5-1. In view of the fact that there are no attractive thermal options, and the relatively high cost of thermal power, this screening is limited to hydroelectric options only.

Figure 5-1 - Location of Hydro Sites

Table 5-1 - Ranking Of Hydro Options

RANK BY ENERGY COST

Name	TOTAL COST $ MILLION	INSTAL CAP (MW)	AVERAGE ENERGY (GWh)	Energy unit cost c/kWh	Cost per kW $/kW
Nzilo II	111,98	33	720	1,73	2448
Wannie Rukula	1457,76	688	6000	2,72	8229
Ruzizi	318,64	270	1300	2,79	2119
Busanga	323,95	224	1304	2,81	2572
Kamanyola	517,79	390	1880	3,12	2090
Bangamisa	123,47	48	420	3,28	1180
Babeba I	122,40	50	351	3,89	2604
Sisi	405,93	174	883	5,14	3414
Mugomba	87,63	40	160	6,13	2191
Kiliba	39,06	15	65	6,70	2868
Muhuma	71,69	25	100	7,98	3798
Panzi	136,72	36	175	8,66	1328
Semliki	95,59	28	120	8,85	9549
Wagenia I	411,46	50	400	11,33	8775
Mwana ngoye	403,65	46	336	13,23	1446
Kitete	200,52	21	153	14,43	3393
Portes d´enfer	346,35	36	263	14,50	9621

RANK BY CAPACITY COST

Name	TOTAL COST $ MILLION	INSTAL CAP (MW)	AVERAGE ENERGY (GWh)	Energy unit cost c/kWh	Cost per kW $/kW
Ruzizi	318,64	270	1300	2,79	1180
Kamanyola	517,79	390	1880	3,12	1328
Busanga	323,95	224	1304	2,81	1446
Wannie Rukula	1457,76	688	6000	2,72	2119
Mugomba	87,63	40	160	6,13	2191
Sisi	405,93	174	883	5,14	2333
Babeba I	122,40	50	351	3,89	2448
Bangamisa	123,47	48	420	3,28	2572
Kiliba	39,06	15	65	6,70	2604
Muhuma	71,69	25	100	7,98	2868
Nzilo II	111,98	33	720	1,73	3393
Semliki	95,59	28	120	8,85	3414
Panzi	136,72	36	175	8,66	3798
Wagenia I	411,46	50	400	11,33	8229
Mwana ngoye	403,65	46	336	13,23	8775
Kitete	200,52	21	153	14,43	9549
Portes d´enfer	346,35	36	263	14,50	9621

The screening of projects is shown in Table 5-2. Comments on specific projects are as follows:

Projects that should be excluded from the candidate list:

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 size and location.

Wannie Rukulu This would be a very large project, with an installation in the order of 700 MW. There is insufficient information for any assessment of the project, however it would be assumed to be a very long term option, and outside the time frame for this study.

Ruzuzi This project would involve the diversion of most of the Ruzizi river flows at the Sisi bend, to an adjacent river. This would preclude development of the Ruzizi III projects, and would presumably be unacceptable for environmental and social reasons.

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.

Kamanyola This is a variant on the Ruzizi scheme referred to above, and would not be a candidate for the same reasons.

Kiliba Small size and lack of data for assessment.

Muhuma Small size and lack of data for assessment.

Wangenia High generation costs.

Mwana ngoye High generation costs.

Kitete High generation costs.

Portes d'enfer High generation costs.

Retained hydroelectric options:

It is proposed that the following sites be retained as future candidates for DRC planning in the context of the regional power scheme. However these are all long term options and should not be considered as part of the current planning exercise, due to lack of specific information on technical feasibility, generation capability and cost.

It is recommended that DRC / SNEL seek funding for prefeasibiltiy studies for these potential sites.

