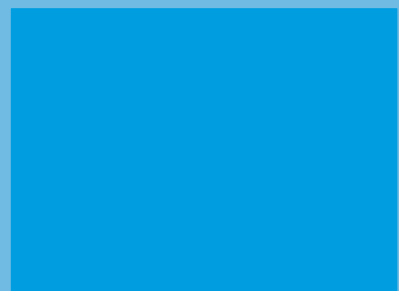
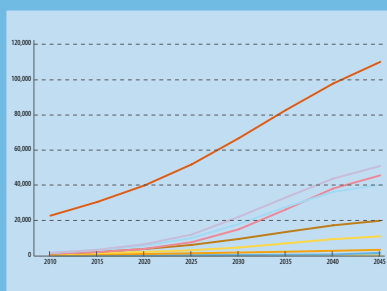
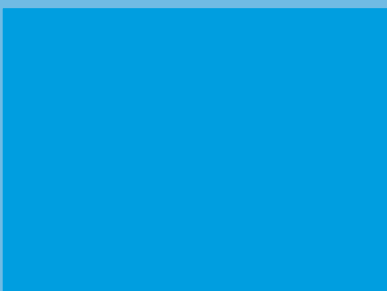
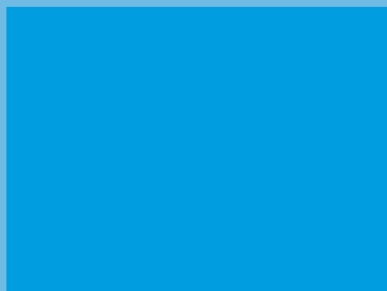
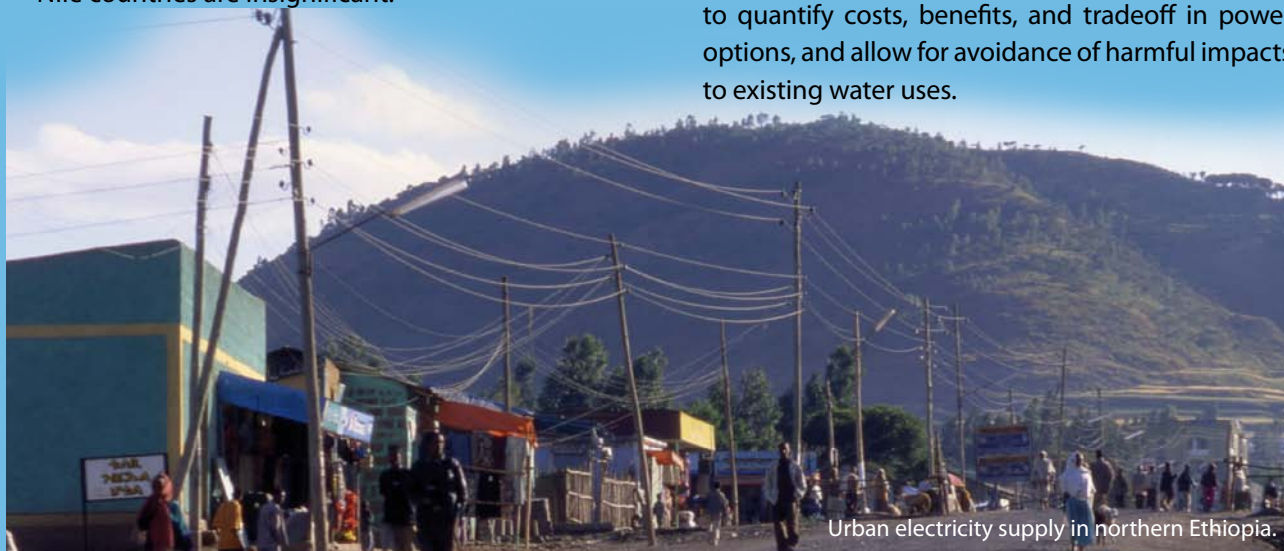


Hydropower Potential and the Region's Rising Energy Demand



KEY MESSAGES

- Power/electricity is a critical requirement for growth and economic production in the Nile countries. In particular, it is important for attracting new investments to the region, supporting expansion of the industrial and service sectors, creating employment and improving living standards.
- The Nile riparian countries are endowed with substantial energy resources that include hydropower potential, natural gas, oil, geothermal energy, coal, peat, biomass, solar, and wind. Among the various energy options, hydropower is the most attractive to the Nile countries because of its long economic life and low per unit energy costs.
- The hydropower potential in the Nile Basin exceeds 20 GW. Existing facilities only represent about 26 per cent of potential capacity. The Nile countries depend on hydropower to varying degrees, with Burundi, DR Congo, Ethiopia, and Uganda reliant on it for 80 per cent or more of their power.
- Electricity supply in the Nile countries (with the exception of Egypt) is inadequate, unreliable, and expensive. Accordingly, electricity consumption in the region is among the lowest in the world. Urban areas are significantly better served than rural areas, where the bulk of the population remains dependent on biomass energy sources, with associated negative impacts on the environment.
- The Nile Basin remains the only region on the African continent without a functional regional power grid. The volumes of power traded amongst Nile countries are insignificant.
- Demand for power in the region is high, rising rapidly, and will exceed supply for many years. The rise in demand is driven by, among other things, improving economic conditions and rising population in the basin. Projections of power demand for 2035 in the Nile countries indicate an increase of 300 percent and higher over present demand.
- Very large investments in power generation and transmission – in the range of tens of billions of dollars – are required for a sustained period to meet the region's power demand.
- Hydropower is the preferred energy source for most Nile countries. To tap and sustainably exploit the vast hydropower potential of the region, the countries need to plan and develop the water resources cooperatively, and mainstream environmental and social considerations in all aspects of power development. Balancing the interests of competing sectors and different countries while optimizing hydropower production will require coordinated reservoir operation across the basin. Total power demand will eventually exceed hydropower potential, and alternative power sources will need to be developed.
- The NBI is contributing to the transformation of the region's power sector by providing a forum for joint planning and cooperative development of hydropower generation and transmission options, and promoting power pooling amongst the Nile countries. The NBI has developed analytical tools such as the Nile-DSS that make it possible to quantify costs, benefits, and tradeoff in power options, and allow for avoidance of harmful impacts to existing water uses.



Urban electricity supply in northern Ethiopia.

HYDROPOWER: A VITAL WATER-USE SECTOR

Turning the spotlight on power

This chapter takes a look at the performance of the region's power and energy sector, with a special focus on hydropower – a key non-consumptive water user in the Nile Basin. The region is well endowed with hydropower potential which, if exploited from a regional perspective, is capable of catalyzing the economic transformation of the region. However, tapping this vast potential calls for careful approaches to ensure that harmful impacts to the environment and society are minimized while interference with existing water uses is avoided.

The chapter examines the various issues related to sustainable management and development of the region's power potential. It starts with an examination of the present levels of electricity production and consumption in the basin, and the extent of reliance on hydropower as a source of energy. It goes on to discuss the region's rapidly rising power demands, and the numerous challenges that the countries must overcome to meet this demand. It ends with a discussion on the role of regional cooperation in steering the region towards energy security.



Hydroelectric power plant, Aswan, Egypt.

Electricity pylons, Egypt.



IMPORTANCE OF POWER/ELECTRICITY

Power/electricity is a critical ingredient in all sectors of national economy, and its supply is directly correlated with the economic performance of the countries. Its impacts are felt in all sectors but it is especially vital to the following:

Industrial sector The problem of frequent power outages in the basin has been blamed for the low levels of industrialization, and the inability of local products to compete with imports even in domestic markets. All NBI countries aspire to join the league of middle-income nations within the next 20 years. The key to this transition is held by the transformation of the industrial manufacturing and processing sector, which in turn is to some extent dependent on a secure power supply.

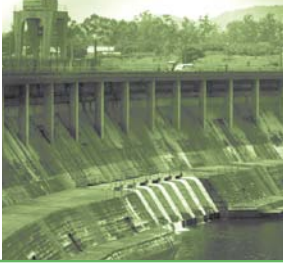
Service sector The service industry, which encompasses sectors such as education, communication, health, transport, banking, and tourism and hospitality, is undergoing transformation with rapid uptake of ICT. The growth of this sector comes with a large demand for electricity which, if not met, will stifle the sector's growth and slow down the region's economic growth.

Attracting new investment While it is not the only factor determining the rate of investment inflows, a country

characterized by unreliable power supply is definitely not attractive to investors. Countries like Egypt and Ethiopia, which have allocated large resources to the development of the power sector, have been the preferred destination for new investments in the region.

Employment opportunities Power/electricity supplies contribute indirectly to employment creation through diversifying economies and stimulating the growth of the industrial and service sectors. Improving access to electricity in the rural areas, and encouraging establishment of rural industries and services has the potential to open up many opportunities for young people at very little additional cost to national economies.

Improving the general standard of living In developing countries, increasing electricity supply has multiple and diverse effects on the economy, and invariably translates into better standards of living for the population.



