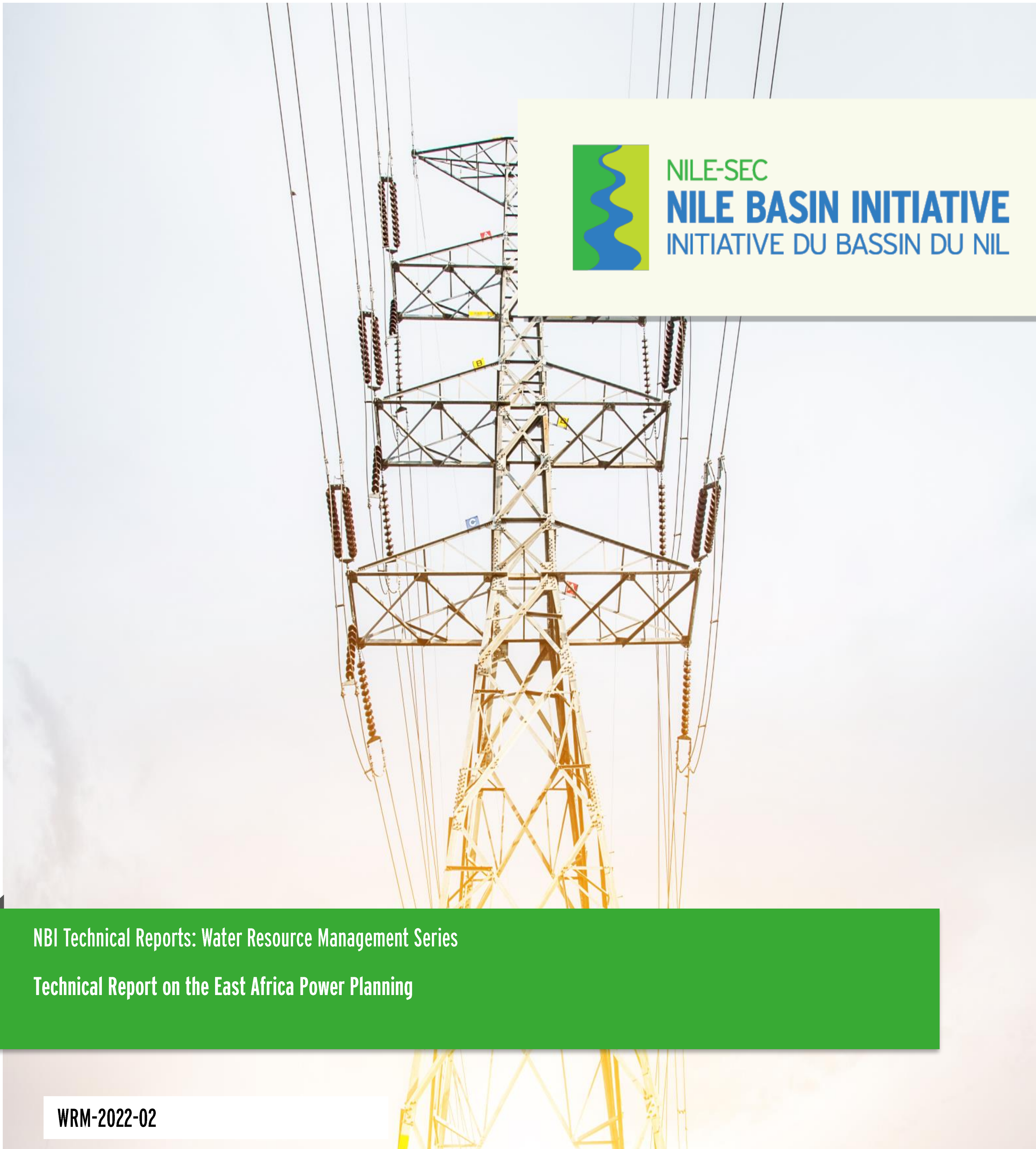

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Technical Report on the East Africa Power Planning

WRM-2022-02

EUROPEAN UNION

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The purpose of the technical report series is to support informed stakeholder dialogue and decision making in order to achieve sustainable socio-economic development through equitable utilization of, and benefit from, the shared Nile Basin water resources.

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CONTENTS

List of Tables

List of Figures

Executive summary

Currently more than 200 million people in the Nile Basin and Eastern Africa Power Pool (EAPP) countries do not have access to electricity. This is an urgent area of needed improvement as increased electricity access, built on sustainable use of natural sources, would support economic development. A low-carbon sustainable multi-resource approach, considering the interconnections between river basins, energy and other resource systems, can help achieve the Sustainable Development Goals while minimising environmental degradation.

To find synergies between sectors and countries an integrated planning and management strategy across both power systems and river basins is needed. Such a strategy could help balance techno-economic and environmental trade-offs (e.g., reliability, greenhouse gases emissions, operational costs) between sectors, regions and countries. Identifying synergies between river basins and energy systems will help achieve energy and water security in the Nile Basin and EAPP region. To this end, an up-to-date understanding of planned energy and water infrastructure developments is needed.

This report summarises proposed energy and water infrastructure development projects from the EAPP master plan, EAPP power balance statement, and Nile Basin Initiative (NBI) strategic plan including cross-border power interconnections, power purchasing agreements, and current and future hydropower developments. This background information aims to help initiate discussions and stimulate interactions between the NBI and the EAPP. Finally new integrated river-basin and energy system planning approaches and tools co-built by NBI, EAPP and the University of Manchester in the context of the FutureDAMS research project are briefly described.

1 INTRODUCTION

Energy reliability and security are essential for the economic and social development of the Eastern Africa countries. The natural resources existing in these countries could help develop and sustain a diversified portfolio of renewable energy technologies including hydropower, wind, solar, biomass, and geothermal energy.

The evolution of socio-economic conditions in the basin countries will have an important influence on energy and other demands. This evolution, although hard to predict, reflects changes in population, urbanization, and overall economic development, all of which increase demand due to their connection to living standards" (Jeuland, 2019). Sustainable economic development needs access to reliable and clean electricity. The population of the 11 Nile basin countries is projected to grow from 556 million (2020) to 1,044 million by 2050 and urbanisation rates will continue to grow rapidly (see Figure 1).

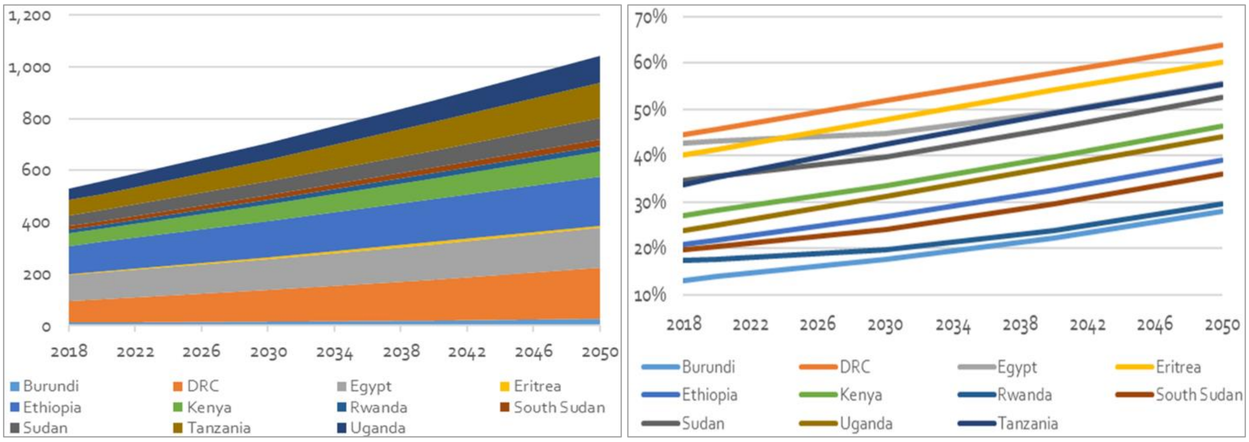
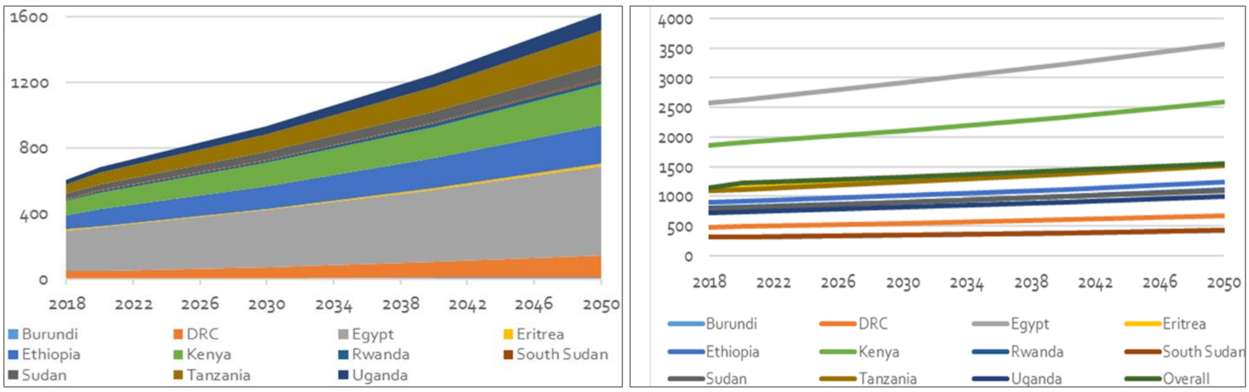


Figure 1: Projected Population growth (left) and rates of urbanisation by country (Source: UN Population DIvision)[1]

Even at the median rate, GDP is projected to grow relatively fast as shown in .Figure 2 which shows both projected growth by country and by per capita (by country).



.Figure 2: Projected growth in GDP by country and per capita[2]

[1] The graphs shown the median projected growth rates

[2] The graphs shown the median projected growth rates based on the historical growth rate of the median growth country

Population growth, urbanisation and economic growth will drive an increase in demand for electricity and so also sustainable economic development needs access to reliable and clean electricity.

As shown in Table 1, more than 200 million people currently do not have access to electricity in the Nile Basin and the Eastern Africa Power Pool countries. Moreover, the grid in some areas has low reliability, resulting in frequent electrical service interruptions. In addition to economic development, the growing population and the need for rural electrification will drive energy infrastructure development in East Africa.

Exploiting synergies between different resources, in particular between river basins and energy systems, will be essential for achieving sustainable energy security in East Africa. Thus, energy sector development should be planned considering a range of renewable technologies as well as the interactions between sectors and countries, which presents a complex challenge.

EAPP reports that electricity demand forecasts for EAPP countries depend primarily on expanding electricity access, infrastructure and industrial development (EAPP, 2020). Table 1 summarises 2020 energy demands, their annual growth, and forecasts for 2030 demands (EAPP, 2020). Based on the EAPP forecasts summarised in Figure 1, energy demand is estimated to grow from 318 TWh in 2020 to 526 TWh by 2030 (65% increase). In terms of peak demand, EAPP projects an increase from 54 GW in 2020 to 90 GW by 2030 (67% increase) (EAPP, 2020). To cater for the significant expected growth, cost-effective strategies covering grid expansion, the development of mini-grids based on distributed renewable energy projects, and standalone systems are needed to increase electricity access.

Conventional power stations are currently the most widely used technologies in Eastern Africa Power Pool countries (65.4 GW installed capacity in 2020), with 93% of this capacity located in Egypt and Libya. As shown in Figure 2, hydropower is also a major electricity source in several EAPP countries. In 2020 hydropower capacity represented 16% of the total installed power generation capacity in the EAPP, reaching 13.4 GW, with 45% of hydropower capacity located in Sudan and Ethiopia. Thermal electricity generation is predominant in the northern part of EAPP, hydropower in the centre and a mix of both is used in the south (IEA, 2019). Using the PyEnSyS, Python Energy System Simulator software developed by The University of Manchester under the FutureDAMS project (FutureDAMS, 2021), it was estimated that the 2020 energy supply portfolio of the EAPP included approximately 73% from fossil-fuelled power stations, 24% from hydropower, and 3% from other renewable power technologies (e.g., solar, wind, and geothermal).

Table 1: Population and electricity access of the EAPP member countries. Source: United Nations (2019). Energy demand forecast 2030. Source: EAPP power balance statement report (2020). Annual energy demand and forecast for Djibouti, and South Sudan were obtained from public data sets (ourworldindata.org, Taliotis et al. (2016)).