The listing of preferred sites, in the context of the NELSAP region is as follows:

Site	MW	Cost /kW	Cost/kWh
Mugomba	40	2191	6.1
Sisi	174	2191	5.1
Babeba I	50	2448	3.9
Bengamisa	48	2572	3.3
Semliki	*28*	*3414*	*8.8*
Panzi	*36*	*3798*	*8.7*

Semliki and Panzi are unlikely to be economic unless considered as a alternates to diesel.

Table 5-2 - First Level Screening Of Hydroelectric Projects

Type	Name	Location	Installed Capacity - MW	Capital Cost - US$/kW	Earliest Installat-ion Date	Average Energy - kWh	Energy cost USCent/kWh	Regional Benefits ***	Enviro/ Socio Risks	Level of Prepared-ness	Multi-purpose	Fast track	Comments
Hydro	Babeba I	HAUT ZAIRE	50	2448	2011	351	3,9	Yes	Acceptable	Recon.	No	No	**Recommended for study**
Hydro	Bangamisa	HAUT ZAIRE	48	2572	2011	420	3,3	Yes	Acceptable	Recon.	No	No	**Recommended for study**
Hydro	Bendera II	KATANGA -NORD	43		2011			Yes	Acceptable	Recon.	No	No	Out - no cost data
Hydro	Busanga	KATANGA -SUD	224	1446	2013	1304	2,8	No	Acceptable	Recon.	No	No	Out - outside area
Hydro	Kamanyola	KIVU NORD/SUD	390	1328	2013	1880	3,1	Yes	high	Recon.	No	No	Out - very high soc/env risk
Hydro	Kiliba	KIVU NORD/SUD	15	2604	2011	65	6,7	Yes	Acceptable	Recon.	No	No	Out - small and lack of data
Hydro	Kisangani	HAUT ZAIRE	460		2013	30		Yes	Acceptable	Recon.	No	No	Out - no cost data
Hydro	Kitete	KIVU NORD/SUD	21	9549	2011	153	14,4	Yes	Acceptable	Recon.	No	No	Out - high energy cost
Hydro	Mugomba	KIVU NORD/SUD	40	2191	2011	160	6,1	Yes	Acceptable	Recon.	No	No	**Recommended for study**
Hydro	Muhuma	KIVU NORD/SUD	25	2868	2011	100	8,0	Yes	Acceptable	Recon.	No	No	Out - small and lack of data
Hydro	Mwana ngoye	KIVU NORD/SUD	46	8775	2011	336	13,2	Yes	Acceptable	Recon.	No	No	Out - high energy cost
Hydro	N´zilo II	KATANGA -SUD	33	3393	2011	720	1,7	No	Acceptable	Recon.	No	No	Out - plant extension and out of area
Hydro	Panzi	KIVU NORD/SUD	36	3798	2011	175	8,7	Yes	Acceptable	Recon.	No	No	V. Long term - after Sisi
Hydro	Portes d´enfer	KATANGA -SUD	36	9621	2011	263	14,5	Yes	Acceptable	Recon.	No	No	Out - high cost and out of area
Hydro	Ruzizi	KIVU NORD/SUD	270	1180	2013	1300	2,8	Yes	high	Recon.	No	No	Out - very high soc/env risk
Hydro	Semliki	KIVU NORD/SUD	28	3414	2011	120	8,8	Yes	Acceptable	Recon.	No	No	**Recommended for study**
Hydro	Sisi	KIVU NORD/SUD	174	2333	2013	888	5,1	Yes	Acceptable	Recon.	No	No	**Recommended for study**
Hydro	Tshopo II	HAUT ZAIRE	17		2011	149			Acceptable	Recon.	No	No	Out - no cost data - plant extension
Hydro	Wagenia I	HAUT ZAIRE	50	8229	2011	400	11,3	Yes	Acceptable	Recon.	No	No	Out - high energy cost
Hydro	Wannie Rukula	HAUT ZAIRE	688	2119	2013	6000	2,7	Yes	Acceptable	Recon.	No	No	Out - high energy cost