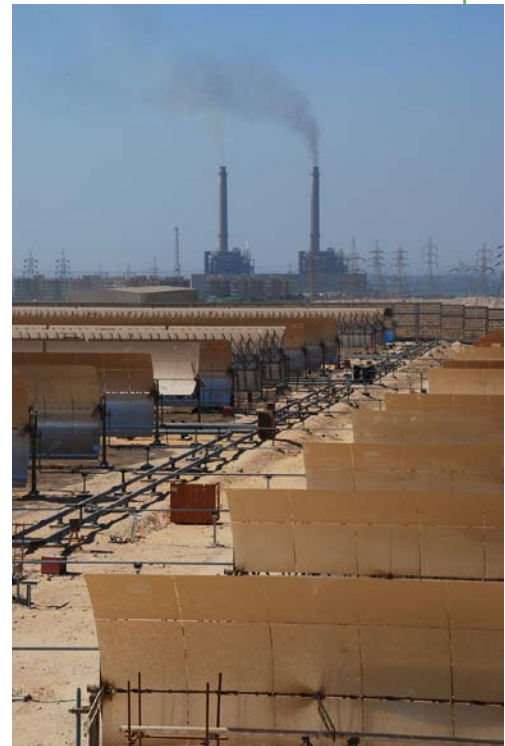
Importance of hydropower in the energy sector

Multiple energy sources

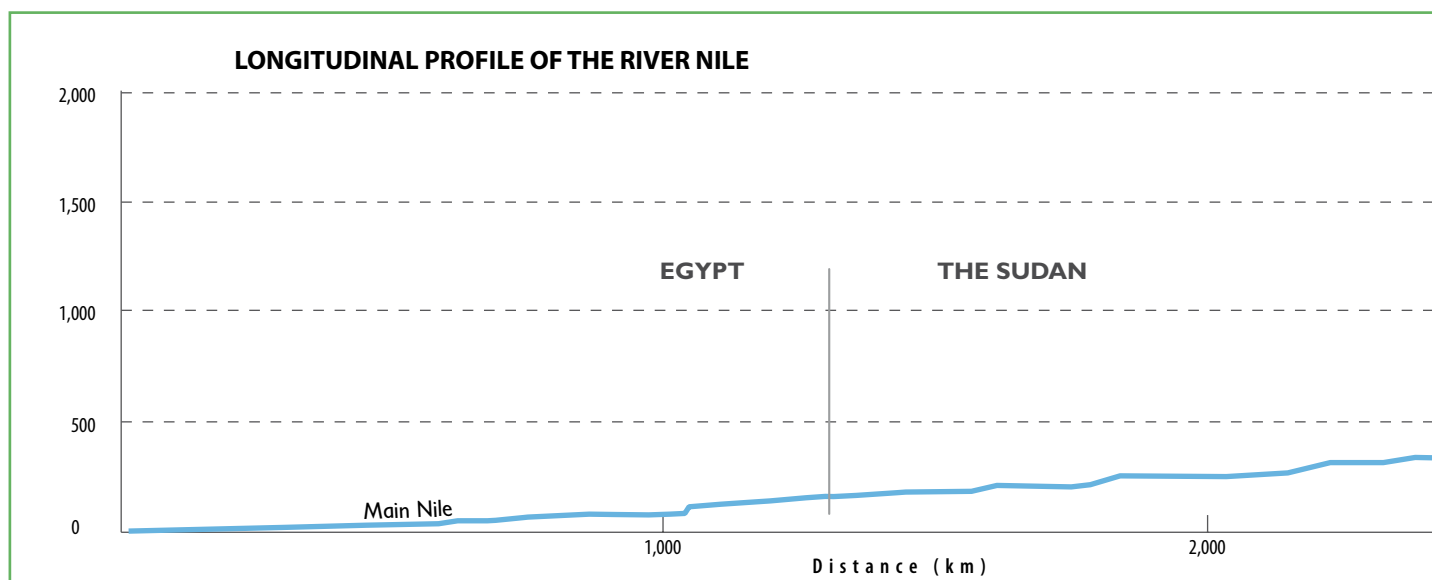
Potential sources of power/electricity in the Nile countries are multiple, including hydropower, natural gas, oil, coal, peat, biomass, geothermal, solar, and wind energy. The identified feasible power options are not uniformly distributed in the region in size and type. Hydro resources are abundant in DRC and Ethiopia, with a possible combined potential exceeding 100 GW; good wind speeds have been identified in northern Kenya, southeastern parts of Ethiopia (45 MW installed; 870 MW under development), southern Tanzania and Egypt (550 MW installed); solar power opportunities are best in Egypt, with 140 MW in operation already; and there is abundant geothermal potential in East Africa's Great Rift Valley (potential in Kenya and Ethiopia estimated at 7,000 MW and 5,000 MW respectively). To maximize the benefits of this rich mix of renewable options, the region must embrace and adopt an integrated strategy to regional power development such as is proposed in the NBI Comprehensive Basinwide Study of Power Development Options and Trade Opportunities (CBWS).

Hydropower: the preferred source of energy

Among the various energy options, hydropower takes a central and dominating role. Despite their potential social and environmental impacts, their requirement for huge initial capital outlay, and long implementation lead-times, hydropower options are still the preferred source of energy in the region for various reasons. Key among the reasons is the low production cost of electricity from hydropower options, which could make electricity affordable to the urban and rural poor, thus presenting real opportunities for reducing pressure on woodlands and forests (presently heavily relied on as a source of energy) and protecting critical watersheds needed for sustained flows of the Nile tributaries.



The Koraymat solar energy site south of Cairo, Egypt, funded by the European Union with the aim of integrating energy markets and moving towards sustainable and clean energy.



WHY HYDROPOWER IS THE MOST ATTRACTIVE OPTION

Hydropower options remain the preferred source of energy in the region because they:

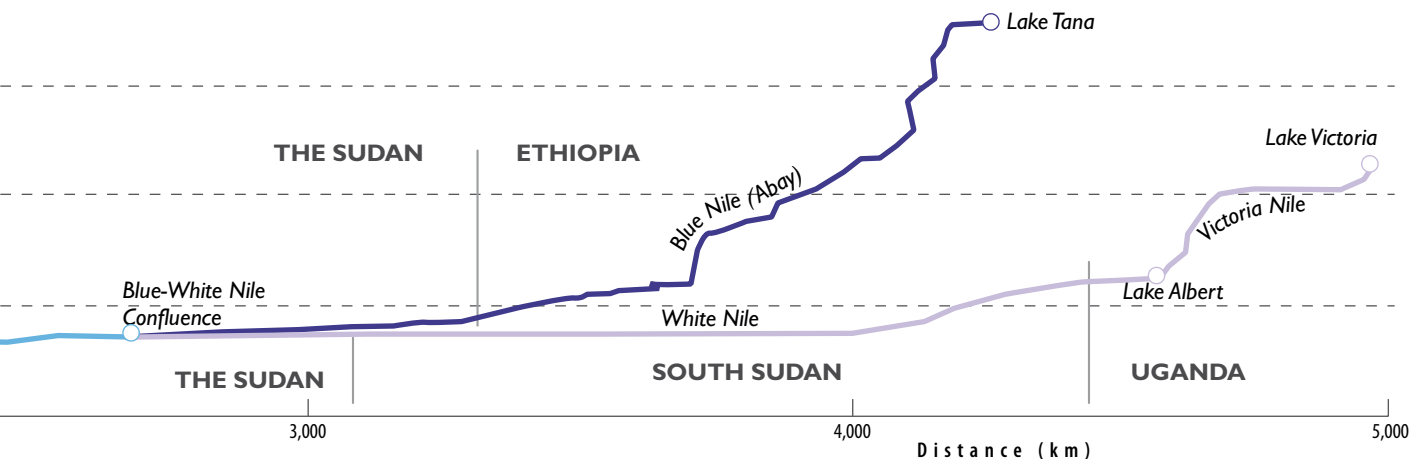
- Exhibit long economic life which translates to very low per unit cost of energy.
- Are a renewable source of energy and with proper preparation of the reservoir, are pollution free and eligible for carbon credits.
- Respond quickly to changing power system conditions, enhancing stability and reliability of supply.
- Provide a cost-effective means for storing surplus energy from non-conventional renewable sources of energy such as solar and wind, which are by nature intermittent.
- Are labour intensive and provide huge employment opportunities during construction and operation.
- Deliver additional benefits such as flood control and river-flow regulation, irrigation, transport and navigation, aqua farming, recreation, industrial and domestic water supply.

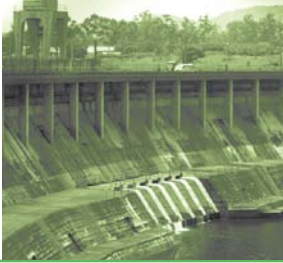


Bujagali power plant under construction.

The potential for hydroelectric power in the Nile basin is huge. The White Nile drops some 500 metres between Lake Victoria and Lake Albert, representing an estimated capacity of over 4,000 MW, of which 380 MW is currently operational. In the eastern Nile region, the 1,300-metre fall of the Blue Nile (Abay) between Lake Tana and the border with The Sudan could provide hydroelectricity in excess of 8,000 MW. Important additional potential exists along the Baro (2,300 MW), Atbara (Tekezze) (450 MW), the Main Nile (3,100 MW), and on the various smaller rivers in the upstream catchments, such as the Kagera (265 MW) and Semliki (100 MW).

The power of the Nile demonstrated at the spectacular Murchison Falls, Uganda.