Country	**Population**	**Access to electricity**	**People without electricity access**	**Annual Energy demand 2020**	**Estimated annual growth 2020-2030**	**Annual Energy demand forecast 2030**
	Million	**%**	**Million**	**GWh**	**%**	**GWh**
Burundi	11.2	11	10.0	357	5.7	624
Djibouti	1	61	0.4	377	2	460
DRC	84.1	19	68.1	1,256	3.4	1,754
Egypt	98.4	100	0.0	194,794	3.4	273,249
Ethiopia	109.2	48	56.8	20,972	10	54,168
Kenya	51.4	70	15.4	12,203	5.8	21,414
Libya	6.7	69	2.1	44,606	7	87,747
Rwanda	12.3	38	7.6	960	10	2,489
Somalia	15	36	9.6	315	7.1	625
South Sudan	11	7	10.2	392	5	639
Sudan	41.8	54	19.2	24,496	4.9	39,482
Tanzania	56.3	38	34.9	13,430	10.4	36,000
Uganda	42.7	41	25.2	5510	4.6	8,646
Total	529.4	52%	251.6	319,707	5.1	527,436

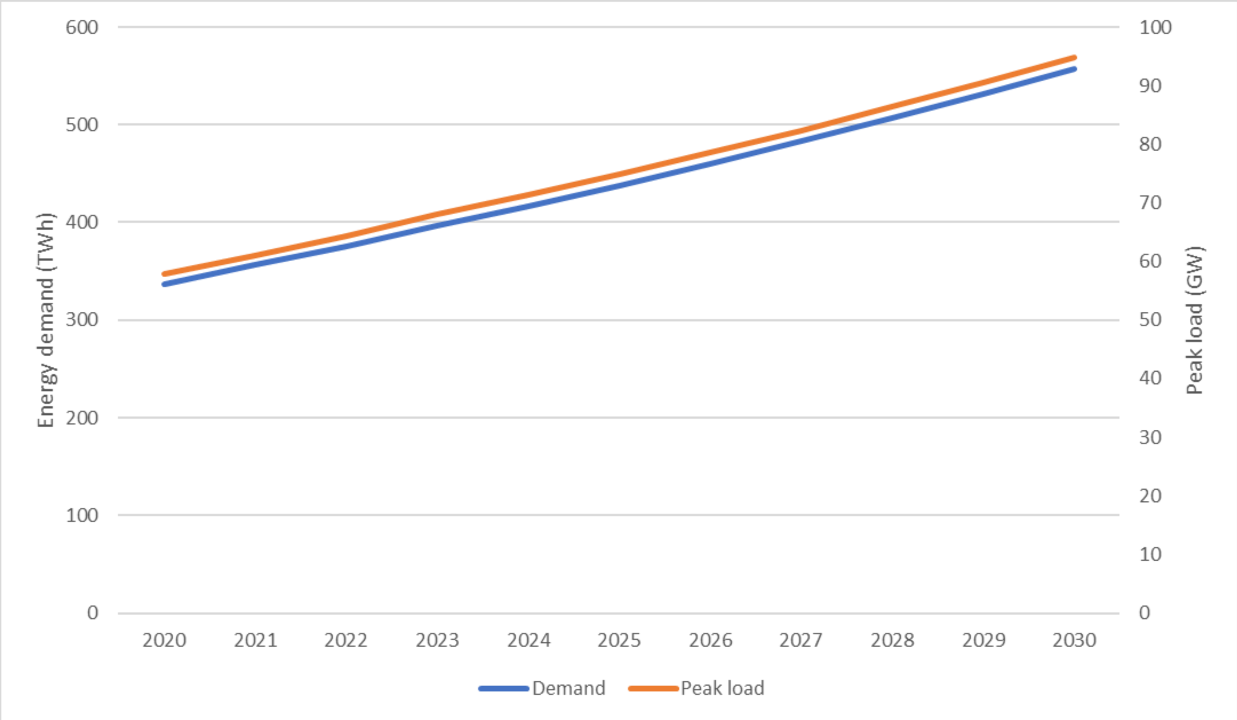


Figure 3: Energy demand forecast for EAPP countries. Source: EAPP power balance statement report (2020)

Figure 4 shows hydropower capacity planned until 2030. Contrary to non-conventional renewable resources such as wind and solar, hydropower offers a high degree of flexibility as, subject to water availability (e.g., in a dam), it can dispatch power when needed. Hence, hydropower can support the large deployment of intermittent solar PV and wind power plants expected during the next few years (IEA, 2019). In this context, EAPP reports that a number of renewable projects under development (i.e., under construction and financing secured) will increase the installed capacity of solar PV from 1,500 MW in 2020 to 3,500 MW by 2030 (EAPP, 2020); in addition, there are 21,600 MW of PV capacity under study across EAPP countries. According to EAPP, Ethiopia and Kenya will develop 994 MW and 1,106 MW in wind projects, respectively, and Kenya has plans to increase its installed capacity of geothermal power stations from 780 MW to 2,850 MW by 2030 (EAPP, 2020).

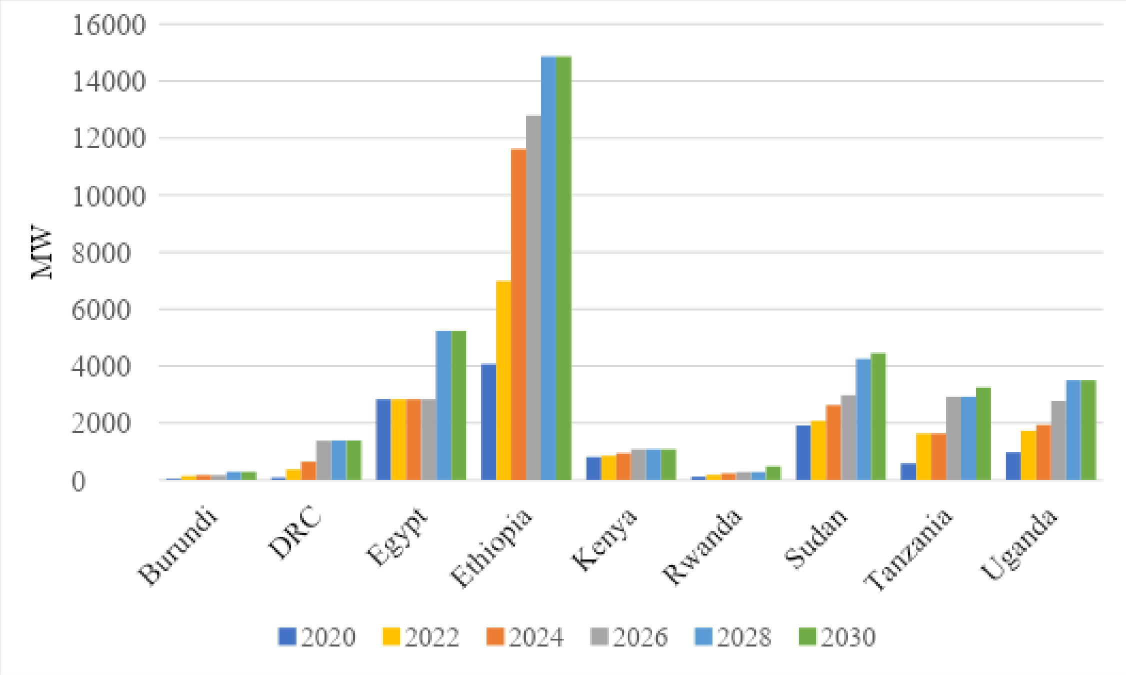


Figure 4: Existing and planned installed hydropower capacity in some countries in the EAPP 2020 - 2030. Source: Input data used in the EAPP power balance statement report (2020).

There will be a likely increase in average temperatures and intensity and frequency of extreme weather events associated with heatwaves, floods and droughts due to future long-term climate change in the Nile Basin and Eastern Africa Power Pool countries (IPCC, 2014). The increase in average and extreme temperatures would stimulate the use of cooling systems in the region, thereby accelerating growth in water and electricity demand. Analysing the impact of extreme events (heatwaves, floods and droughts) on the energy and water systems of the Nile and the interactions between power conversion, transmission capacity, power demand, water availability and water demand will be instrumental. Additionally, extreme hydrological events would affect the operation of hydropower facilities constructed in cascades along the Nile. Such studies will improve the water-energy system's resilience and help devise climate change adaptation strategies.

The Nile basin area covers over one-tenth of Africa and is geographically shared by eleven countries (see Figure A1 in Annex). The White Nile, the Blue Nile, and the Tekeze-Atbara are the three main tributaries of the Nile with a mean annual contribution to the river's streamflow of around 30%, 57%, and 13%, respectively, as measured near the Sudanese-Egyptian border. The basin is characterised by strong spatial and temporal variabilities in the availability of water resources; these vary strongly year to year. River flow is highly seasonal with extreme floods and droughts causing loss of lives and property (NBI, 2010). Water demand is rapidly growing due to population and economic growth.

The Nile Basin has a hydropower generation potential exceeding 20 GW, with existing hydropower accounting for 19% of potential capacity and in 2022 this figure is expected to reach 41% (NBI, 2020). Hydropower assets have long economic lifetimes and relatively low cost per unit of energy produced. However, the disparity in the spatial and temporal availability and variability of water resources continues to be a source of dispute in the region. Tackling this issue requires coordinated planning between water and energy systems. Regional institutions responsible for coordinating and developing water and energy should consider the nexus between river basins and energy systems.

The NBI and the EAPP are the two main regional institutions established to help foster a collaborative regional approach to managing water and energy resources of the Nile Basin and East Africa. Figure A1 (in Annex 6.1) shows existing and some proposed water and energy infrastructures in the Nile Basin and EAPP region. Except for Libya and Djibouti, all the EAPP member countries are Nile Basin riparian. The NBI was established in 1999 with a vision "To achieve sustainable socio-economic development through equitable utilisation of and benefit from the shared Nile Basin water resources" (NBI, 2017). The EAPP was founded in 2005 by seven East African countries (Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Rwanda, and Sudan) with the ultimate goal of creating a regional electricity market. Libya, Tanzania, Uganda, and Djibouti joined the EAPP later; South Sudan is the latest country to join EAPP in 2021, and Somalia is expected to become a member soon. EAPP also has 15 member power utilities working across the countries. EAPP's vision is:

- To transform the Eastern part of Africa into a region of communities and businesses with universal access to reliable and affordable modern energy services based on sustainable resources.
- To transform the Eastern part of Africa into a region recognised as one of the best investment destinations in the world by energy intensive users.

EAPP highlights that large-scale projects across EAPP countries (especially hydropower stations) will require large investments in regional electricity interconnectors for them to become financially feasible (EAPP, 2020). Figure 5 shows existing (2020) and proposed (2025) cross-country interconnections between EAPP current and expected member countries. Note the width of the red and purple coloured lines indicate the relative capacity of power transmission, with the thickest and thinnest lines corresponding to 1200 MW and 4 MW respectively). Source (EAPP (2020) and NBI Investment Projects Database). Table A3 in the annexes provides more detail.

Power trade between countries could improve water and energy security throughout Eastern African countries and maximise the power conversion from renewable energy sources. Table 2 summarises existing and proposed power purchasing agreements, transmission line capacity, and the volume of energy traded in 2020 in the EAPP region.

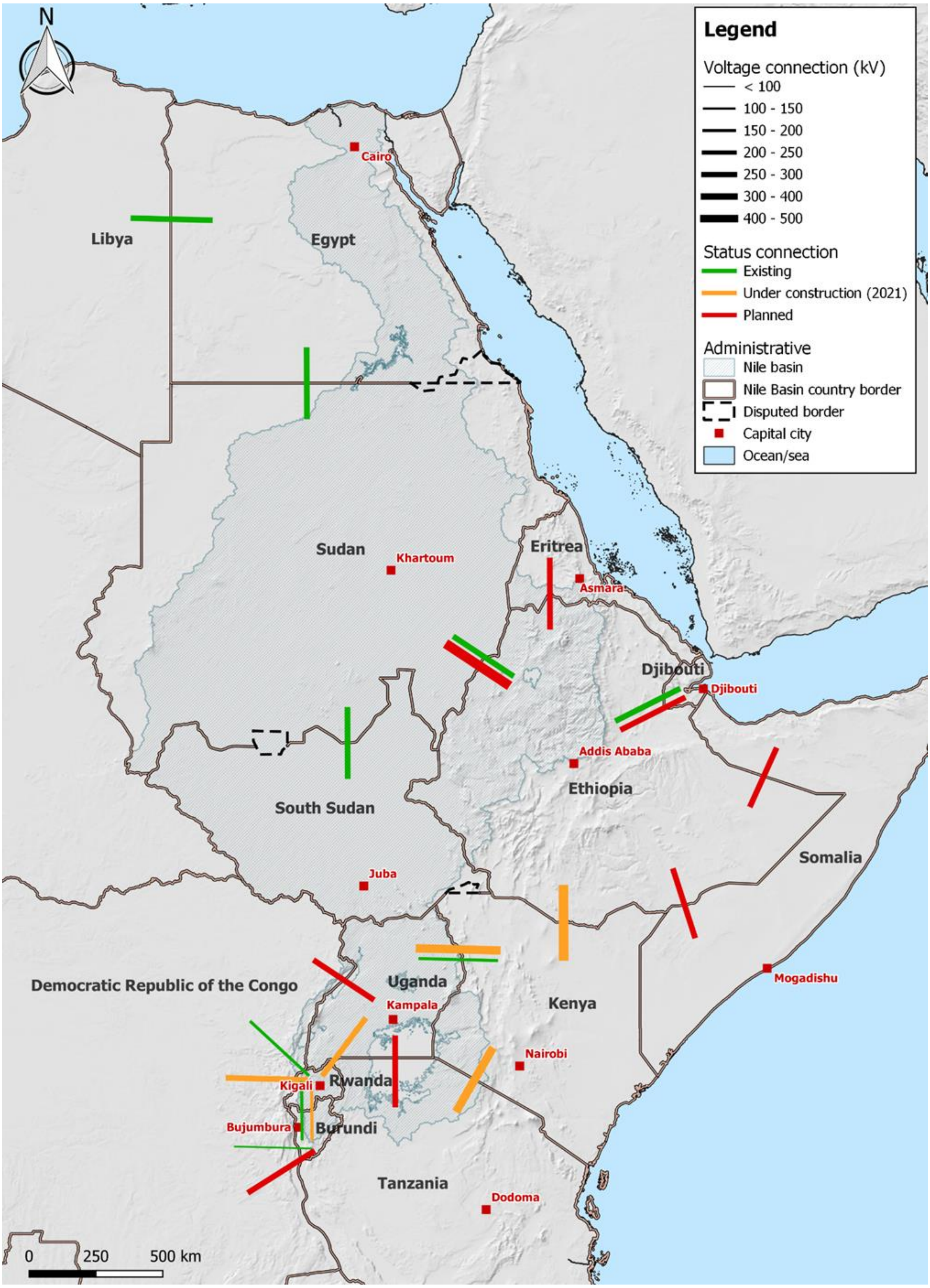


Figure 5: Existing and future cross-border transmission between EAPP member countries.