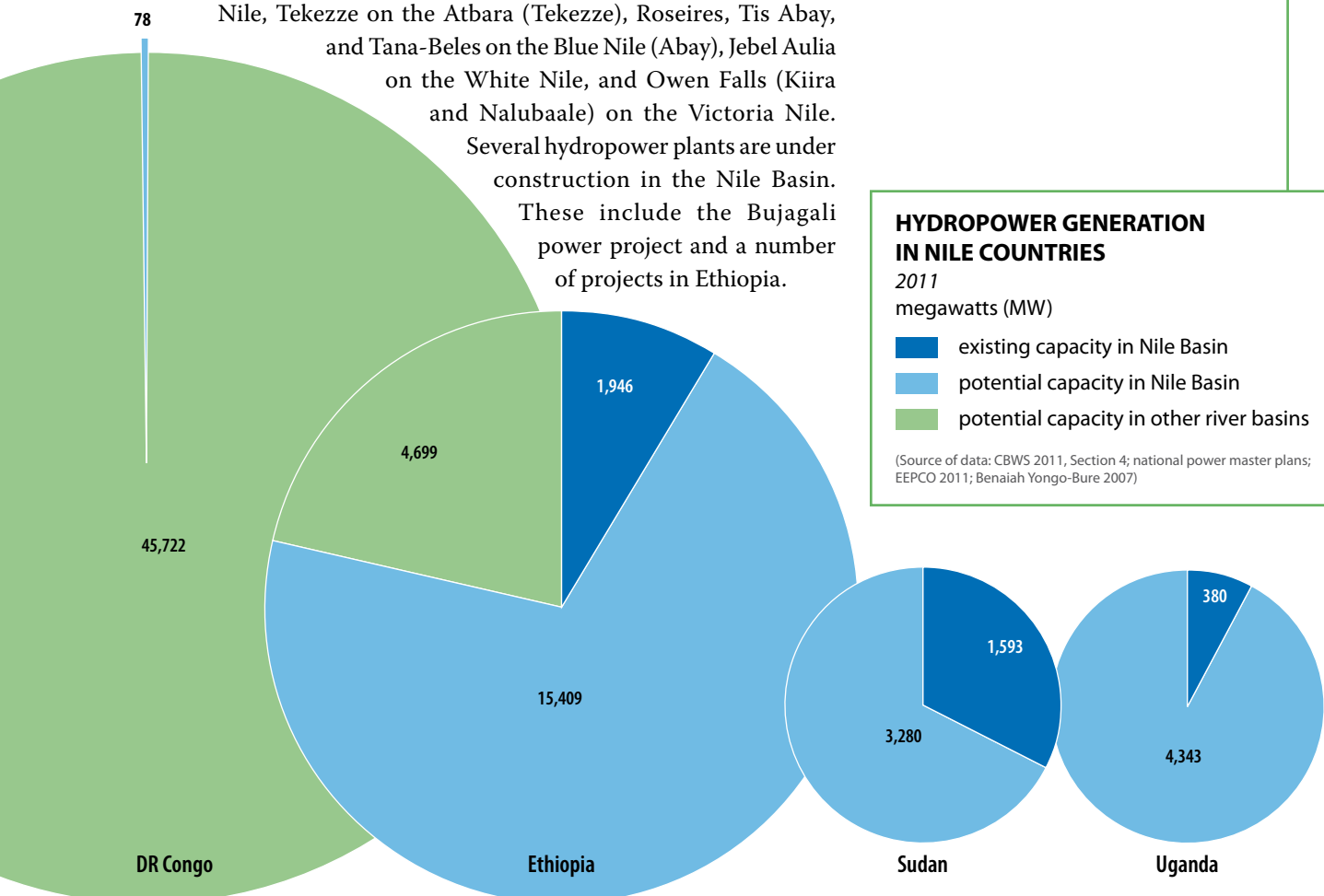
POWER SUPPLY AND CONSUMPTION

Power generation

The present power situation in many Nile countries is characterized by inadequate, unreliable, and expensive power for domestic, commercial, and industrial use, and by very low power consumption levels. Throughout 2011, the power supply situation in most of the NBI member states was extremely challenging. Most member states were unable to meet the projected national demand. They also fell short of the constrained demand resulting in substantial load curtailment in a number of countries.

The extent of dependence on hydropower as an energy source varies from country to country. Hydropower is the single most important source of electricity in DR Congo, Ethiopia, Burundi, and Uganda, and it provides a substantial share of total power production in Kenya, The Sudan, Tanzania, and Rwanda. However, its contribution is relatively insignificant in Egypt, South Sudan, and Eritrea. The latter two countries rely almost entirely on thermal plants and operate no hydropower facilities, although South Sudan has vast untapped hydropower potential. Existing hydropower generation facilities only represent a small portion (26%) of the potential capacity. The main schemes currently operational are at Aswan and Merowe on the Main Nile, Tekeze on the Atbara (Tekeze), Roseires, Tis Abay, and Tana-Beles on the Blue Nile (Abay), Jebel Aulia on the White Nile, and Owen Falls (Kiira and Nalubaale) on the Victoria Nile.

Several hydropower plants are under construction in the Nile Basin. These include the Bujagali power project and a number of projects in Ethiopia.



PROJECTED ENERGY DEMAND AND SUPPLY, 2011

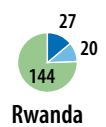
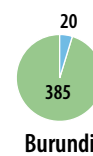
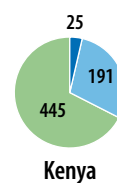
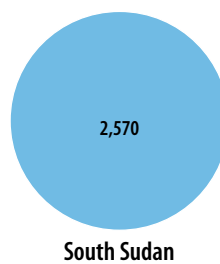
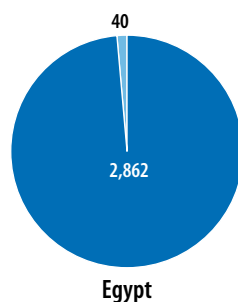
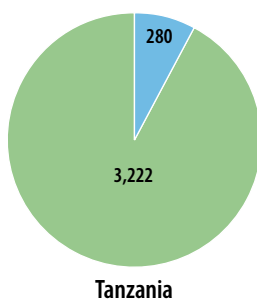
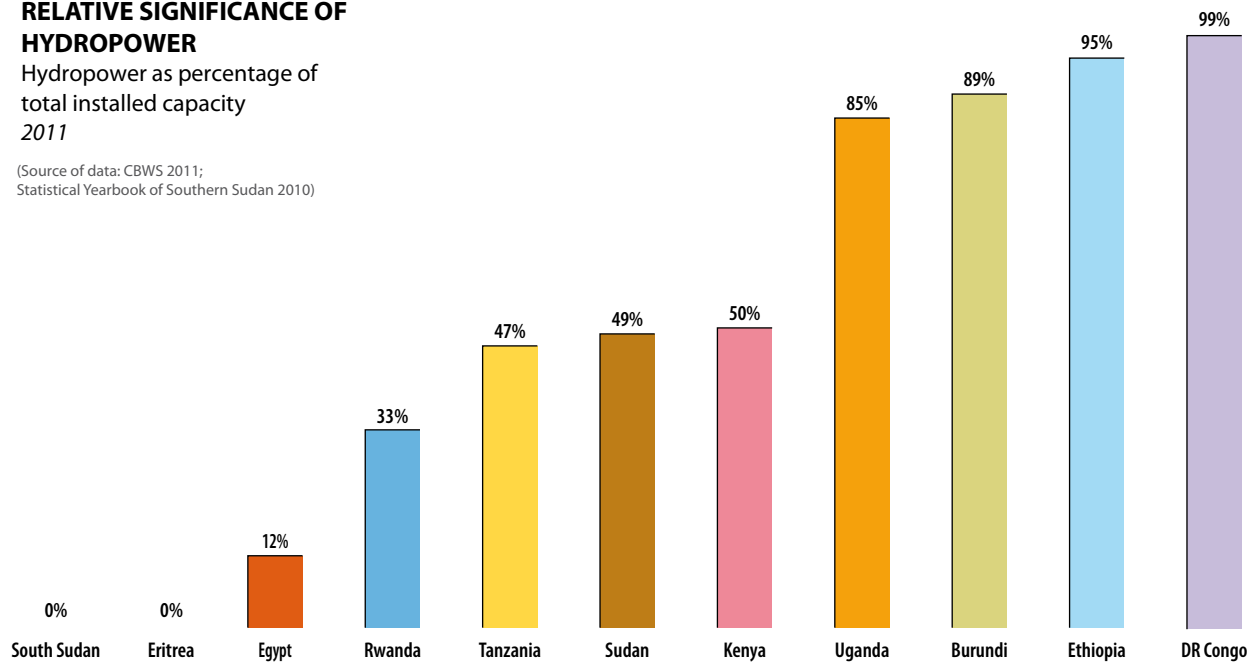
	Projected peak demand (MW)	Demand peak recorded (MW)	Projected energy demand (GWh)	Energy supplied (GWh)	Energy deficit (Load Shed in GWh)	Unconstrained energy deficit (GWh)
Burundi	60	52	525	245	15	280
DR Congo	2,018	1,050	13,568	6,911	1.4	6,657
Egypt	24,183	23,470	147,273	146,796	0	0
Ethiopia	1,396	914	6,335	3,823	0	4,130
Kenya	1,352	1,194	8,292	5,785	23.6	2,507
Rwanda	76	78	413	418	0	0
Sudan (2010)	1,143	1360	7,211	7,499	0	0
Tanzania	971	829	6,069	4,792	718	1,277
Uganda	471	446	2,819	2,639	147	180

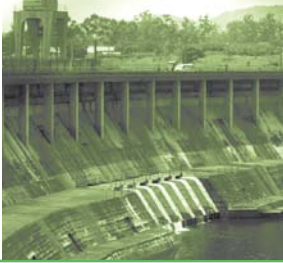
(Source: CBWS)

RELATIVE SIGNIFICANCE OF HYDROPOWER

Hydropower as percentage of total installed capacity
2011

(Source of data: CBWS 2011;
Statistical Yearbook of Southern Sudan 2010)



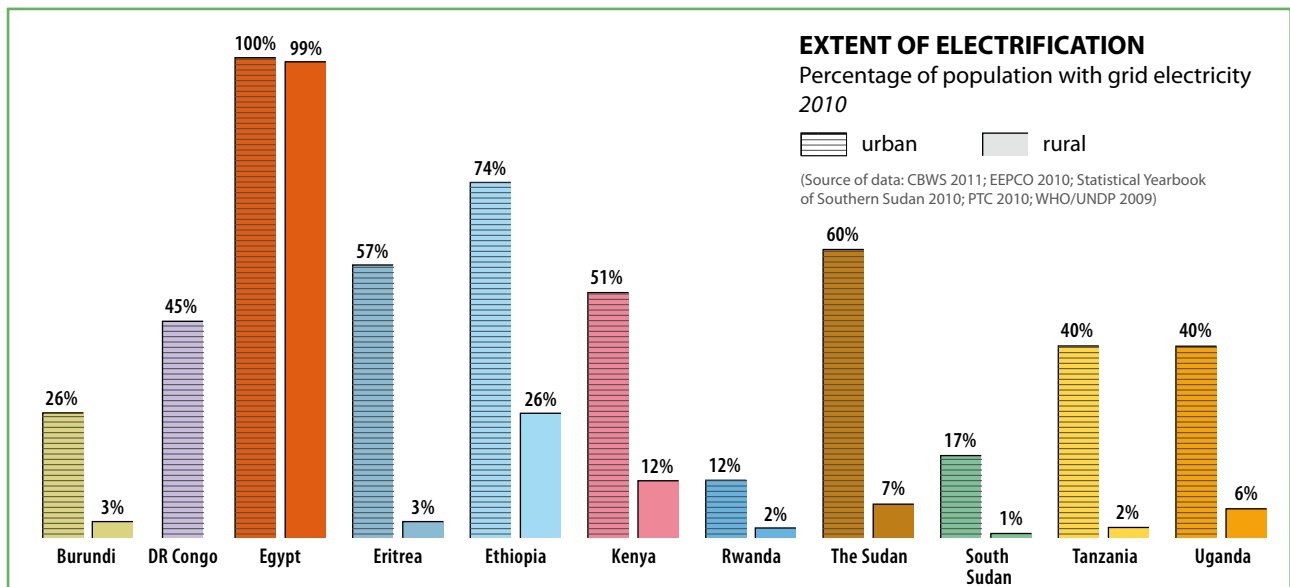
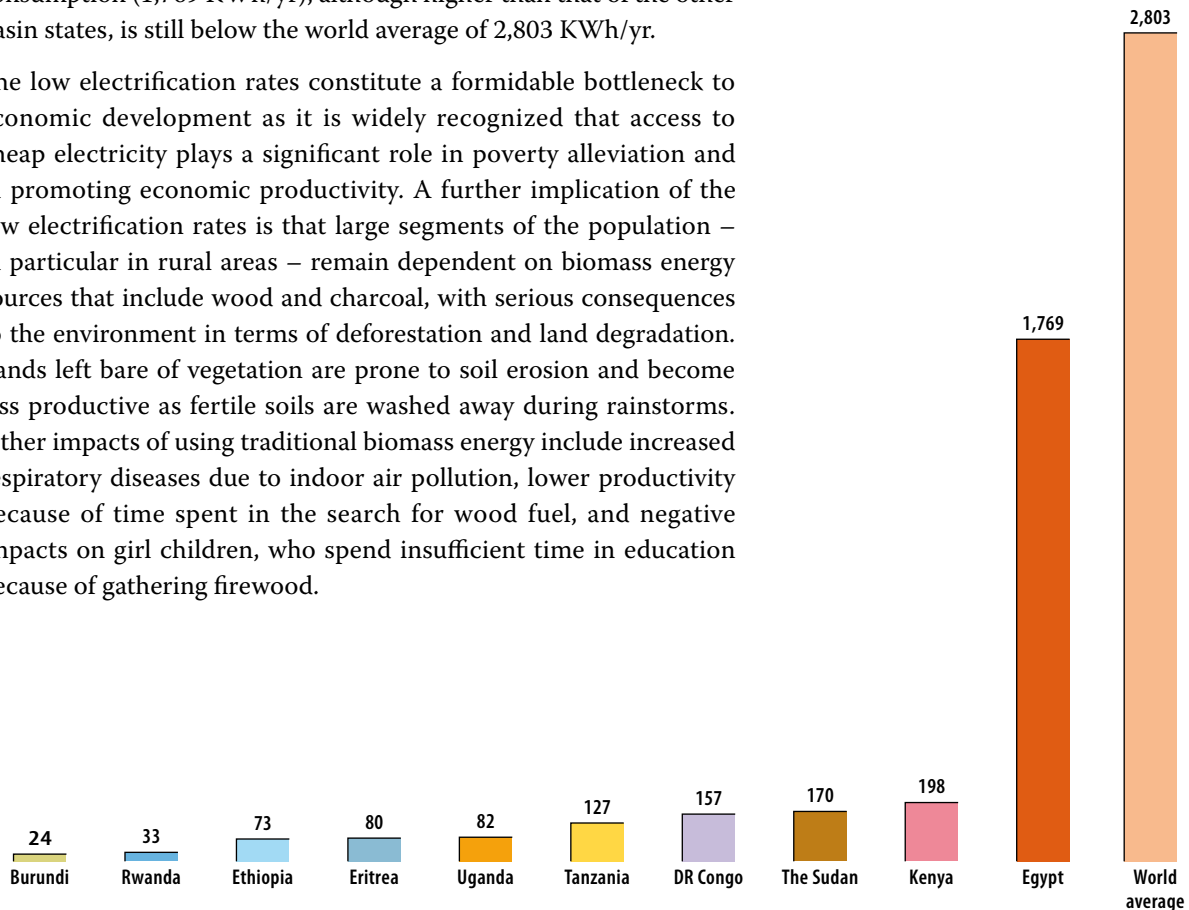


Power consumption

Electricity consumption per capita in the Nile region is very low compared to the rest of the world. All the Nile countries with the exception of Egypt had a per capita electricity consumption of less than 200 kWh/yr in 2011, compared to the 10,000 kWh/yr or higher that is common in the industrialized world. Egypt's per capita consumption (1,769 kWh/yr), although higher than that of the other basin states, is still below the world average of 2,803 kWh/yr.

The low electrification rates constitute a formidable bottleneck to economic development as it is widely recognized that access to cheap electricity plays a significant role in poverty alleviation and in promoting economic productivity. A further implication of the low electrification rates is that large segments of the population – in particular in rural areas – remain dependent on biomass energy sources that include wood and charcoal, with serious consequences to the environment in terms of deforestation and land degradation. Lands left bare of vegetation are prone to soil erosion and become less productive as fertile soils are washed away during rainstorms. Other impacts of using traditional biomass energy include increased respiratory diseases due to indoor air pollution, lower productivity because of time spent in the search for wood fuel, and negative impacts on girl children, who spend insufficient time in education because of gathering firewood.

ELECTRICITY CONSUMPTION
Per capita in Nile Basin countries
2010
kWh per year
(Source of data: PTC 2010; World Bank 2009)



FUTURE POWER DEMAND SITUATION

Power demand projections

Demand for power in the Nile Basin region has been rising steadily over the years. Between 2000 and 2010, demand grew from 86,000 GWh to 180,000 GWh – an increase of over 100 per cent. This strong growth is expected to be sustained for several decades to come. Egypt currently accounts for three-quarters of the regional load demand, but disproportionately faster growth in the upstream countries is expected to bring Egypt's share down to half by 2030.

Power-demand scenarios developed under NBI's CBWS show that very significant additional power-generation capacity is required to satisfy future electricity demand. In the Base Case Outlook for 2035, peak demand is forecast to increase by about 300 per cent in Egypt, Eritrea, and Uganda. For the other Nile countries this figure is even higher, with demand predicted to double every five years after 2010. Kenya has the most ambitious projected demand increase – by a factor of 20 relative to 2010 levels. In the Enhanced Regional Cooperation Scenario, growth rates for 2035 are even higher. The projections predict the integrated system peak demand to equal the total hydropower potential in the region by 2030.

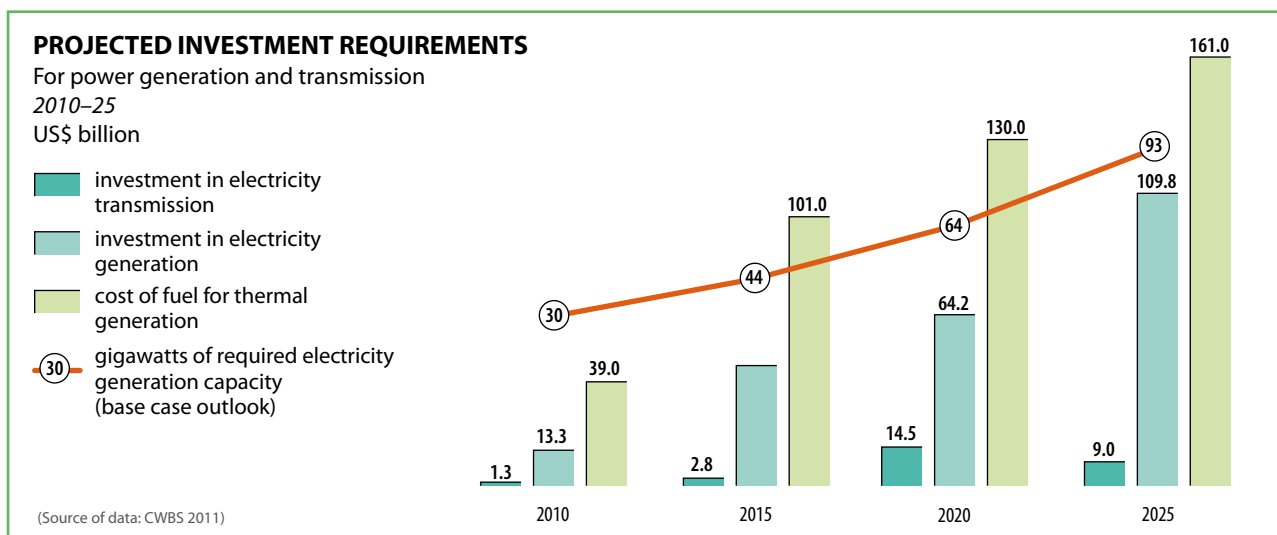
The factors behind the steady growth in demand are multiple, and include the success of regional efforts at economic reform, improving investment climate, increasing cross-border trade, and rising population in the basin.