Table 2: Existing and proposed power purchasing agreements in the EAPP region. Note: data sources for the "Firm power" column is shown in the footnotes.

Countries	Status	Transmission line capacity (MW) (EAPP 2020)	Firm power (MW)	Total energy exchanged (MWh) in 2020 (EAPP 2020)
Ethiopia – Djibouti	Existing	180	100[3]	__
Ethiopia – Sudan	Existing	200	100[4]	955178
Egypt – Sudan	Existing	80	__	148138
Kenya – Uganda	Existing	70	__	132000 (Imported) 16518 (Exported)
Egypt – Libya	Existing	240	__	655818
Ethiopia – Djibouti (Upgrade)	Proposed	__	220[5]	
Ethiopia – Kenya	Proposed	2000	400[6]	

This report builds on NBI and EAPP planning processes and research projects such as FutureDAMS. We aim to achieve two objectives in this report:

- Review and summarise updated information about current and future cross-country interconnection and hydropower development and power purchasing agreements.
- Provide a summary of the EAPP and NBI master/strategic plans and give background information to initiate discussions and stimulate interactions between NBI and EAPP.

The rest of this report is structured as follows: section two summarizes the EAPP's master plan and NBI's strategic plan. Section three lists hydropower and cross-border and within country interconnections under the EAPP and NBI plans. Section four introduces water-energy analysis tools developed in FutureDAMS that enable assessing or optimising future water, energy or water-energy interventions.

[3] (African Development Bank Group, 2021)
[4] (The World Bank, 2019)
[5] (The World Bank, 2019)
[6] (African Development Fund, 2012)

2 FUTURE REGIONAL PLANS

2.1 EAPP MASTER PLAN AND POWER BALANCE STUDY

This section summarises information obtained from the following EAPP reports:

- EAPP (2014), EAPP Master Plan 2014. Eastern Africa Power Pool.
- EAPP (2020), Power Balance Statement. Eastern Africa Power Pool.

According to EAPP, there are natural gas reserves in several countries including Libya, Egypt, Tanzania, Ethiopia, DRC and Rwanda that can support industrial development (EAPP, 2014). In this context, IEA states that conventional power technologies based on natural gas will provide the system flexibility (e.g., correcting imbalances between generation and demand) needed to integrate with distributed renewable power technologies and increase the affordability and reliability of clean energy systems (IEA, 2019). Nevertheless, the development of gas infrastructure (refining and distribution networks) will require high investment to be available in domestic markets (IEA, 2019). The use of natural gas will also contribute to the displacement of diesel or heavy oil products in Egypt and Libya in the coming decades. Diesel and heavy oil emit higher amounts of greenhouse gases than natural gas, and are more expensive fuels. Hence, natural gas could help the transition to greener economies by supporting and complementing hydropower stations and renewable sources such as wind and solar.

Figure 7 shows the photovoltaic (PV) power potential for Africa, highlighting that Northern Africa has an excellent solar resource and a large potential for solar PV development. According to IEA, there will be a large deployment of solar PV power plants in EAPP countries during the next decade (IEA, 2019). In this context, EAPP reports that a number of solar PV projects under development (under construction and financing secured) will increase the installed capacity from 1,500 MW to 3,500 MW by 2030; in addition, there are 21,600 MW PV under study across EAPP countries, with 17,600 MW in Egypt (EAPP, 2020). A recent study revealed that repurposing the operations of large hydropower (e.g. the Grand Ethiopia Renaissance Dam) could help integrate variable renewable energy and retain the natural flow pattern of the Blue Nile flow (Sterl, 2021). EAPP also informs that Ethiopia and Kenya will develop 994 MW and 1,106 MW in wind projects, respectively, and that Kenya has plans to increase its installed capacity of geothermal power stations from 780 MW (2020) to 2,850 MW by 2030.

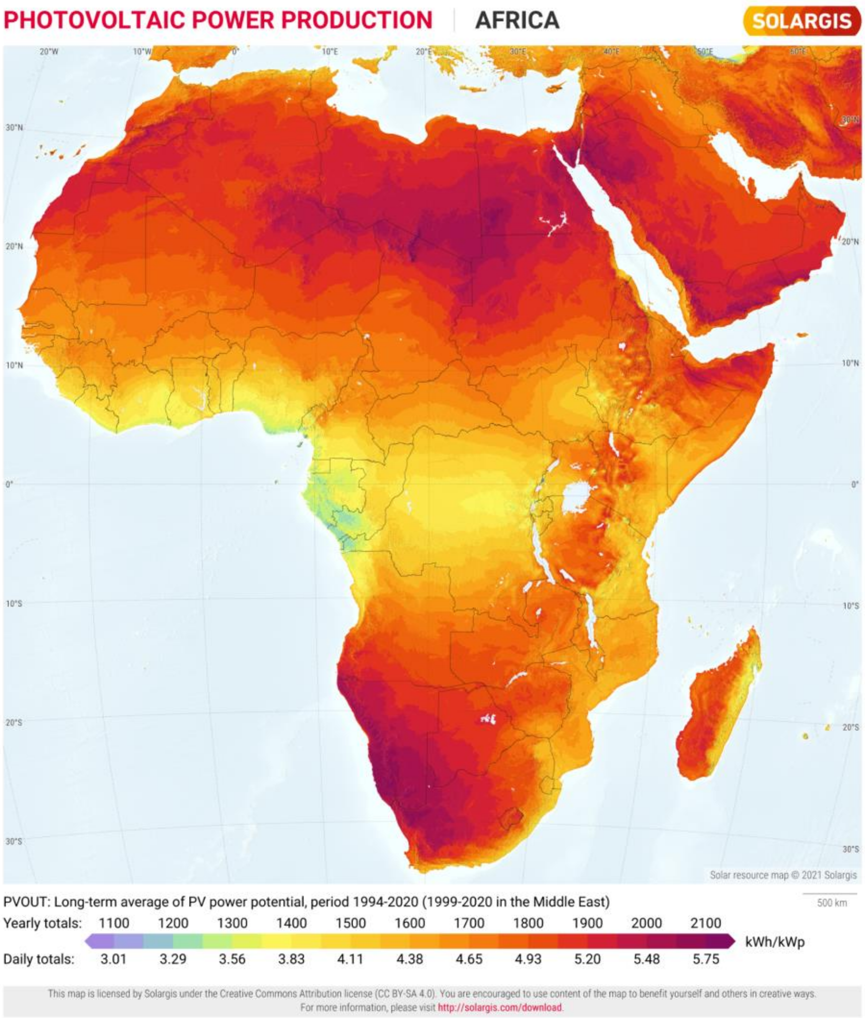


Figure 6: Photovoltaic power potential African countries. Source: Solar resource map 2021, Solargis. https://solargis.com

According to EAPP, large-scale projects under study across Eastern Africa countries (e.g., solar PV, wind, hydropower stations) will require regional coordination, where electricity interconnectors between countries and the development of regional electricity markets will be crucial (EAPP, 2020). EAPP highlights that some large-scale projects (especially hydropower) will require regional integration to become financially feasible. Hence, the future power system will require investment in transmission and distribution networks.

Box 1: High level summary of EAPP master plan and 2020 power balance statement.

- Planned expansion of variable renewable energy generation in EAPP is expected to see a growth in installed capacity from 4 GW in 2020 to 29 GW in 2030 (PV: 25 GW, Wind: 4 GW).
- According to the EAPP power balance statement, considering existing projects only (generation and transmission), there is a potential electricity supply deficit in 2021 for the DRC, Ethiopia, Libya, Rwanda, Sudan and Tanzania. For the DRC, Libya, Sudan and Tanzania, the deficits during peak demand are all in the range from 1,000 to 1,500 MW. For instance, Libya's deficit is estimated at 1,334 MW (while Libya’s peak demand is 8,815 MW); Sudan's deficit: 1,479 MW (Sudan total peak demand: 5,351 MW); Tanzania’s deficit: 1,080 MW (Tanzania total peak demand: 2,484 MW).
- Then, according to the EAPP power balance statement, even when considering projects currently under construction, there are six countries that will have significant electricity deficits. These countries are DRC, Kenya, Libya, Rwanda, Tanzania and Sudan. Nevertheless, EAPP highlights that the power demand deficit can be reduced via imports from neighbours' countries.

Currently, conventional power stations (principally combined cycle gas turbines, open-cycle gas turbines, and steam turbines) are the most widely used technologies in EAPP countries, reaching 65.4 GW installed capacity in 2020. Figure 7 illustrates the installed capacity segmented by technology in the current EAPP member countries. From the total installed conventional power technologies, 75% is located in Egypt and Libya, highlighting the regional differences where fossil fuels are predominant in the north, hydropower in the centre and a mix of both in the south.

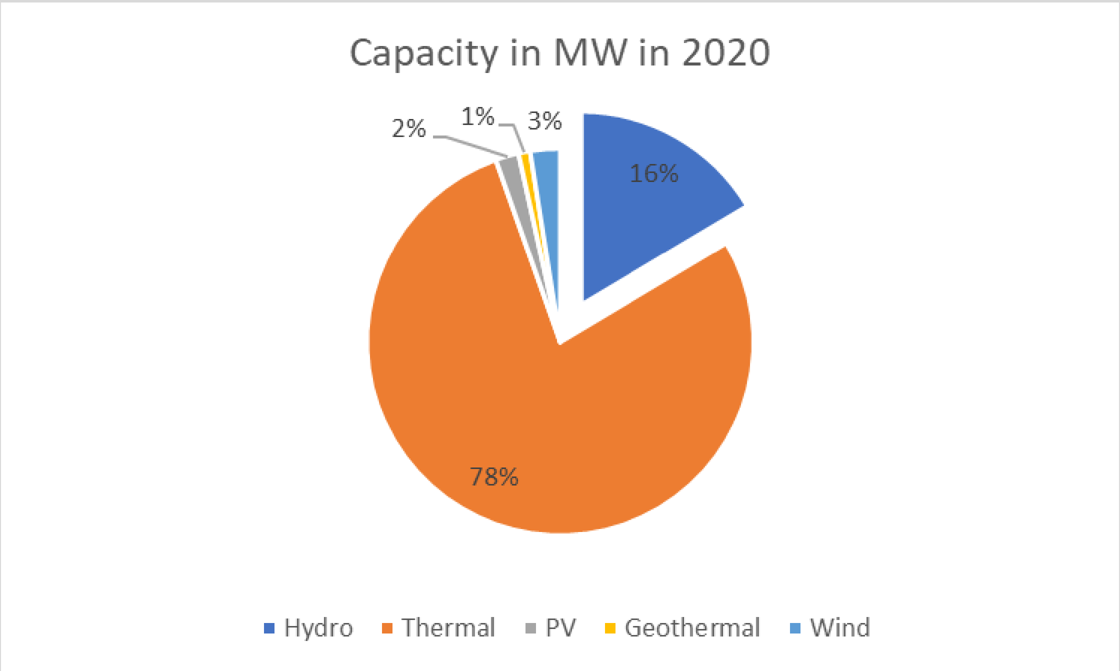


Figure 7: Current installed capacity by country and technology. Source: EAPP, 2020.

Figure 8 summarises the estimated annual generation mix using four representative days. As shown in the rightmost bar "Total EAPP", the electricity generation from fossil-fuelled power stations reached almost 73% of the overall electricity generation mix in EAPP countries during 2020, followed by 24% from hydropower stations, and 3% from renewable technologies (wind, solar, geothermal).