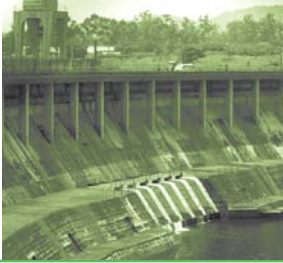
Investments needed to satisfy future power demands

It is clear that very large investments in electricity generation capacity and transmission facilities are required to meet the above projected demands. For the period 2010 to 2015, an amount of US\$13.3 billion is required for new generation projects, while US\$1.3 billion is required for new transmission lines. For the subsequent five years (2015 to 2020), US\$45 billion is required for new generation projects.



Africa at night, showing the low electrification rate of most of the Nile region.





To raise the huge investments required, the member states need quickly to formulate a regional framework for resource mobilization that will target multiple funding sources, including the private sector. Concerted effort is also required to expedite implementation of the transboundary transmission interconnector to move energy from countries with surplus to countries with deficit, and facilitate displacement of expensive thermal power by embracing peak power swapping.

Failure to respond with adequate speed will see power demand in the region continue to outstrip supply, with a consequent increase in installation of thermal-based emergency power plants. This, in turn, will negatively impact on the unit cost of electricity, reduce competitiveness of the region's products, and slow down economic growth.

MAIN ONGOING HYDROPOWER DEVELOPMENTS

Bujagali is a 250-MW run-of-river development on the Victoria Nile, 8 kilometres downstream from Lake Victoria in Uganda. Civil works were completed, and five generating units were commissioned in July 2012, adding 250 MW to the national grid in Uganda.

The Bujagali facility is currently the largest power plant in the region that is funded by private investors. It will play a critical role in stabilizing power supply in Uganda in the short term. Its operation needs to be closely coordinated with the upstream Kiira and Nalubaale facilities.

Several hydropower projects are being developed in the Ethiopian part of the basin. According to the Ethiopian power utility, EEPSCO, work has started on the largest hydropower project in Ethiopia, the Grand Ethiopian Renaissance Dam, near the border between The Sudan and Ethiopia on the Blue Nile (Abay). The plant will have a capacity of 5,250 MW, and will create a reservoir with a surface area of 1,680 km² at full supply level.

Aerial view of Bujagali power plant under construction, September 2011.



DEVELOPING THE REGION'S HYDROPOWER POTENTIAL

Constraints to development of the basin's hydropower potential

To most of the Nile riparian countries (with the exception of Egypt, whose hydropower potential is fully developed), hydropower is the preferred source of energy for meeting the burgeoning power needs of the region. There are several factors that make hydropower attractive to the Nile countries, as discussed above. However, there are also many constraints that hinder the full exploitation of the vast hydropower potential in the region.

Transboundary context

Cost and benefit sharing – In a transboundary basin with no legal/institutional framework for cooperative development of basin resources there is usually no mechanism for quantifying and equitably sharing the costs and benefits related to investment projects, making it difficult to proceed with such projects.

Cumulative impacts and competing water uses – delays in implementation of transboundary hydropower projects may arise from complaints from co-riparian states who object to the proposed projects on grounds of potential harm to the uses and benefits they are currently enjoying from the shared water resources.

Environmental considerations

Damage to global environmental assets – The Nile Basin has several globally significant environmental assets such as the 17 international Ramsar sites and a similar number of national parks and game reserves with rare and threatened species. Dam construction can also result in loss of exceptional scenic and cultural assets, such as waterfalls and rapids, and traditional worship shrines.

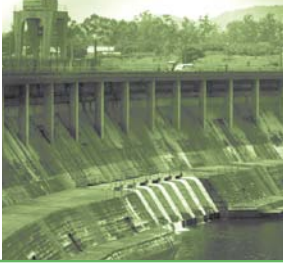
Water quality, sedimentation, and soil erosion – Poor project design can lead to soil erosion, water quality deterioration, and eutrophication during the construction and operation of hydropower facilities. The very high sediment loads in the headwater areas (especially in the eastern Nile region) will affect the economic feasibility of possible hydropower projects by reducing the storage capacity and water volume available for generating electricity. Trapping the sediment load in the new reservoir has the effect of altering downstream scour and deposition patterns, ultimately producing changes in river morphology.

Greenhouse emissions and aquatic weeds – Improper excavation methods during construction may lead to disturbance of soils or sediments rich in organic matter and lead to greenhouse gas emissions. Eutrophication during the filling and operation of reservoirs may also lead to proliferation and cross-border transfer of invasive aquatic weeds.

Climate variability and change – Large areas in the basin are vulnerable to drought because of high variability in rainfall and high

Rusumo Falls, where the waters of the Kagera River run red with silt washed from the hill farms in Burundi and Rwanda. The falls are a proposed site for a new hydroelectric dam.





evapotranspiration rates. Seasonal shortages in water associated with natural climate variability make it difficult to maintain peak-generation capacity throughout the year, and may reduce the long-term economic feasibility of candidate hydropower projects. The negative impacts of climate on the power sector are expected to greatly increase with global climate change, as discussed in Chapter 8.

Social considerations

Land and resettlement issues – Dam construction brings considerable hardship to local communities. Some people lose their land and assets because of the newly created reservoir and need to be resettled. Those who remain may find their livelihoods affected by changes in river flow. Typically, local communities do not share the benefits of the hydropower project, while carrying most of the burden.

Public health – Newly created water bodies can introduce water-related diseases such as malaria and bilharzia that affect public health.

Lead times and financing

Long lead time – Many potential hydropower options in the region are at very preliminary levels of preparation, although it is well known that hydropower development involves very long lead times. The period between project initiation and commission exceeds 10 years or more in a transboundary context where there are competing interests and unique environmental assets. When electricity demand is rising rapidly – as is the case in the Nile Basin – the long lead time of hydropower projects is a major obstacle to power security.

Financing – Hydropower development typically involves large capital requirements that are beyond the financial resources of most governments in the Nile region and have to be provided by external financing agencies. These agencies – such as The World Bank – follow strict rules with regard to environmental and social appraisal, mitigation management, and transboundary consultation that may

RUSUMO HYDROPOWER PLANT

The establishment of the Rusumo hydroelectric facility illustrates the long lead time associated with hydropower development. Project studies were carried out under the auspices of the Kagera Basin Organization (KBO) in the mid-1980s up to detailed design stage, but due to the political situation in the region, the project could not progress further, and KBO became defunct.

With the establishment of the NBI, the Rusumo Hydropower project was re-initiated. A 2003 Strategic/Sectoral Social and Environment Assessment study in the region recommended the project as a regional least-cost option. Between 2006 and 2008, the Nile Basin Trust Fund (NBTF) and African Development Bank (AfDB) funded a number of feasibility studies for the project. However,

the studies experienced delays and budget constraints, as a result of which the transmission line studies became obsolete and required updating.

Additional funding sought from NBTF for completing the feasibility studies became available in September 2010. The Rusumo HPP will be implemented through a Special Purpose Vehicle (SPV) with the three member states – Burundi, Rwanda, Tanzania – as the key shareholders.

The financial closure for the project is expected to be reached in 2013, construction works to start in 2014, and commissioning in 2016. If all goes according to plan, it will have taken 13 years from re-initiating the Rusumo project to its commissioning in 2016.

delay project implementation. Since 2000, the region has exhibited high electricity demand growth rates, but the new generation has not been forthcoming due to challenges associated with resource mobilization. The countries have found it difficult to attract private investment for power development in the absence of a working regional electricity market.

Overcoming the constraints to hydropower development

The impediments to full exploitation of the region's hydropower potential are not insurmountable. To overcome the constraints and draw on the multiple benefits that come with hydropower development, concerted efforts and resources must go into formulating and implementing mitigation measures for identified negative impacts right from project conception. The basin states must implement a set of measures, key among which are the following.

Transboundary context

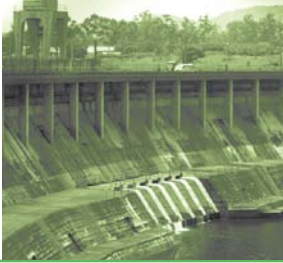
Competing water use conflicts: Developing an integrated basin-wide water resources management and development plan incorporating the various sources and uses of water can help to reduce water-use conflicts. The views of all key stakeholders at national and regional level need to be carefully considered in the preparation of such a plan. Multi-stakeholder institutions need to be established to monitor and resolve water-use conflicts (such as proposed for the Rusumo Project). At the regional level, a forum for discourse on issues pertaining to the equitable utilization of the common Nile water resources, and the analytical capacity to support informed decision making need to be maintained through institutional mechanisms such as the NBI and Nile River Basin Commission.

Cumulative impacts: Considering that several large hydropower projects are under construction on the Nile, and many more have been identified for immediate implementation, it is necessary that a basin-wide cumulative impact assessment is undertaken to establish the key risks with concurrent dam development and operation, and formulate mitigation measures to be implemented alongside development work. The determination of cumulative impacts could be part of the process of developing an integrated basin-wide water resources management and development plan, and will reduce the time required to obtain approval from other riparians to proposed water-development projects.

Political risk: Implementing transboundary hydropower projects through a cooperative arrangement such as under the NBI allows for greater transparency, accountability, and good governance, and consequently reduces perceived political risks related to conflicts amongst the riparians and self-interested direct interference by any member state.

Environmental considerations

Changes in the flow regime and damage to global environmental assets: Potential environmental impacts need to be anticipated and



avoided, or mitigated through mainstreaming environmental and social management in all phases of the project life. Environmental flow policies need to be developed for the major sub-basins of the Nile that will inform the process of reservoir filling, and guide decisions on reservoir-level drawdown management on a daily and seasonal basis. Such policies should mimic, as far as possible, the natural flood pattern of the river, and take into account the needs of downstream riparian communities and ecosystems.

Climate variability and change: Climate-change adaptation and mitigation needs to be mainstreamed in all aspects of project development and operation, as discussed in Chapter 8.

Water quality, sedimentation, and soil erosion: Integrated water-resources management and development plans need to be prepared for each sub-basin. The plans should include such measures as the restoration of degraded watersheds, promotion of good land-use practices, and creation of awareness amongst local communities of the benefits of controlling soil erosion. Sedimentation problems should be anticipated and addressed at the design stage of hydropower reservoirs by including flood-diversion channels, sedimentation traps upstream of the reservoir, and ensuring adequate dead storage area to last the design life of the reservoir.

Greenhouse gas emissions and invasive aquatic vegetation: The threat of greenhouse gas emissions (GHGs) can be reduced by proper clearing of the reservoir before impounding. Proliferation of invasive aquatic weeds can be avoided by building traps upstream of the point of entry of the river into the reservoir, and carrying out proper watershed management.

Social considerations

Land and resettlement issues: Reservoir and power-plant designs need to be optimized to reduce the project footprint, and employ efficient construction methods to reduce disturbance, or avoid altogether sensitive environmental and cultural sites. Resettlement plans need to provide adequate land for compensation away from the reservoir and river banks. Alternative livelihoods must be identified for displaced communities.

Public health: Projects need to be accompanied by appropriate disease prevention and control measures such as awareness raising, providing health facilities, treating affected people, and controlling disease vectors to mitigate impacts related to public health.

Bujagali Falls, Uganda, before the completion of the downstream dam caused them to be submerged.



Lead time and financing

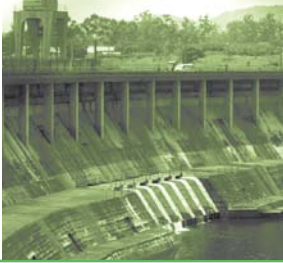
Shortening the implementation period: One way to reduce Project Implementation Duration is to ensure adequate project preparation, and to build strong ownership of the project right from local level. Countries, with the facilitation of the NBI, need to quickly put aside resources for upgrading the level of information on hydropower options identified under the CBWS, and reviewing the portfolio of projects, as necessary. Allowing potential investors access to vital information early in the project preparation phase gives them greater confidence in taking investment decisions.

Resource mobilization: Considering the huge capital requirements for implementation of hydropower options, public funding alone will not suffice. Resource mobilization must therefore embrace private–public partnership models, especially through Special Purpose Vehicles. The NBI member countries need also to develop project financing structures that allow participation of local capital markets and take advantage of the vast insurance and pension funds in the region. Ability to leverage domestic capital in power infrastructure financing has been demonstrated in Ethiopia and Kenya, where Initial Public Offers (IPO) have attracted great interest. In the long-term, the region should consider setting up a dedicated hydropower development fund, where international equity funds could play an important role.

Renewable power options: In the short-term, the region needs to promote implementation of renewable power options, such as geothermal, wind, and solar, which are environmentally friendly and have much shorter incubation periods. The low-risk and short implementation period renders renewable power options very attractive for private investment if the tariff is right.

The massive Koraymat solar energy site outside Cairo, Egypt. The concentrator mirrors turn automatically to focus the sun's rays upon a single point until the viscous liquid that fills the pipe at the centre of the mirror reaches a temperature of 400°C.





DIVERSIFYING REGION'S ENERGY SOURCES

Hydropower has limited ability to meet region's energy needs

While hydropower can meet considerable energy needs in the region, the total power demand, as presented in the CBWS scenarios, will exceed hydropower potential in the longer term, and alternative power sources need to be developed. Projections in growth of power demand indicate that the integrated system peak demand will equal the total hydropower potential in the region by 2030. Diversifying energy sources – for example developing non-conventional renewable resources such as wind and solar – will help to bridge the energy deficits and will make power production less vulnerable to climate variability and change.

Complementing hydropower with other renewable energy sources

When water availability is the principal limiting factor to hydropower production, and sufficient reservoir storage capacity is available, there is an opportunity to combine hydropower with other renewable energy sources – possibly solar and wind – allowing water to be stored for use at peak load time. Hydropower's fast response time (i.e. the time it takes to start the powerplant or adjust the turbines to the new system load) mitigates sudden fluctuations in power demand, and enables a steady power supply and stable power system to be maintained.

The Kiira and Nalubaale power stations on Lake Victoria could serve as an example for this approach. When lake levels fall below 1,137 metres above mean sea level, water releases from the two power stations are gradually reduced in accordance with the 'agreed curve' (i.e. the release policy) for the Owen Falls Dam. Therefore, average power production at the Kiira and Nalubaale facilities is below capacity even as power demand continues to rise each year. Complementing the hydropower facility with, for example, a solar plant, could allow some of the generation units at Kiira and Nalubaale to shut down at periods of low demand, store water, and release it to generate power at periods of peak demand. Such a mode of operation allows for increased energy production and improved use of the grid connection of the hydropower facility without having to make major investments.

Proposed and ongoing power generation projects

NBI has identified a total of 88 potential power generation projects in the Nile Basin and adjacent river basins that could be part of the regional power grid; 49 of these are hydropower schemes. Unit costs of power production differ greatly, ranging from 2.15



Wind farm under construction at Ashegoda, near Mekelle, Ethiopia.

Nalubaale Hydroelectric Power Station (Owen Falls Dam), Uganda.



GRAND INGA PROJECT

At Inga in west DR Congo, the Congo river drops some 96 metres over a stretch of 15 kilometres. It is the site of two hydropower dams, Inga I and Inga II (see photo below), which currently operate at low output. There are plans for a massive extension of the facility.

The Grand Inga Hydropower station will have a total capacity of 39,000 MW. Detailed studies have been completed, including environmental-impact assessment, power generation layout and design studies, and

sustainability analysis. Grand Inga will be connected to the power grids in the Nile region and could thus supply part of the basin's growing electricity need.

The power options will be combined to create a reliable and economic regional electricity supply system. The Nile countries have made important progress towards creating a regional power pool.

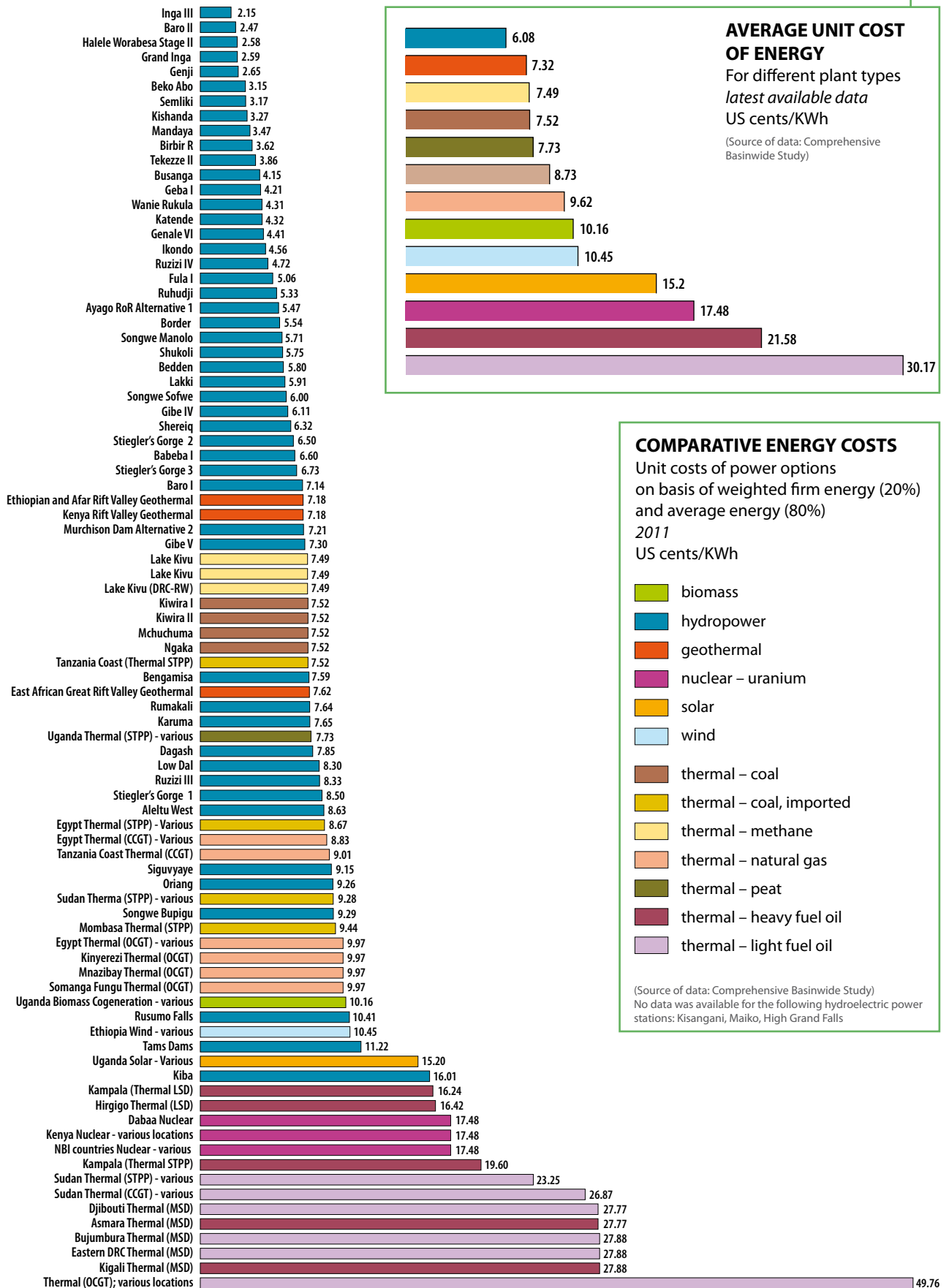
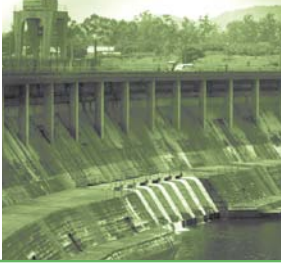