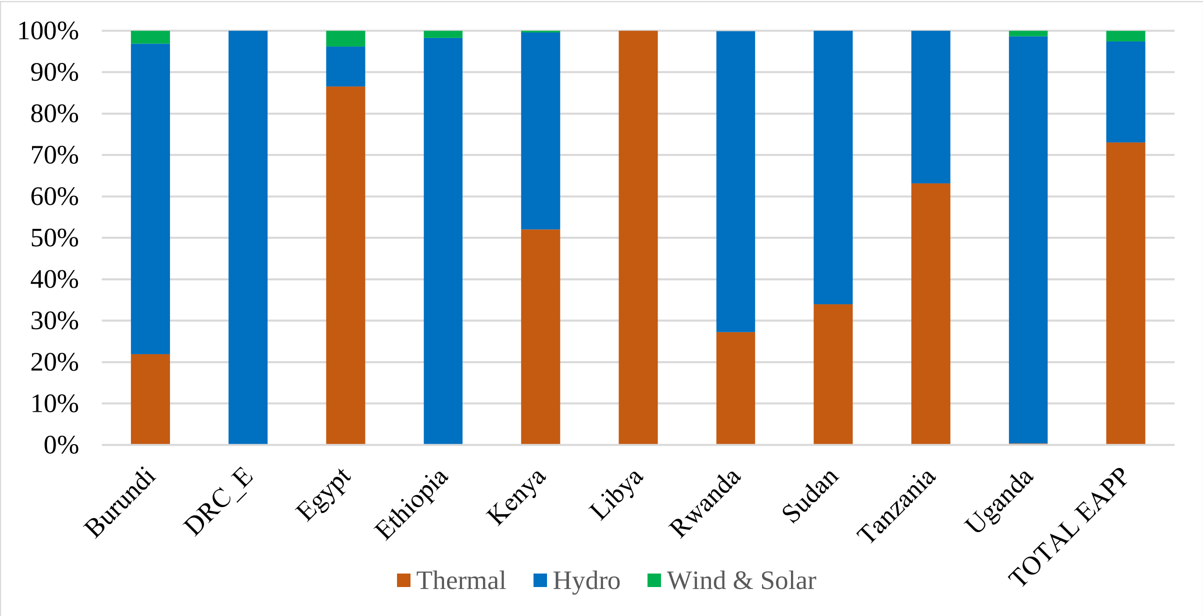


Figure 8: Estimated generation mix in EAPP countries, and Total EAPP. Source: University of Manchester estimation by running 4 representative days in PyEnSyS (Python Energy Systems Simulator), FutureDAMS (2021).

The difference in the dominant technologies between the north (fossil fuels) and the south (hydropower) creates a motivation for regional power exchange (EAPP, 2020). Coordinated operation could exploit synergies by maximising production from renewable energy technologies while minimising marginal operational costs and greenhouse gases emissions. Besides, extensive regional interconnections will improve the security of supply throughout all EAPP countries. The expansion of solar and wind power plants, where EAPP estimates an increase from 4 GW in 2020 to 29 GW by 2030, would increase the benefits and incentives to expand the cross-border transmission systems between countries (EAPP, 2020). Table 3 summarises the existing (2020) and planned (2025) cross-border transmission capacity between EAPP countries (EAPP, 2020).

The EAPP Power balance statement 2020 optimises the net transfer capacity values between countries by reducing national power supply deficits (generation capacity minus demand), under different levels of coordination (power exchange between countries) and considers demand forecast, estimations in power capacity by technologies, as well as the uncertainty in the development and commission of future generation and transmission projects. (EAPP, 2020). Table 3 shows a snapshot of the total expected installed capacity for 2020, 2025, and 2030, of the projects considered in the Power balance statement study. EAPP highlights that the study is an important step in analysing the security of supply under different scenarios.

Table 3: Existing (2020) and planned (2025) cross-border transmission capacity within the EAPP, in MW. Source: EAPP Power balance statement 2020. Note that the capacity is the maximum transfer capacity during safe operation (Net transfer capacity, NTC).

Interconnection (MW)	Year	Burundi	DRC-East	Egypt	Ethiopia	Kenya	Libya	Rwanda	Sudan	Tanzania	Uganda
Burundi	2020		4								
	2025		53					27			
DRC-East	2020	4						4			
	2025	53						104			140
Egypt	2020						240		80		
	2025						240		300		
Ethiopia	2020								200		
	2025					1100			1200		
Kenya	2020										70
	2025				1100					500	370
Libya	2020			240							
	2025			240							
Rwanda	2020		4								5
	2025	27	104								357
Sudan	2020			80	200						
	2025			80	1200						
Tanzania	2020										
	2025					500					279
Uganda	2020										
	2025		140			300		347		279	

In order to assess probability of realisation of the starting operation of the projects evaluated, the EAPP Power balance statement 2020 divides the future generation and transmission projects into 4 different categories:

1. Construction started
2. Finance secured, and construction expected to start in a specific year
3. Specific candidate project, location and design determined
4. General candidate project

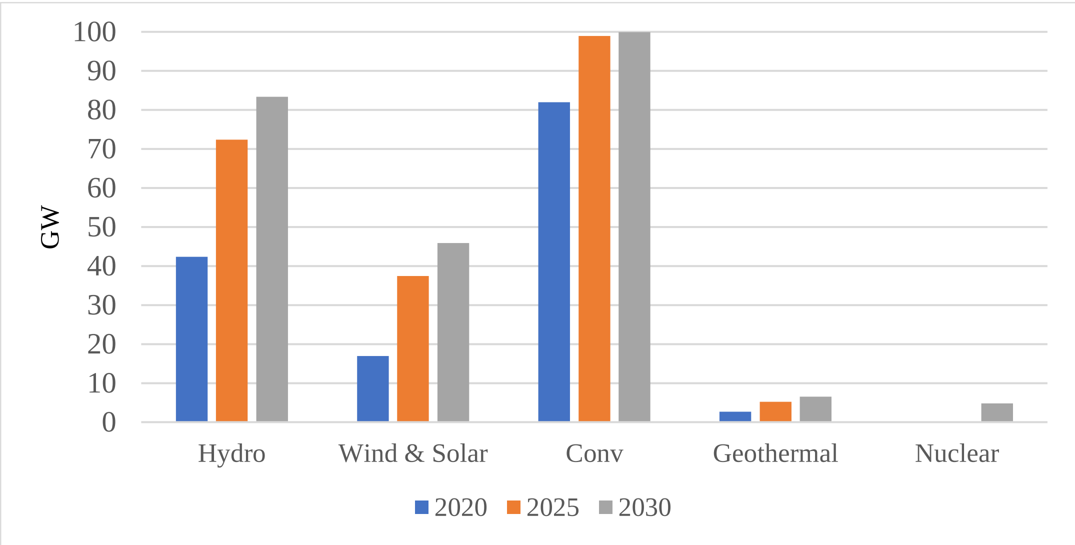


Figure 9: Current and future installed capacity in EAPP by technology. Source: Input data used in the EAPP power balance statement report (2020)

Power balance without power exchanges between countries

In the EAPP Power balance statement, the short-term data (2021-2022) shows that even if there is no power exchange between countries, Egypt and Uganda can cover the forecasted demand growth with their current installed capacity. For other countries like Burundi, Ethiopia, Kenya, Libya, Rwanda, and Tanzania, avoiding energy curtailment requires inaugurating category 1 projects (projects under construction where the operation should start on time). Sudan should depend on both category 1 and category 2 projects (category 2 are projects with secured finance, but the construction is expected to start in a specific year). Finally, DRC cannot meet peak demand even when all categories are included; this means that the security of supply for DRC is not possible to cover without power exchange with other countries.

For the years 2023-2027, the EAPP Power balance statement reports that DRC will continue facing challenges in the security of supply if power exchange from other countries is not available. Finally, in the last years of the study (2027-2030), all nations could meet the demand by including category 3 projects, i.e. specific candidate projects that operate from 2027 (EAPP, 2020).

Table 4 summarises the total capacity deficit during peak demand hours for the whole EAPP by 2030. For 2030, EAPP Power balance statement (2020) estimates a total peak demand of 94.8 GW.

Table 4: Total capacity deficit, without power exchanges between countries. Total peak demand by 2030: 94.8 GW. Source: EAPP Power balance statement (2020).

Projects	Total capacity deficit (GW) by 2030
Existing projects	29
Construction started	11
Finance secured	7.5
Specific candidate project	0.2
General candidate project	0

Power balance with power exchanges between countries

When only existing projects are considered, Libya, Sudan, Ethiopia, DRC, Rwanda and Tanzania would have power demand curtailment in the short term without power exchange (see Table 5). Then, when power exchanges are considered, Egypt can help reduce some deficits in Libya and Sudan. In other countries, since neighbours have no surplus capacity, there is no power available for exchange. Finally, when including category 1 projects (currently under construction), Sudan's power deficit can be reduced by more than 50%.

In the medium term (2025), Sudan and DRC would face challenges in securing power supply during peak hours even when including projects under construction. Nevertheless, the curtailment level for Sudan will be 45% of the original value calculated without interconnections.

Finally, by 2030, and considering category 1, 2, and 3 projects, the following table provides a high-level summary of the countries facing power capacity deficits and compare them without and with power exchange:

Table 5: Total capacity deficit by country, considering category 1, 2, and 3 projects. Source: EAPP Power balance statement (2020).

Country	Total peak demand (MW) by 2030	Total capacity deficit (MW) by 2030	
		Without power exchange	With power exchange
DRC	5,495	558	150
Kenya	3,540	1,340	100
Libya	16,207	3,493	3,253
Rwanda	415	78	0
Sudan	7,706	904	404
Tanzania	5,870	955	885

In conclusion, **EAPP highlights the need to accelerate the development of generation and transmission projects** to minimise potential challenges in power security. In addition, projects in category 4 (general candidate project) should be pushed forward to avoid power supply issues in DRC, Kenya, Libya, Sudan and Tanzania (EAPP, 2020).

2.2 NBI Strategic Plans

The NBI prepared a ten-year strategic plan for the period 2017-2027. This strategic plan is a way to implement NBI's shared vision through six strategic priorities: water security, energy security, food security, environmental sustainability, climate change adaptation, and strengthening transboundary water governance. The six strategic priorities are aligned with and shaped by regional and global development goals such as the African Union Agenda 2063 and the UN Sustainable Development Goals (SDGs). Hereafter, the six strategic priorities, emphasising their nexus with water energy are summarised.

Water security

The NBI strategy for water security focuses on: (i) enhancing availability and sustainable management of the transboundary Nile water resources through identifying and preparing investment projects to increase storage capacity in the basin; (ii) supporting the improvement of water use efficiency in major water-use sectors; (iii) strengthening river basin monitoring and analysis of data from monitoring networks; (iv) promoting conjunctive use of surface and groundwater resources; (v) improving preparedness to flooding and drought risks is Nile sub-basins.

Energy security

The cross-country interconnection will reduce the cost of electricity, exploiting different energy generation resources due to climate variability across the Nile Basin and difference in hourly and seasonal demand variability. According to NBI strategic plan, reducing costly system redundancy could lead to a direct saving of nearly US$ 22 million per annum and an increase in annual GDP of nearly US$ 21 billion in the Nile Basin. The Strategic Plan will improve energy security through investments focused on increasing hydropower production, availability and accessibility. The focus is on two main areas, the development of hydropower and increasing the level of interconnection both between and within countries (Table 7). So far, the NBI/NELSAP were involved in conducting a number of power interconnection feasibility studies, interconnection & hydropower projects (Table 6).

Table 6: Power interconnection feasibility studies, interconnection & hydropower projects by NBI/NELSAP.

Project	Implementation stage
Uganda (Olwiyo) – South Sudan (Juba)	on-going
Kenya-Uganda-Rwanda-Burundi and DRC Interconnection of Electric Grids feasibility studies	completed
Coordination implementation of NEL interconnection project connecting 5 countries (6 interconnection lines, 927km network with 17 sub stations)	on-going
Rusumo Falls hydroelectric project 80MW on behalf of 3 countries (Rwanda, Tanzania, Burundi)	on-going
Power studies funded by European Union through Africa Development Bank to ensure commissioning initial trading	completed
Tanzania (Mbeya) – Zambia (Kabwe) 730km power interconnection Feasibility studies	completed
Regional Rusumo Falls Hydroelectric and Multipurpose Project- project preparation	completed
Uganda (Nkenda) - DR Congo (Beni-Bunia-Butembo) Power Transmission Line Study	completed
Tanzania (Iringa-Mbeya) interconnection feasibility study	completed
Kenya–Tanzania Power Interconnection Project	completed

Food security

Improving food security by increasing the efficiency of agricultural water use, modernising and developing new irrigation schemes, improving the rainfed farming sector by rehabilitation of watersheds, improving sustainable fisheries and aquaculture production, and improving inland navigability to develop transport corridors with minimal impact on watersheds. To meet these targets, NBI will introduce and promote an analytical framework and approach that examines and proposes options for addressing the water-food nexus in the Nile Basin.

Table 7: NELSAP Strategic direction and actions for energy security (source: NELSAP strategic plan document).

NELSAP SP Specific Objective 2: Improve energy security through on-the-ground investments for increased hydropower production, availability and accessibility.		
Outcomes	**Outputs**	**Strategic Actions**
Strategic Direction 2.1: Increase hydropower production		
Outcome 2.1: The hydropower production in the NEL region has increased.	Output 2.1.1: New hydropower development projects are identified and developed.	• Strategic Action 2.1.1.1: Identify and prepare hydropower development projects • Strategic Action 2.1.1.2: Develop new hydropower development projects
Strategic Direction 2.2: Increase interconnection of hydro-power grids and trade		
Outcome 2.2: Availability, accessibility and stability of power has increased; losses and costs have reduced	Output 2.2.1: New projects in power transmission, interconnection and trade are identified and developed.	• Strategic Action 2.2.1.1: Identify and prepare power transmission, interconnection and trade projects. • Strategic Action 2.2.1.2: Support countries in the implementation of power transmission, interconnection and trade projects.
	Output 2.2.2: Capacity for systems management and operation is strengthened.	• Strategic Action 2.2.2.1: Develop guidelines for systems management and operation.

Environmental sustainability

In this theme, the NBI will conduct diagnostic studies and prepare inventories to promote the effective use and sustainable management of wetlands of transboundary significance. NBI will also support environmental flow assessments for critical river and lake ecosystems, support partner states in establishing and operating a strategic network of water quality monitoring stations, and identify and prepare projects to restore degraded watersheds and wetlands.

Climate change adaptation

The NBI plans to conduct climate vulnerability assessments for major water systems and water use sectors in the Nile Basin; generate water availability estimations under different climate change scenarios; prepare short-term to seasonal river flow forecasts to support operational water resources management; support harmonisation of climate change policies of the Partner States; and build the capacity of NBI centres and Member States in areas of global climate finance.

Strengthening transboundary water governance

The last goal of the strategy addresses the issue of transboundary water governance. This goal focuses on building the capacity for efficient operation of the three NBI Centres; facilitating meetings and other activities of NBI's governance bodies; raising funds for Nile cooperation; building the capacity of the transboundary water units of the Member States; organising multi-stakeholder dialogue events to deliberate on issues of Nile cooperation and the management and development of the shared Nile water resources; preparing and disseminating NBI information and knowledge products; and forging strategic partnerships with other regional intergovernmental institutions such as Intergovernmental Authority on Development and East African Community/Laker Victoria Basin Commission.

3 HYDROPOWER AND INTERCONNECTION PROJECTS UNDER EAPP AND NBI PLANS

Table A1 in the annexes shows the NBI/NELSAP-CU plans for hydroelectric projects, whereas Table A2 in the annexes lists hydroelectric projects considered by the EAPP in the power balance statement. Both tables provide the location, name and capacity of the projects, as well as their expected current conditions. There are some differences between the data sets which should be reviewed. Table 8 combines information from both tables (A1 and A2) to illustrate the portfolio of projects from the NBI that are in consideration by the EAPP in the power statement report. It should be noted that not all projects presented in the portfolio of NBI investment are present in EAPP data, meaning that coordination between both institution, by sharing planned project details such as names, location, capacity, and status, is crucial to analyse and plan the future energy system in EAPP countries. For example, NBI reports that the Dal project (Number 6 in Table 8), located in Sudan, is under feasibility study with a capacity of 400 MW; however, EAPP reports that the project under investigation has a power capacity of 648 MW.

Table 9 summarizes the status of cross-border and within country power interconnection projects in the EAPP region.

Table 8: Hydropower projects common in both NBI and EAPP database

No	Country	Project name	NBI data		EAPP data	
			Capacity (MW)	Status	Capacity (MW)	Status
1	Burundi Rwanda Tanzania	Regional Rusumo Falls	84	Under construction	26.6 MW Burundi 26.6 MW Rwanda 26.6 MW Tanzania	Under construction
2	DR Congo	Mugomba	100	Feasibility studies	40	General candidate plant
3	DR Congo Uganda	Semuliki	72	Feasibility studies	28	General candidate plant
4	Kenya	Gogo Falls	20	Under construction	12	Specific candidate plant
5	Rwanda, Tanzania Uganda	Nsongezi	48	Feasibility and design studies completed	35 MW Uganda	Specific candidate plant
6	Sudan	Dal	400	Feasibility and design studies	648	General candidate plant
7	Tanzania	Kakono	87	Feasibility and detailed studies completed	132	Specific candidate plant
8	Ethiopia	Gibe III	1870	Implementation	1870	Existing
9	Ethiopia	GERD	6000	Implementation	5150	Under construction
10	DRC Burundi Rwanda	Ruzizi III	147	Implementation	49 MW DRC 49 MW Burundi 48 MW Rwanda	Existing
11	DRC	Inga I HEP	351	Implementation	351	Existing

Box 2: Regional Rusumo Falls Hydroelectric Multipurpose Project.

Countries: Burundi, Rwanda, Tanzania

Financing: Burundi, Rwanda and Tanzania

Description: Run-of-river hydropower on the Kagera River, near Rusumo town, located on the Rwanda-Tanzania border.

- 80 MW hydropower station (construction started in March 2017)
- 3 power transmission lines (220 kV, 378.2 km total length) from Rusumo to: Burundi, Rwanda and Tanzania.

Purpose: Promote use of renewable energy, reduce electricity costs, support

Table 9: Cross-border and within country power interconnection projects in the EAPP region. Source: NBI Investment Projects Database.

Countries Transmission Line	Point of connection(s)	Power interconnection	Status
Kenya-Tanzania	Namanga	Cross-border	
Kenya-Uganda	Lessos- Tororo	Cross-border	
Uganda-Rwanda	Mbarara - Mirama/Shango	Cross-border	
Uganda- DR Congo	Nkenda- Bunia- Butembo-Beni	Cross-border	Under Preparatory (NELSAP CU doing it through AfDB/NEPAD-IPPF)
Rwanda- Burundi	Kigoma-Butare- Ngozi	Cross-border	
Uganda-South Sudan	Olwiyo/Juba	Cross-border	Under Preparation (NELSAP CU doing it through AfDB/NEPAD-IPPF)
Burundi-Tanzania	Jiji/Mulembwe- Kigoma	Cross-border	Under Preparation (NELSAP CU doing it through AfDB)
Ethiopia -Kenya		Cross-border	
Ethiopia- Sudan		Cross-border	
Egypt- Libya		Cross-border	
Ethiopia- Djibouti		Cross-border	
DR Congo – Burundi	Kamanyola/Bujumbura	Cross-border	Construction
Burundi-DRC-Rwanda		Cross-border	Construction
Burundi – Tanzania	Jiji- Mulembwe/Kigoma	Cross-border	Project Identification
DR Congo - Rwanda	Buhandahanda – Goma/Gisenyi – Kibuye - Shango	Cross-border	Construction
Ethiopia – South Sudan	Dedesa-Tepi/Bor- Juba	Cross-border	Project Identification
Ethiopia – South Sudan – Phase 1	Gambela/Malakal	Cross-border	Project Identification
Ethiopia – South Sudan	Guba/Juba	Cross-border	Project Identification
South Sudan – Kenya – Phase 1	Torit- Kapoeta/Lokichogio	Cross-border	Project Identification

Kenya – Tanzania		Cross-border	Construction
South Sudan - Uganda	Juba/Karuma	Cross-border	Feasibility studies completed; detailed designs and tender documents prepared
Uganda -Tanzania	Masaka/Mwanza	Cross-border	
Tanzania – Zambia	Mbeya/Kasama-Kabwe	Cross-border	Feasibility studies completed; detailed designs and tender documents prepared
Democratic Republic of Congo	Goma-Buhandahanda	Within country	
South Sudan	Bor – Malakal	Within country	Project Identification
South Sudan	Malakal – Bentiu	Within country	Project Identification
South Sudan	Renk – Malakal	Within country	Project Identification
South Sudan	Juba- Bor	Within country	Project Identification
South Sudan	Juba-Torit	Within country	Project Identification
Tanzania	Iringa-Mbeya Transmission Line	Within country	Feasibility studies completed; detailed designs and tender documents prepared

4 FUTUREDAMS WATER-ENERGY ANALYSIS TOOLS

NBI, EAPP and the University of Manchester (UoM) have been collaborating since 2017 in the context of a UK funded research project entitled 'FutureDAMS' (Future Design and Assessment of water-energy-food-environment Mega-Systems'). The tools developed within FutureDAMS have the potential to assist NBI, EAPP and their partners to assess or optimise future water, energy or water-energy interventions. To motivate further development and refinement of datasets relating to future energy sector developments (the main topic of this report), we have summarised in this section the new tools created by NBI, EAPP and UoM and provide a list of ongoing and proposed future case studies.

4.1. FUTUREDAMS INTEGRATED WATER-ENERGY SIMULATOR

The FutureDAMS project has created a suite of generalised regional-scale water, energy, and water-energy computer models to simulate interconnected river basins, power networks and their interconnections over space and time. 'Generalised' means these models can applied to any system. The generalised models are open-source, which means the simulation computer code is public. This makes model results transparent; they can be verified by anyone. Finally, every effort has been made so that the generalised simulation models run quickly. This means models can be used for risk analyses or climate change adaptation studies (when many futures scenarios must be considered) or in design (optimisation) studies, where an external algorithm runs the models repeatedly to identify which decisions (like new infrastructure and/or new operating policies) work best.

The suite of generalised models developed during the FutureDAMS project were applied to the East African system. This has resulted in 4 new model applications: a water resources model of the Nile Basin, a high level power system model of the EAPP system (with hundreds of nodes), an integrated water-energy model (which links the first and second models), and a detailed power system model of the EAPP system (with thousands of nodes). These four model applications are summarised in the table below.

Table 10: Four model applications developed jointly by NBI, EAPP and the University of Manchester during the FutureDAMS project.

FutureDAMS simulation model applications	Generalised model used	Generalised model license	Model application ownership	Web user-interface now available?
The Nile river basin model	Pywr	Open-source (GPL*)	NBI-EAPP	Yes
The strategic EAPP power network model	Pyenr	Open-source (GPL)	NBI-EAPP	Yes
The integrated water-energy model of East Africa	Pywr linked to Pyenr	Open-source (GPL)	NBI-EAPP	Yes
The advanced EAPP power network model	PyEnSyS	Open-source (GPL)	NBI-EAPP	No, but it could be in future

* GPL means 'general public license', this is an open-source software license

Below we briefly describe these 4 model applications and the generalised models they use.

The FutureDAMS Nile river basin simulation model can be used for infastructure investment and operations studies. It is built with Pywr (Tomlinson et al. 2020), a generalised fast open-source Python library for water resource systems analysis. Pywr is an optimization-driven simulation library that uses linear programming solvers for computational speed and simplicity.

The strategic EAPP power system simulator is designed for rapid strategic planning studies. It uses Pyenr, a DCOPF (Direct Current Optimal Power Flow) energy system simulator written in Python using similar methods to Pywr. It is designed for strategic studies and aggregates the EAPP power network into a network with approximately 400 nodes.

The integrated model combines two generalised water and energy simulation models named “Pywr” and “Pyenr” respectively. A model integration framework names ‘Pynsim’ is used to connect the independent Pywr and Pyenr models and to manage their iteration, run sequencing, and time stepping.

The water model, the strategic power system model, and the integrated water-energy model can be accessed via a web interface that enables developing, visualising, sharing and running the models. Table 10 shows a screenshot of the integrated East African water-energy model in the web interface. Maintaining, securely sharing and running models online helps facilitate planning, collaboration and data sharing in a transboundary and regional context.

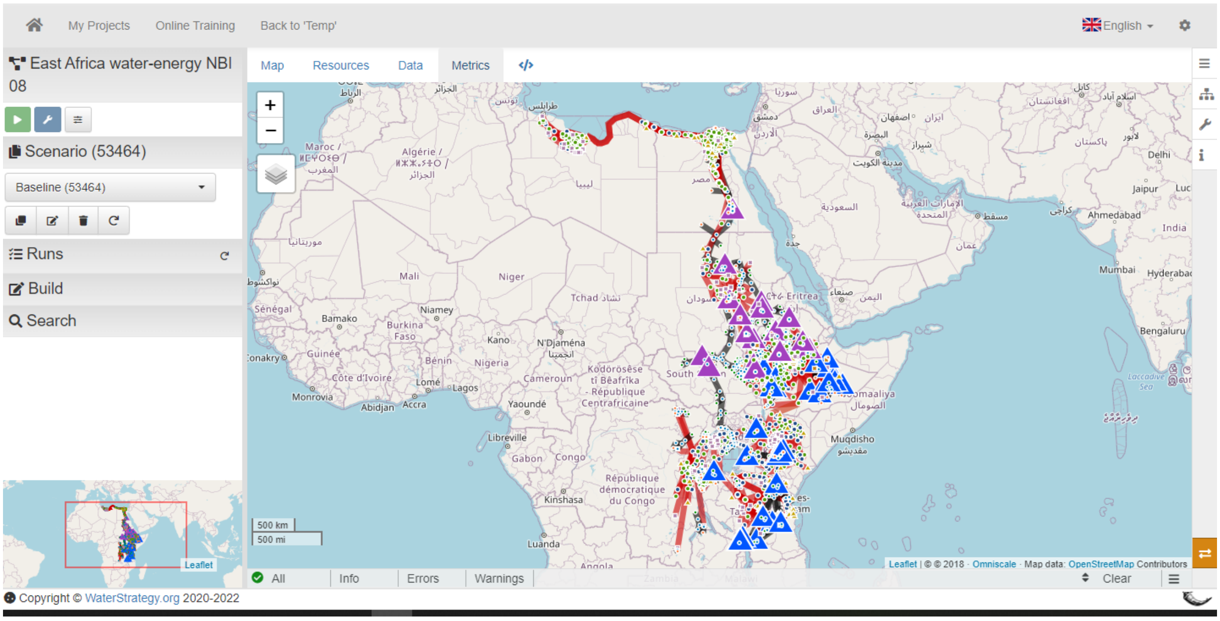


Figure 10: Snapshot of East African integrated water-energy model in the web interface. The model and user interface were built during the FutureDAMS research project. The web interface allows to visualise, maintain, securely share, and run the model. User access to this FutureDAMS model will be administered jointly by NBI and EAPP.