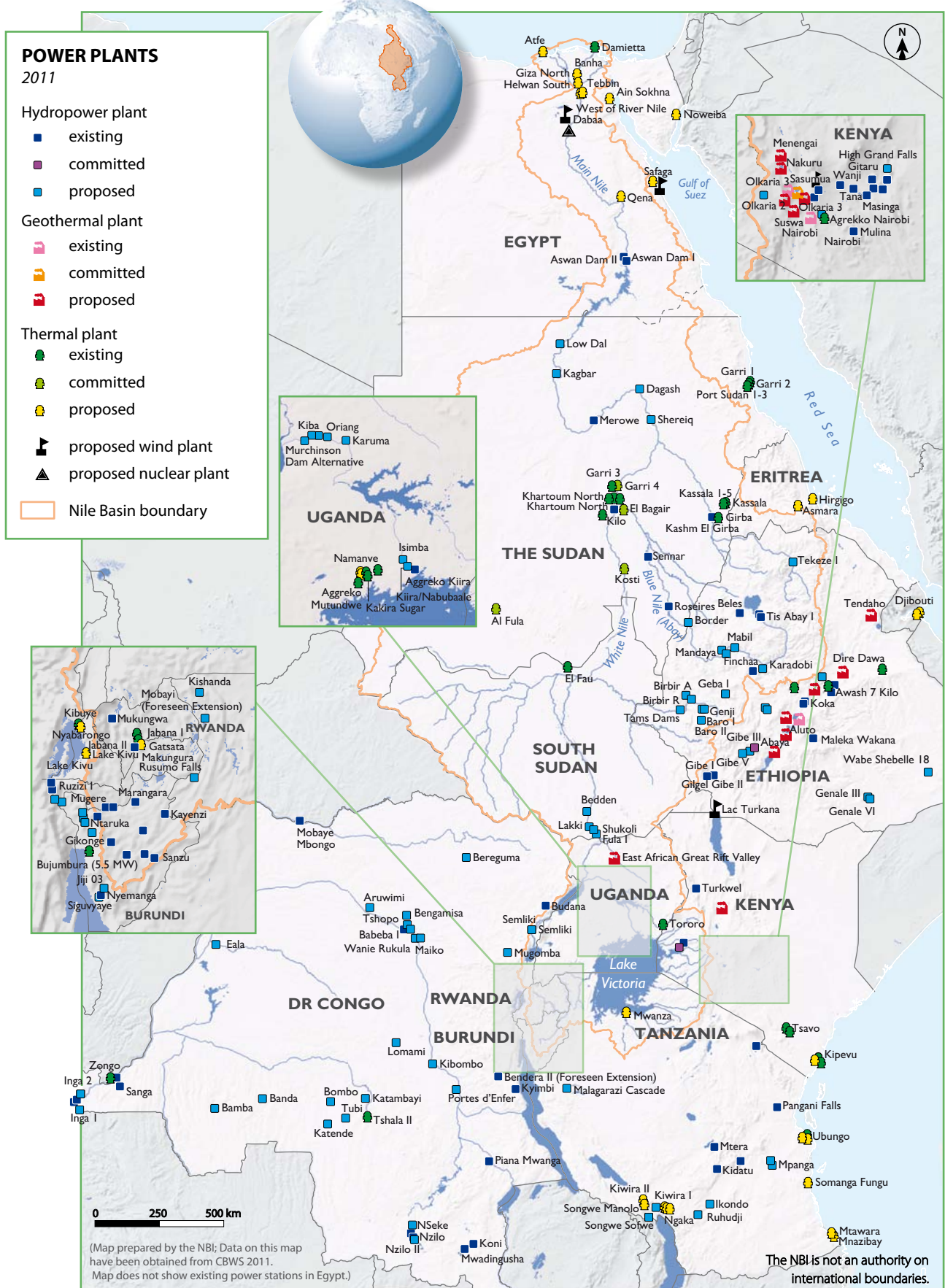
USc/KWh to 49.76 USc/KWh. Hydropower schemes, with an average unit energy cost of 6.08 USc/KWh, clearly present the cheapest energy options in the region. The cheapest among the identified hydropower schemes are the Inga III and Grand Inga in the Democratic Republic of Congo; and the Baro II, Halele Worabesa Stage II, Genji, and Grand Ethiopian Renaissance Dam in Ethiopia; all with unit energy costs below 3.0 USc/KWh. Following hydropower schemes are geothermal generation plants, which have an average unit energy cost of 7.32 USc/KWh. The unit cost of renewable energy sources such as solar and wind energy are on the costlier side of the spectrum, but the most expensive options are thermal generators using heavy and light fuel oils (and various technologies – mainly medium speed diesel engines, steam thermal power plants, open cycle gas turbines and closed cycle gas turbines). The average unit energy costs for these options are 21.58 USc/KWh for generators using heavy fuel oil (HFO) and 30.17 USc/KWh for generators using light fuel oil (LFO).

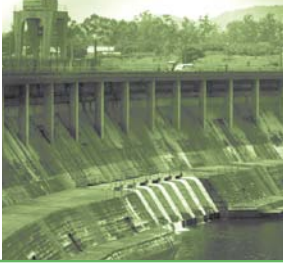
Each of the identified power options has been assessed in the CBWS against risk criteria relating to its likely environmental, socio-economic, and political impacts. The power options were grouped into three categories on the basis of the assessed impact:

- Group A: options with no significant negative environmental, social, or political impacts
- Group B: options with limited but important dilemmas
- Group C: options with major dilemmas.

No hydropower options in the Nile region fall under the Group A category. A total of 40 candidate projects are ranked as Group B, while 30 power options are in Group C. The remaining 18 options could not be ranked because of insufficient information. These include important projects with low generation cost, such as the Grand Inga, Inga III, and Baro II. Clearly, no project, however effective it appears, is exempt from some level of risk. It is important to realize that being ranked in Group C does not disqualify a candidate project. Rather, it implies that appropriate mitigation measures are needed to improve the acceptability of these projects. Further studies need to be considered to complete their assessment or improve their acceptability through inclusion of appropriate mitigation measures.







COOPERATING TO ENHANCE REGIONAL ENERGY SECURITY

Optimizing the use of shared water resources

Cooperative management of shared water resources is important as it brings about an atmosphere of trust, thus allowing co-riparians to maximize benefits to themselves from optimal use of common water resources, and to work towards energy security for the region. Balancing the interests of the competing sectors (hydropower, irrigation, flood, control, and environment) while optimizing power production, requires coordinated reservoir operation across the basin, and thereby affects the release policies of individual dams. Management tools – like the Nile Decision Support System that is under development – could assist in supporting this process by quantifying the benefits and trade-offs of alternative development and operation scenarios. In a setting without cooperation, there is little or no data sharing and information exchange, limited regional consultation, and no transparent or objective discussion of power options. In such a situation, the risk of interstate conflicts is high, and few international funding agencies are willing to finance power projects under such circumstances.

Regional power interconnection and power pooling

Cooperation facilitates regional power pooling

Cooperation further paves the way for integration of national power generation and transmission infrastructure, thereby increasing the economic viability of investments in the power sector and making the region more attractive for investment. The Nile Basin is the only region on the African continent without a functional regional power grid. The level of interconnection amongst Nile countries is generally unsatisfactory, with power being generated almost exclusively at national level. Bilateral power exchange agreements exist between some countries, but the volume of power exchanged is not significant, and exporting parties have frequently failed to meet their contractual obligations because of deficits in their own systems. This status quo is a major weakness, considering that the region is characterized by large asymmetries in endowment of energy resources and of demand, and has the lowest levels of electricity access and per-capita electricity consumption in the world.

NBI – a key player in the regional power sector

The Nile Basin Initiative has been working with the governments of the Nile countries and with regional bodies to foster cooperation and collaboration in addressing the multiple constraints that hamper development of the region's vast hydropower resources, and in promoting regional power interconnection and trade. Cooperation under the framework of the NBI has made it possible to mobilize considerable resources for transmission and interconnector projects whose construction commences in 2012. Besides enabling cross-border exchanges of surplus energy between member states, the

REGIONAL POWER POOL

Power pools aim to secure reliable and cheap energy provision by 'pooling' capacity and diversifying energy sources. Pooling reduces the capacity for peak loads that each individual country needs maintained, and thus lowers the overall capital investment requirements and electricity cost.

Diverse power sources combined with shared reserve capacity also diminish the need for back-up facilities to meet extreme droughts or unexpected events such as a greater-than-forecast demand for power, or delayed commission of power projects. Hence, pooling leads to cheaper and more robust electricity supplies.

A power pool requires technical infrastructure in terms of transmission grids, and institutional infrastructure that consists of agreements regarding rules of operation, payment mechanisms, and harmonized legal and regulatory frameworks.