In addition to Pyenr, FutureDAMS produced a more advanced running generalised energy system simulation model named the Python Energy Systems Simulator (PyEnSyS). PyEnSyS was applied to the EAPP system to form an 'advanced' detailed model with thousands of nodes. Next we provide more details about this new generalised model. PyEnSyS is a python-based, open-source optimisation-based simulation software that can be used for power system analysis, including power flow, economic dispatch, unit commitment problems. PyEnSyS can include multiple generation technologies (conventional thermal power plants, hydropower stations, wind farms, solar power plants, etc.) and the electricity network. PyEnSyS has been implemented to identify modelling assumptions that better capture the uncertain future conditions in both energy and water sectors, for instance, water scarcity, and temperature rise, highlighting the trade-offs between computational accuracy and computational costs (E.A. Martinez Ceseña et al., 2022). PyEnSyS can optimise time-series operation (for instance, one year with hourly timesteps), evaluating the seasonal variability of energy sources and electricity demand. Analyses developed in PyEnSyS include techno-economic studies of generation portfolio, reliability analysis at national and regional scales, evaluation of greenhouse gases emissions, optimal operation of assets for interconnected countries, among others.

PyEnSyS is ideally suited for detailed operational analyses whereas the quicker running Pyenr model make it suitable for investment screening, planning and optimised design studies.

4.2. ONGOING AND FUTURE WORK

It is beyond the scope of this report to describe the current or future multi-sector ('nexus') studies being undertaken within the FutureDAMS project. However, below we provide a brief summary of ongoing and future work to underscore the importance of the questions that can be addressed with up to date datasets and the newly built multi-sector analysis tools.

Ongoing studies of the FutureDAMS project

- Analysis of how cross-country power trade in the Eastern Nile can act to alleviate water stress. Preliminary results from this study were presented at the workshop.
- New floating solar in the Nile region could decrease water conflict and increase energy security.
- Climate change impact assessment on the combined East African water-energy system (supply, demand and operation).

Future work UoM could engage in with NBI and regional partners

- Investigating the advantage of interconnecting regional power pools (EAPP and SAPP)
- Optimising infrastructure investments in the EAPP region in order to consider multisector (water, energy, food, environment) impacts and outcomes.

5 REFERENCES

African Development Bank Group (2021) *African Development Fund extends $83.6 million in grants to boost Ethiopia-Djibouti electricity trade*. Available at: https://www.afdb.org/en/news-and-events/press-releases/african-development-fund-extends-836-million-grants-boost-ethiopia-djibouti-electricity-trade-44549.

African Development Fund (2012) 'Ethiopia-Kenya Electricity Highway Regional'.

EAPP (2014) *EAPP REGIONAL POWER SYSTEM MASTER PLAN*.

EAPP (2020) *Eastern African Power Pool Power balance statement* https://eappool.org/wp-content/uploads/2021/04/Eastern-Africa-Power-Pool-Power-balance-statement-2020-December.pdf.

E. A. Martínez Ceseña, Y. Zhou, J. N. Melchor Gutierrez, W. Zhu, M. Panteli, J. Mutale, P. Mancarella, J. Tomlinson, R. Baisie, E. Obuobie, J. J. Harou, "Quantifying the Impacts of Modelling Assumptions on Accuracy and Computational Efficiency for Integrated Water-Energy System Simulations Under Uncertain Climate", IEEE Transactions on Sustainable Energy, in Press.

IEA (2019), Africa Energy Outlook 2019, IEA, Paris https://www.iea.org/reports/africa-energy-outlook-2019

IPCC, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

Fernández, O. *et al.* (2020) 'Interconnection performance report_Q2_2020', 2017(1), pp. 1–9.

FutureDAMS, Python Energy Systems Simulator (PyEnSyS), 2021. University of Manchester. URL https://github.com/jnmelchorg/pyensys

Hannah Ritchie and Max Roser (2020) - "Energy". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/energy' [Online Resource]

NBI (2010) *THE NILE STORY BRIEFING NOTE 7 Reducing flood devastation in the Nile Basin*.

NBI (2017) *NBI Strategy Final Draft 2017 - 2027*.

NBI (2020) *State of the River Nile Basin Report*.

Solar resource map 2021, Solargis. https://solargis.com

Sterl, S., Fadly, D., Liersch, S., Koch, H. & Thiery, W. Linking solar and wind power in eastern Africa with operation of the Grand Ethiopian Renaissance Dam. Nat. Energy 6, 407–418 (2021).

Taliotis, C., Shivakumar, A., Ramos, E., Howells, M., Mentis, D., Sridharan, V., Broad, O., & Mofor, L. (2016). An indicative analysis of investment opportunities in the African electricity supply sector - Using TEMBA (The Electricity Model Base for Africa). Energy for Sustainable Development, 31, 50–66. https://doi.org/10.1016/j.esd.2015.12.001

The World Bank (2011) 'Second Djibouti-Ethiopia Power System Interconnection Project', pp. 1–8. Available at: http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2011/03/25/000001843_20110329141118/Rendered/PDF/P1217550PID0ap1or0InfoShop0March25.pdf.

The World Bank (2019) *From Subsidy to Sustainability: Diagnostic Review of Sudan's Electricity Sector*, *From Subsidy to Sustainability*. doi: 10.1596/33702.

Tomlinson, J. E., J. H. Arnott and J. J. Harou (2020). "A water resource simulator in Python." Environmental Modelling & Software 126: 104635. https://doi.org/10.1016/j.envsoft.2020.104635 (open access)

United Nations (2019), Sustainable Development Goals, Energy. Department of Economic and Social Affairs. Retrieved December 5, 2021, from https://sdgs.un.org/topics/energy

ANNEX 1. EXISTING AND FUTURE WATER AND ENERGY INFRASTRUCTURE IN THE NILE BASIN AND EAPP MEMBER COUNTRIES

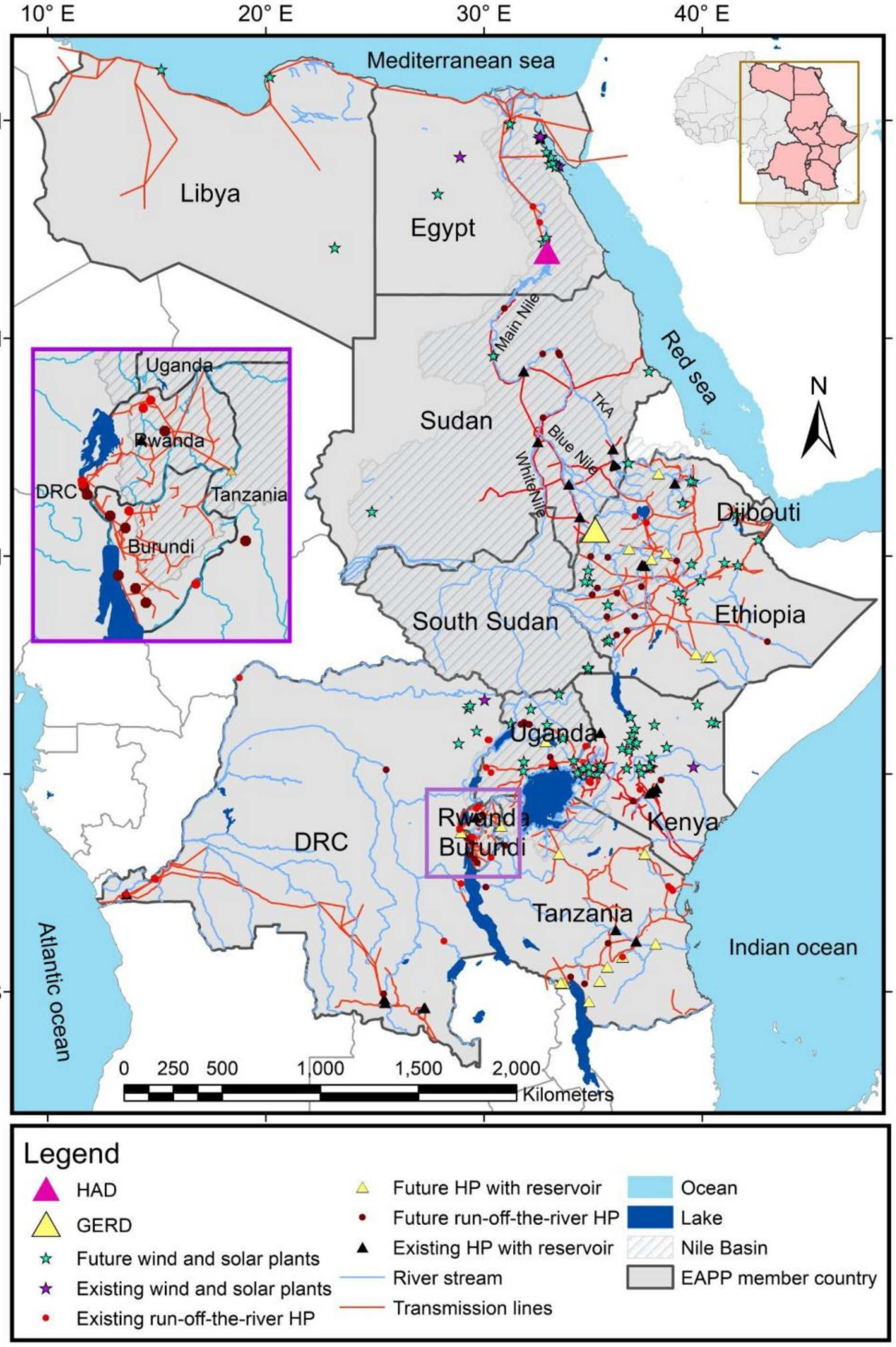


Figure A1: Existing and future water and energy infrastructure in the Nile Basin and EAPP member countries. (Source: Transmission line shapefile: https://energydata.info/organization/world-bank-grou; Wind and solar plants location:

https://www.africa-energy.com; Locations of hydropower; Lakes shapefile: https://koordinates.com/layer/1293-world-lakes-110-million/webservices/)

ANNEX 2. NBI / NELSAP-CU PLANS FOR HYDROELECTRIC PROJECTS

Table 11: NBI / NELSAP-CU plans for hydropower projects

	Country	Project name	Capacity (MW)	Next steps
1	Burundi	Buyongwe	0.065	Financial planning and resource mobilization
2	Burundi	Upper Ruvubu	3.6	Feasibility and detailed design studies
3	Burundi, Rwanda	Ruvyironza	22	Construction/implementation
4	Burundi, Rwanda	Akanyaru	14.5	Resource mobilisation and construction/implementation
5	Burundi, Rwanda, Tanzania	Regional Rusumo Falls	84	Completion of construction, handover and commissioning
6	DR Congo	Mugomba	100	Feasibility studies
7	DR Congo, Uganda	Semuliki	72	Feasibility studies
8	Ethiopia	Mandaya	2000	Feasibility and design studies
9	Ethiopia, South Sudan, Sudan	Integrated BAS	2072	Pre-feasibility, feasibility and design studies
10	Kenya	Amala Norera	1	Resource mobilisation and construction/implementation
11	Kenya	Bunyunyu	2	Continue construction and commissioning
12	Kenya	Namba Kodero	6.41	Continue construction and commissioning
13	Kenya	Gogo Falls	20	Continue construction and commissioning
14	Kenya	Keben	1.5	Feasibility and design studies
15	Kenya	Moi University	1.8	Feasibility and design studies
16	Kenya	Mushangubo	42	Feasibility and design studies
17	Kenya	Nandi Forest	50	Feasibility and design studies
18	Kenya	Ol-Ngobor	10	Feasibility and design studies
19	Kenya	Kocholio Dam	1.091	Feasibility and design studies
20	Kenya	Sio-Sango	0.26	Resource mobilisation and construction
21	Kenya	Angololo	1.75	Feasibility and design studies
22	Kenya	Gongo	17.11	Feasibility and design studies
23	Kenya, Uganda	Soono	1.9	Feasibility and design studies
24	Kenya, Uganda	Maira Dam	1.05	Mobilising balance of funding and implementation of dam works
25	Rwanda	Taba-Gakomeye	0.064	Financial planning and resource mobilization
26	Rwanda	Muvumba	2.9	Resource mobilisation
27	Rwanda	Akanyaru River	25	Feasibility studies
28	Rwanda, Tanzania, Uganda	Nsongezi	48	Resource mobilization and financial structuring.
29	South Sudan	Bedden	540	Resource mobilization
30	South Sudan	Lakki	300	Resource mobilization
31	South Sudan	Shukoli	235	Resource mobilization
32	South Sudan, Uganda	The Fulla Rapids	855	Pre-feasibility and feasibility studies
33	South Sudan, Uganda	Nyimur	0.8	Further resource mobilisation followed by implementation

34	Sudan	Dal	400	Feasibility and design studies
35	Tanzania	Mugango	1.2	Feasibility and detailed studies completed
36	Tanzania	Mugozi	1.8	Resource mobilization
37	Tanzania	Borenga	2.85	Resource mobilization and implementation
38	Tanzania	Buligi Valley	1.8	Resource mobilization
39	Tanzania	Kakono	87	Resource mobilisation and construction
40	Tanzania	Malagarasi	41	Resource mobilisation and construction
41	Uganda	Kabuyanda	0.16	Construction/implementation
42	Ethiopia	Gibe III	1870	Operation
43	Ethiopia	GERD	6000	Operation
44	DRC, Burundi, Rwanda	Ruzizi III	147	Operation
45	DRC	Inga I HEP	351	Operation
46	Ethiopia, Kenya	Dawa	8.2	Project Definition

ANNEX 3. EAPP DATA FOR HYDROELECTRIC PROJECTS

Table 12: EAPP data for hydropower projects

	Country	Project name	Capacity (MW)	Project Status
1	Burundi	Mpanda	10.4	1 - Under construction
2	Burundi	Kabu 16	20	1 - Under construction
3	Burundi	Ruzibazi	15	1 - Under construction
4	Burundi	Jiji	33	1 - Under construction
5	Burundi	Mulembwe	17	1 - Under construction
6	Burundi	Rusumo (Burundi's share: 33%)	26.6	1 - Under construction
7	Burundi	Ruzizi III	49	3 - Specific candidate plant
8	Burundi	Siguvyaye	6.6	3 - Specific candidate plant
9	Burundi	Ruvubu	50	4 - General candidate plant
10	Burundi	Mini Hydropower	11	4 - General candidate plant
11	DRC - E	Mugomba	40	4 - General candidate plant
12	DRC - E	Wannie Rukula	688	3 - Specific candidate plant
13	DRC - E	Kiyimbi FUKA	153	4 - General candidate plant
14	DRC - E	Sisi	205	4 - General candidate plant
15	DRC - E	Semliki	28	4 - General candidate plant
16	DRC - E	Ulindi	30	4 - General candidate plant
17	DRC - E	Panzi	42	4 - General candidate plant
18	DRC - E	Muhuma	25	4 - General candidate plant
19	DRC - E	Kitete	21	4 - General candidate plant
20	DRC - E	Kiliba	15	4 - General candidate plant
21	DRC - E	Ruwenzori I & II	12	4 - General candidate plant
22	DRC - E	Ruthuru, Ngingwe, Osso, Binza	15	4 - General candidate plant
23	Egypt	Pump Storage	2400	2 - Financing secured
24	Ethiopia	Grand Ethiopia Renaissance Dam	5150	1 - Under construction
25	Ethiopia	Koysha	2160	1 - Under construction
26	Ethiopia	Genale 6	246	3 - Specific candidate plant
27	Ethiopia	Dabus	798	3 - Specific candidate plant
28	Ethiopia	Geba I	214	3 - Specific candidate plant
29	Ethiopia	Geba II	157	3 - Specific candidate plant
30	Ethiopia	Birbir	467	3 - Specific candidate plant
31	Ethiopia	Karadobi	1600	3 - Specific candidate plant
32	Kenya	Raising Masinga Dam		3 - Specific candidate plant
33	Kenya	Pumped Hydro		3 - Specific candidate plant
34	Rwanda	Small hydropower (IPP) (A)	9	1 - Under construction
35	Rwanda	Rusumo (A)	26	1 - Under construction
36	Rwanda	Number of small Hydropower (IPP)	31	3 - Specific candidate plant
37	Sudan	Rosaries Heightening	162	2 - Financing secured
38	Sudan	Sennar East	126	2 - Financing secured
39	Sudan	Shereik	420	3 - Specific candidate plant
40	Sudan	Kajbar	360	3 - Specific candidate plant
41	Sudan	Mograt	312	4 - General candidate plant
42	Sudan	Dagash	312	4 - General candidate plant
43	Sudan	Dal	648	4 - General candidate plant
44	Sudan	Sabaloka	205	4 - General candidate plant
45	Tanzania	Rusumo Falls	26	1 - Under construction
46	Tanzania	Steiglers Gorge II	2100	1 - Under construction
47	Tanzania	Kakono, Malagaresi	132	3 - Specific candidate plant

48	Tanzania	Iringa Nginayo	86	3 - Specific candidate plant
49	Tanzania	Ikondo	340	4 - General candidate plant
50	Uganda	3 Mini Hydro sites	12.3	1 - Under construction
51	Uganda	3 Mini Hydro sites	13.8	1 - Under construction
52	Uganda	Agago-Achwa HPP I (ARPE)	41	1 - Under construction
53	Uganda	Karuma HPP	600	1 - Under construction
54	Uganda	Nyamagasani 1 HPP	15	1 - Under construction
55	Uganda	4 Mini hydro Sites	22.1	2 - Financing secured
56	Uganda	Kikagati HPP Project	14	2 - Financing secured
57	Uganda	Muzizi HPP	44.7	2 - Financing secured
58	Uganda	9 Mini Hydro Sites	48.4	3 - Specific candidate plant
59	Uganda	10 Mini Hydro Sites	58.45	3 - Specific candidate plant
60	Uganda	Agago-Achwa HPP III (ARPE)	13	3 - Specific candidate plant
61	Uganda	Agago-Achwa HPP IV (ARPE)	10.5	3 - Specific candidate plant
62	Uganda	Ayago HPP	840	3 - Specific candidate plant
63	Uganda	Kiba	330	3 - Specific candidate plant
64	Uganda	Nshongezi HPP Project	35	3 - Specific candidate plant
65	Uganda	Oriang HPP	392	3 - Specific candidate plant

ANNEX 4. WORKSHOP PROCEEDINGS ON "EASTERN AFRICA POWER PLANNING AND REGIONAL POWER TRADE WORKSHOP"

Session 1. Workshop objectives and opening remarks

Workshop background information and key points from the opening remarks of NBI:

In the spirit of regional integration, the governments of the Eastern African countries are working on enhancing the regional interconnection of their electricity grid networks to address the electrification challenges and provide sustainable, affordable, and reliable energy to all based on socio-economic development.

The sustainable development of the Nile's water resources is the responsibility of all the riparian countries, not only the Nile basin Initiative (NBI). However, despite goodwill and intention, the Nile Basin faces many challenges which are multisectoral and transboundary by nature; therefore, there is a need to coordinate to achieve the desired objective.

NBI identifies the investment projects that are listed below with the highest priority of regional significance. These investment projects are drawn from the investment program of regional organisations and endorsed by the head of State of the Nile basin repairs.

- Increase the number of multipurpose projects
- Construction of new hydropower plant and rehabilitation of existing hydropower plants
- Management of watershed and water towers at basin level
- Increase irrigation development
- Improve irrigation efficiency and enhance agricultural water management
- Mitigate impacts from hydrological floods and drought and create a risk management plan for climate change disasters

In addition to relying on new hydropower plants, plans should also focus on diversifying the energy mix and analysing the technical and economic feasibility of deploying renewable energy technologies. In addition, there will be power exchange options between countries and markets in the future interconnected power network that need to be developed.

Furthermore, climate change will significantly impact the water and energy systems. Therefore, organisations need to work together to implement the best strategies for resource and infrastructure management, coordination and sharing essential information between sectors.

The NBI supports other regional organisations and states to implement the strategies. However, there is a need to formalise and coordinate projects to maximise effectiveness, minimise duplication, and exploit synergies between institutions.

The electricity sector requires water and generates greenhouse gasses emissions, impacting other goals in the sustainable development agenda. Integrated management of water and energy resources in the East African region can increase electricity access and water availability for basic purposes. On the other hand, deploying renewable energy technologies can reduce air pollution and carbon emissions. Finally, interconnected power grids between the riparian countries increase the efficient use of natural resources by facilitating electricity sharing (reducing spilling of renewable power) and helping sustainable and affordable development.

The workshop aims to support the NBI prepare a Nile River Basin Management Plan (NRBMP) and a Nile River Basin Investment Programme (NRBIP). The main objective of the workshop and report is to provide information about proposed energy and water infrastructure development projects from the Eastern Africa Power Pool (EAPP) master plan, EAPP power balance statement, and NBI strategic plan documents, including cross-border power interconnections, power purchasing agreements, and current and future hydropower developments. In addition, the draft report on "Eastern Africa Power Planning and Regional Power Trade Workshop Report" aims to help initiate discussions between stakeholders and stimulate interactions between the NBI and the EAPP to develop the strategies.

Key points from the opening remarks of EAPP

EAPP aims to facilitate and secure the power supply to the EAPP member countries at the lowest possible cost. It is expected that the inputs provided by the workshop participants will assist EAPP deliver these objectives.

Workshop Rationale

- Eastern African countries aim to improve their electricity generation and cost-effective electricity supply.
- Electricity generation impacts other sectors (e.g. water supply, irrigation, and environment).
- Integrated planning and management of water and energy resources in the basin could help increase electricity access while minimising impacts on water resource systems.
- There are opportunities for the Nile River Basin member countries to design and implement long-term cooperation in the energy sector and address water shortages through interconnections and energy trade.
- Benefit-sharing solutions among neighbouring countries like power trade in the EAPP should be considered.

Hence, this workshop, the first of its kind, will help analyse integrated water-energy systems to study strategies for coordinated regional design and operation of water-energy infrastructure. Explored solutions and recommendations from this workshop will be used to shape the NBI management plant and investment program.

Workshop objectives

1. Presentation of the "Eastern Africa Power Planning and Regional Power Trade Workshop Report".
2. Review the Nile Basin management plan.
3. Analyse the available power exchange agreements and the State of their implementation.
4. Examine the alignments between EAPP and NBI plans (EAPP master plant and NBI strategic plants).
5. Review the short and long term priorities in terms of interconnections in the management of large hydropower projects in the regional power in the EAPP region.

Participants

- NBI (Nile-SEC, NELSAP-CU, ENTRO)
- EAPP
- Rusumo Power Ltd
- Consultants – BRLi
- University of Manchester – FutureDAMS project team members

Expected results

- A shared understanding of the East African Power portfolio and its interconnections.
- Joint review of the power investment portfolio for key stakeholders within the basin.
- Plan for integration of the power portfolio within the development of the NRBIP.
- Roadmap for interactions between the consultants and stakeholders.

Session 2. Presentation of known NBI and EAPP plans and discussion of reconciliation

Comments on the report

The initial draft of the "Eastern Africa Power Planning and Regional Power Trade Workshop Report" was distributed to participants for review and comment. Below are the comments provided by the participants on the initial draft report:

1. Why is South Sudan not included in the initial draft report?
    a. South Sudan is not a member of EAPP but is expected to join soon. Accordingly, the last version of the report includes data for South Sudan.
    b. Figure 2 in the report need to be updated as there are many missing interconnections. Also, the Power Purchase Agreements table is not up to date and needs to be updated. Mr Tom Waako of NBI NileSEC will share soft copies of prepared reports to the consultants. The consultants can also get the hard copy reports available in the workshop room.
2. Why was the interconnection from Zambia to Tanzania (1983 plan) not considered?
    a. The Zambia to Tanzania interconnection is considered, and the project consists of 620 km of 400 kV double circuit transmission lines, starting in Iringa and going through Kisada and Mbeya to Tunduma, close to the border with Zambia, and continuing from Tunduma to Sumbawanga, linking the Tanzanian national grid with the Zambian network.
3. There is a huge difference in the timescale considered when planning water and energy systems. Water planning considers long timelines (50 years or longer), whereas energy planning considers a shorter term and places greater focus on the production of cheaper power with the available energy mix. To be more specific, there are dedicated power studies focused on the use of power resources across short time frames, e.g., days, hours and minutes. Also, as the lifetime of most power system assets is normally 20 years; after that time, a large portion of the infrastructure could be replaced. Participants from EAPP also clarified that there are two plans: the short-term plan, the power balance statement, and the long-term plan, which is the EAPP master plan. The EAPP master plant investigates plans for future generation and transmission lines for the next 25 years.
4. Experience from Norway: there is abundance of hydropower plants, and there is a well-developed electricity market, the NORDIC power pool. The water planning is for 50 years, and the focus of energy planning is more on integrating variable energy sources, such as offshore wind.
5. The report should also refer to the State of the Basin report to update some data. Besides, mapping power projects (generation and interconnections) between EAPP and NBI/NELSAP CU need to be included.
6. The report should include different hydropower and interconnection projects statuses, e.g., finance secured, operational, planned, the next actors are pushing the main project.

7. The map showing existing and future cross-border transmission between EAPP member countries should include the capacity status of the interconnections.

Summary of the presentation from NBI (Alloyce Oduor)

Advances towards regional power trade through transboundary power interconnections in Eastern Africa

In the course of the next three years, Burundi, Eastern DRC, Kenya, Rwanda, South Sudan, Tanzania and Uganda will be gradually interconnected. Benefits of regional interconnection includes:

- Interconnection increase levels of energy security.
- Increase affordable electricity access through synergies of the energy mix in the different countries.
- Differing or avoiding construction of new power plant by sharing electricity among the countries through trading.
- Reducing the reserve capacity requirement within each country.
- Enhancing regional integration.