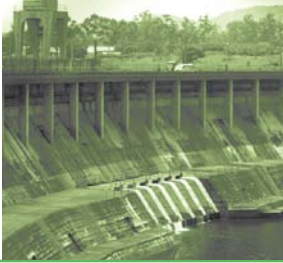
All Nile countries except Eritrea, South Sudan, and Uganda are members of the East African Power Pool. Tanzania and DR Congo also participate in the Southern African Power Pool – which is operated under the auspices of SADC – while Egypt is interconnected with the North African Power Pool.

NBI's subsidiary action program – through NELSAP and ENSAP – is leading the efforts to create regional power markets by strengthening transboundary planning, coordinating the construction of the regional transmission grid, and encouraging further integration of the regulatory and supervisory framework.

interconnectors are expected to trigger private-sector interest in the development of large hydropower options identified in DR Congo, Ethiopia, The Sudan, and Uganda to address regional energy deficits. An interconnected grid system not only allows for peak swapping of surplus power with energy deficient countries, but also results in improved quality and reliability, and a reduced price of electricity.

REGIONAL INTERCONNECTION PROJECTS

<p>Coordinated by Nile Equatorial Lakes Subsidiary Action Programme (NELSAP)</p>	<p>Bujagali–Tororo–Lessos Funded by AfDB and JICA, the 220-kV line is expected to be commissioned in 2014. The resettlement program has been completed. Procurement of contractors is ongoing in Kenya and Uganda.</p> <p>Uganda–Rwanda Interconnection Funded by AfDB and JICA, the 220-kV line is expected to be commissioned in early 2014. The resettlement program has been completed. Procurement of contractors is ongoing in Rwanda and Uganda.</p> <p>Uganda–DR Congo Funding for the feasibility study for this interconnection project was secured from Norway. The feasibility study was launched in May 2012.</p> <p>Singida–Arusha–Nairobi The technical study and Environmental and Social Impact Assessment (ESIA) for this 400-kV line are in progress and expected to be completed by October 2012. The line is expected to be commissioned in 2015.</p> <p>Rusumo–Bujumbura The feasibility study and ESIA for the 220-kV transmission line were completed in December 2010. The process of mobilizing funding for construction is ongoing.</p> <p>Rusumo–Kigali The feasibility study and ESIA for the 220-kV transmission line were completed in December 2010. The process of mobilizing funding for construction is ongoing.</p> <p>Rusumo–Nyakanazi (Tanzania) The feasibility study and ESIA for the 220-kV transmission line were completed in December 2010. The process of mobilizing funding for construction is ongoing.</p> <p>Kibuye–Gisenyi–Goma–Kigali The feasibility study and ESIA for the 220-kV transmission line are complete. Project funding has been secured from AfDB, Germany and Netherlands. Procurement of contractors is ongoing in DR Congo and Rwanda.</p> <p>Rusizi III–Bujumbura The feasibility study and ESIA for the transmission line were completed in June 2012. Project funding has been secured from AfDB. The 220-kV line is scheduled for commissioning in 2014.</p> <p>Iringa–Mbeya The feasibility study and ESIA for the 400-kV transmission line is ongoing; expected to be completed in 2012.</p>
<p>Coordinated by Eastern Nile Subsidiary Action Program (ENSAP)</p>	<p>Gondar–Gedarif This 321-km, 220-kV line and substations connects Ethiopia and The Sudan, and is currently under construction.</p> <p>Dire Dawa–Djibouti This 283-km, 220-kV line and substations connects Ethiopia and Djibouti, and is currently under construction.</p> <p>Ethiopia–The Sudan–Egypt The detailed design for a 2,220-km, AC/DC 500/±600-kV, 3,200-MW line and substations has been completed and the project is now awaiting funding/investor interest.</p>
<p>Coordinated by NELSAP and ENSAP</p>	<p>Sodo–Isinya This 1,120-km, DC ±500-kV line will connect Ethiopia and Kenya, and has been renamed the Eastern Africa Interconnector Project. It is at feasibility and design stage.</p>



TRANSMISSION LINES

2011

Capacity of transmission lines

- 600kV (DC)
- 500kV (AC)
- 500 kV (DC)
- 400kV
- 220kV
- 132kV

Status of transmission lines

- existing
- committed
- proposed

Hydropower plant

- existing
- committed
- proposed

Geothermal plant

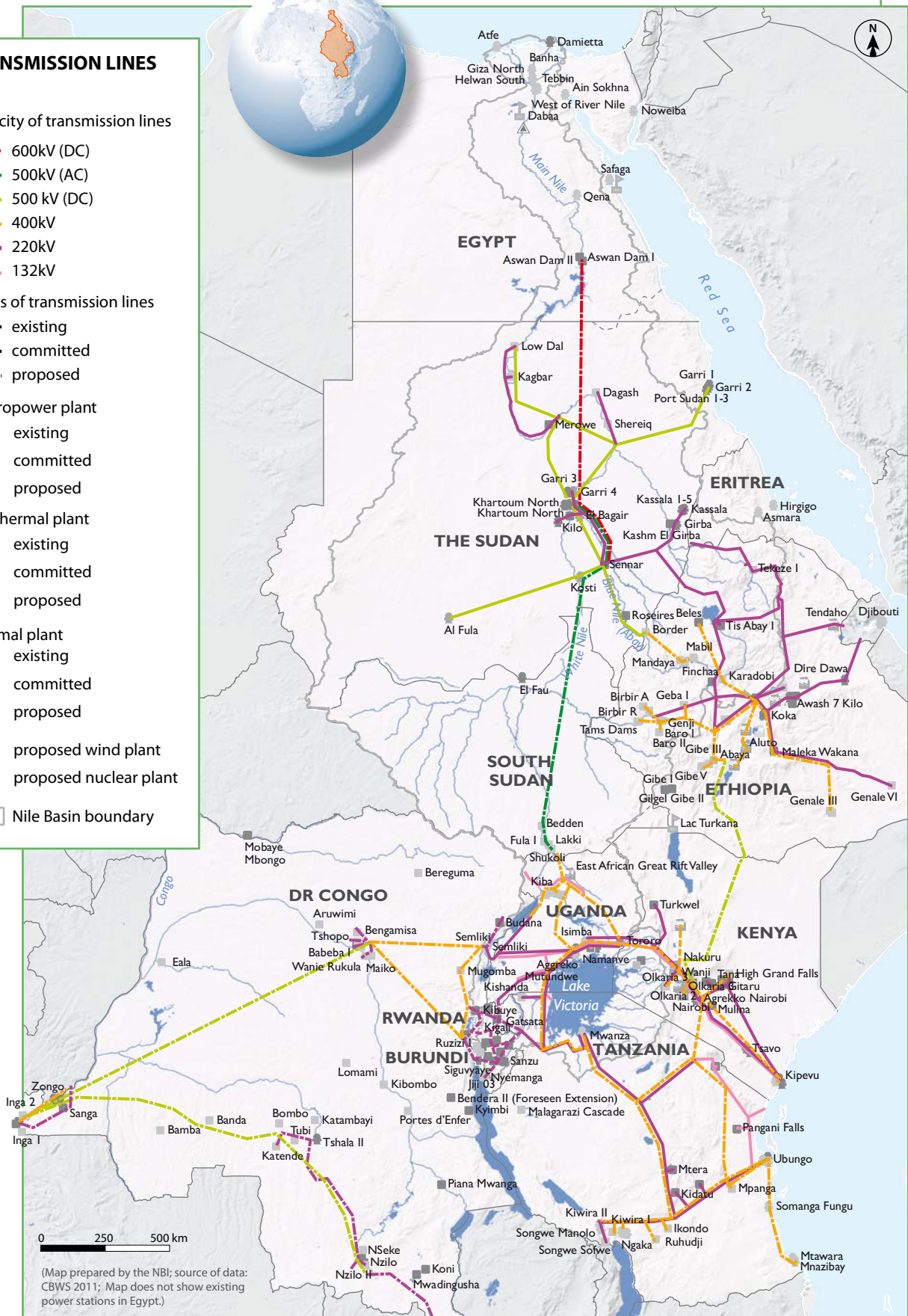
- existing
- committed
- proposed

Thermal plant

- existing
- committed
- proposed

- proposed wind plant
- proposed nuclear plant

Nile Basin boundary



(Map prepared by the NBI; source of data: CBWS 2011; Map does not show existing power stations in Egypt.)

Legal and institutional framework

From a legal and regulatory perspective, no obstacles exist to the development of a regional electricity market that allows for cross-border power trade. As a result of ongoing reforms in the energy sector in many Nile countries, the core elements of an enabling environment (i.e. policy, legal, and institutional frameworks) for regional power trade are in place – or in advanced stages of being introduced. The power sector in the region is rapidly transforming into a liberalized and regulated electricity sector with functional separation (generation, transmission, distribution, sales) and private-sector participation. Further harmonization of energy regulation amongst basin states is being discussed.

CONCLUSIONS AND RECOMMENDATIONS

The region has substantial hydropower potential, both within the Nile Basin and in adjacent river basins which, if developed, could help quench the region's power thirst. To develop the hydropower potential without harmful impacts on the environment and riparian communities, and to work towards regional energy security, the countries should:

- Continue with joint implementation and exploitation of hydropower options on shared water resources; this presents opportunities for significant reduction in project financing risks, and enhances regional cooperation and trust.
- Mainstream environmental and social management in the project life-cycle of power generation and transmission projects.
- Mainstream climate-change adaptation in the project life-cycle of power generation and transmission projects.
- Develop an integrated basin-wide water resources management and development plan that incorporates various uses of water across the basin.
- Diversify financing sources for power projects, targeting, among others, private sector and local capital markets.
- Increase interconnection between national power grids, and power trade between the countries.