The interconnection of Nile Equatorial Lakes countries (Kenya, Uganda, Rwanda, Burundi, D.R. Congo) is planned with a total of 931.5 Km overhead transmission line at various voltages. The interconnection between Rwanda-Eastern DRC and Uganda-Rwanda is near commission. Kenya with Uganda, Burundi, Rwanda and Eastern DRC are already interconnected. There is the readiness for a market including commercialisation and operationalisation of the GRID network; there is interest to facilitate agreements such as Power Sales Agreements (PSAs), Power Purchasing Agreements (PPAs), Power Wheeling Agreements (PWAs) and Power Exchange Agreement (PEAs). A transmission line between Ethiopia and Kenya is expected to start operating this year (2022).

- 220 kV transmission lines associated with the Regional Rusumo Falls Hydroelectric Power Project, Rusumo-Nyakanazi (Tanzania), Rusumo-Bugesera-Shango (Rwanda), Rusumo-Muyinga-Gitega (Burundi); Projects ongoing with expected full commissioning in 2022.
- Burundi (Bujumbura) – DRC (Kamayola) 220 kV Interconnection project implementation is ongoing: to evacuate generation from Rusizi III to Burundi and also strengthen the energy for the great Lakes (EGL) region network.
- Rwanda (Kibuye/Karongi) – DRC (Kamanyola) 220 kV interconnection: evacuate generation from Rusizi III to Rwanda and strengthen the EGL network.

Areas for harmonisation and coordination in regional power projects

Harmonisation and coordination are required in the entire value chain in the region: planning, procurement, design, operations and maintenance for the smooth operation of regional interconnectors. Areas of focus in this regard are:

- Power generation and demand forecasts, including power market analysis
- Power trading instruments (PPAs, PWAs, PEA, etc.).
- Technology for interconnection (synchronous vs asynchronous solution), the route selection and location of the transformation substation/converter stations.
- Environmental conditions include altitude-hence insulation coordination, temperature-hence sagging, wind, etc.
- Study and validate interconnected power systems models to analyse the system's dynamic behaviour (fault levels, voltage stability, dynamic stability-oscillations, and transient stability related to TCC, NTC, OOS, contingency analysis, and reactive compensation).
- Need to enforce network GRID codes that dictate design, operation and commercial issues (spinning reserve dimensioning, frequency load dimensioning, telecommunication, etc.).
- Protection schemes and telecommunication compatibility (for overall interconnected system stability and network synchronism).

Challenges in financing and implementing regional energy projects

- Lack of political compliance in the eye of development partners.
- Lower rating for creditworthiness for sectors projects, for instance, one country might be interested in being interconnected with another, but the other country’s energy development may not be a priority.
- Asymmetry in project priority between countries sharing a project.
- Policy and regulatory frameworks not harmonised between participating countries. In some countries, institution(s) that manages the generation, transmission and distribution may be different, while in other countries, these sectors are vertically integrated or have different procurement procedures.
- Different financing conditions between development partners.

Summary of the presentation from EAPP (Daniel Eshete)

Existing, commissioned and planned cross-country interconnections within the East African region, and voltage level is given in Table A3. Most of the interconnection expected to be operational within the next two years are between the Nile Equatorial Lakes region countries. However, the interconnection between Ethiopia and Kenya is expected to link the Eastern Nile basin and the Nile Equatorial Lakes region, which is intended to be operational in the year 2022. In addition, there are plans to upgrade the existing interconnection between Ethiopia-Sudan and Ethiopia-Djibouti in 2025. The interconnections after 2025 will be with countries that are not yet members of EAPP or are still in the process of joining the EAPP.

Table 13: Existing, committed and planned interconnections within the East African region.

No	Interconnector	Voltage level (kV)	Status	COD
1.	Libya-Egypt	220	Existing	
2.	Egypt-Sudan	220	Existing	
3.	Sudan-Ethiopia	230	Existing	
4.	Djibouti-Ethiopia	230	Existing	
5.	Kenya-Uganda	132	Existing	
6.	Burundi-Rwanda	110	Existing	
7.	Burundi-DRCE	70	Existing	
8.	DRCE-Rwanda	110	Existing	
9.	Sudan-South Sudan	220	Existing	
10.	Ethiopia-Kenya HVDC	500	Under construction	2021
11.	Tanzania-Kenya	400	Under construction	2021
12.	Rwanda-Uganda	220	Under construction	2021
13.	DRCE-Rwanda	220	Under construction	2021
14.	Kenya-Uganda	400	Under construction	2022
15.	Rwanda-Burundi	110	Under construction	2022
16.	Burundi-DRCE	220	Planned	2025
17.	DRCE-Uganda	220	Planned	2024
18.	Ethiopia-Sudan Second L	500	Planned	2025
19.	Ethiopia-Djibouti Second L	230	Planned	2025
20.	Tanzania-Uganda	220	Planned	2024
21.	Ethiopia-Somalia (North)	230	Planned	>2025
22.	Ethiopia-Somalia (South)	230	Planned	>2025
23.	Ethiopia-Eritrea	230	Planned	>2025

A 2.6 TWh is traded in 2020, with 94% of it being sold with Ethiopia and Egypt with their neighbours and 56% of the exchange was between Nile Basin riparians (see Table A4).

Table 14: The year 2020 bilateral energy exchange between EAPP member counties.

No	Interconnector	Voltage level (kV)	Capacity (MW)	Exchange (GWh)	Share (%)
1.	Libya-Egypt	220	180	684	26
2.	Egypt-Sudan	220	300	374	14

3.	Sudan-Ethiopia	230	240	955	36
4.	Djibouti-Ethiopia	230	184	456	17
5.	Kenya-Uganda	132	145	148	6
Total				2618	100

The EAPP Short–Term Action Plan (STAP) has defined priority actions to:

- Improve stable operation of existing cross-border transmission capacity.
- Support least-cost development of additional cross-border transmission capacity.
- Facilitate cross-border trade.

EAPP plan to start a power market in the EAPP region at the start of 2023 (Figure A2). In order to open the power market, there are activities undertaken by EAPP under different categories (see Table A5). Power system planning, operation, regional power market and institutional strengthening will be covered in the STAP.

Table 15: Different categories of activities the EAPP undertakes.

Activity categories	**Activities**
Long term plans	• Publish annual Power Balance Statement and Transmission System Capability Statement • A complete update of the EAPP Master Plan • Maintenance and update of regional power system model • Yearly status report on transmission projects of regional interest • Technical assistance and problem-solving for individual projects/interconnectors • Undertake priority interconnection feasibility study (Tanzania-Uganda, Ethiopia-Sudan 2nd interconnector, Ethiopia-Somalia)
On operation	• Operationalisation of the EAPP GRID coordination Unit • Establish control areas • Quarterly Operation reporting and monitoring • Harmonisation of the operation planning cycle • Design and implementation of the EAPP Energy Information System • Develop Regional SCADA infrastructure • Prepare for synchronisation with SAPP (South African Power Pool) • Improve frequency control
Power market	• High-level EAPP Power Market Design • Shadow Market training • Develop bilateral trade standardised documents • Market rules – Centralise EAPP trade • Prepare platform for Day-Ahead Market (DAM) • Start trade on EAPP market platform • Publish annual market report on the status of bilateral and centralised trade
Institutional strengthening	• Various capacity building activities of the EAPP staff and Technical Committees • Develop IRB Strategic Plan and prepare three years action plan • Membership expansion (Somalia, South Sudan and Eritrea) • Implementation of IRB strategic plan and action plan • Operationalisation of social and environmental protection committee • Greater coordination with regional bodies

	• Training and certification of system operators

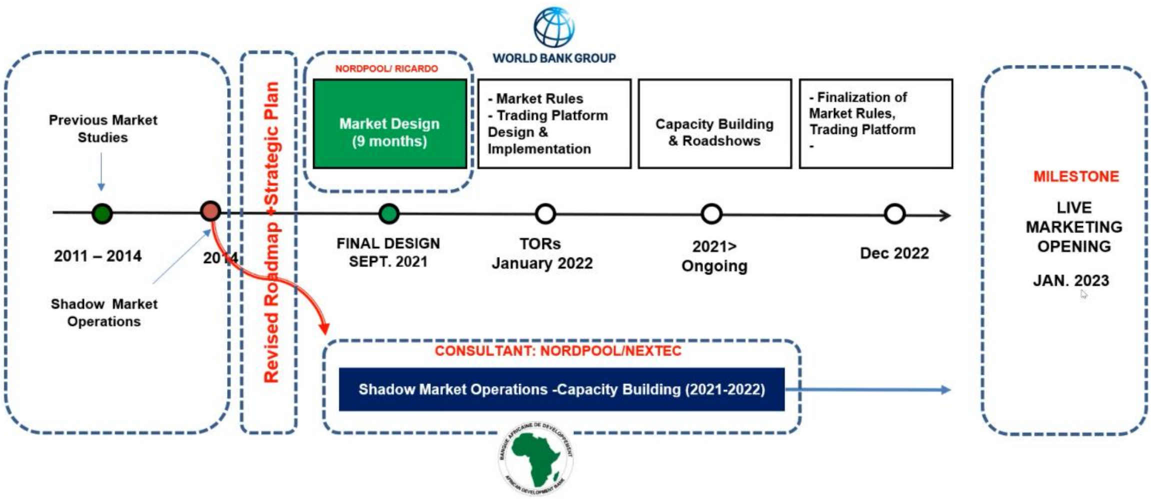


Figure A2: EAPP power market implementation timeline (Source: EAPP presentation slide 17).

Questions from participants:

1. There is a power master plan for the East African Community; how is that included in the EAPP work? What mechanisms exist to take the National Power Plans? (Question from NBI participant).

   ✓ EAPP relies on the member countries. The first Master Plan cooperates with the East African Community interests. The countries develop generation projects, and EAPP focuses on interconnectors. EAPP does not impose the EAPP Master plan on countries. EAPP works for the countries and depends on the participation of countries and utilities. All documentation is shared across the board when projects are being prepared to inform better planning and designs. EAPP is the custodian of protocols and guardian of the GRID codes.

2. How does the NELSAP CU and EAPP coordinate in terms of the interconnections?

   ✓ Currently, EAPP and NESAP CU are working smoothly. Apart from the horn of African countries that brought their interconnections to the EAPP, most of the bi-lateral interconnections are developed by the countries.
   ✓ Coordination between the NELSAP and EAPP:
      - We work for the countries to develop planning strategies, and these plans depend on the participation of national and regional utility companies. All the documents are shared across the board to inform member countries.
      - EAPP is the custodian of protocols like GRID code, and all the NELSAP projects should be according to the GRID code developed by the power pool.

- If there is a commission of interconnection, the drivers are both NELSAP and EAPP. There is coordination between EAPP and NELSAP from planning, implementation, commission, and operation.
- What is the financing arrangement?
    - During the planning and preparation stage of a transmissions line or hydropower development project, the financiers could be multi-later and bilateral organisations (for instance, Rusumo hydropower is funded by The World Bank, and The African Development Bank funds the transmission line).

3. Is financing purely national, or can that be done at a regional level?

   There is a slight challenge in financing and implementation. At NELSAP CU level, projects preparations are by grant financing, and at the implementation level, countries take the projects themselves and deal with the financier on how to close the project financially.

4. Membership of EAPP
   - ✓ Somalia and Eritrea will be members of EAPP.
   - ✓ EAPP has 11 countries and 15 utilities as members.

5. Why in the NELSAP CU presentation Tanzania and Burundi interconnection is , not included?
   - ✓ Switchyard in Rusumo project can technically serve as an interconnector between Burundi, Rwanda and Tanzania. The lines are designed to come from Rusumo Fall hydropower plant to the countries (Nyakanazi, Muyinga-Gitega and Bugesera-Shango).

Session 3. Opportunities for water-energy-synergies

Participant comments and questions on the presentation on "Cross-country power trade in the Eastern Nile could alleviate water stress":

- ✓ What other synergies could NBI and EAPP model? Response: Some topics include for example …
    - Assessing the impact of the Jonglei canal
    - Investigating the benefit of floating solar panels on both the water and energy system
    - Investigating complementarity of hydropower with other renewable energy sources
- ✓ The 1.5 billion cubic meters deficit for High Aswan Dam (HAD, 200 billion cubic meters) is not significant. Response: It was clarified that this might happen quite often, especially during drought, and if it persists for 20 years and beyond, this becomes significant to HAD.

- ✓ The time steps used here are monthly time steps, and therefore the conclusion concerning Sudan may not be precise. The best way is to do daily time steps (this applies solely to Sudan). Response: It was clarified that the Model was calibrated to run daily time step.

Session 4. Power Purchase and Power Wheeling Agreements overview and discussion implications

1. What are the challenges/elements of a good PPAs/PWAs?
   - ✓ Ideally, we should be able to use cheap resources to supply power in the region. Agreements allow you to do that. Next, some countries do not have the capacity and good infrastructure, while this is a requirement. There is going to be profit by trading from one country to another, and that profit determines the cost/investment, i.e., the more profit one country gets from trading power means that they have the capacity to invest more.
   - ✓ In the case of EAPP, in the north, countries are using fossil fuels. In the middle, it's 50:50 (fuels and hydropower), and in the south, there is more hydropower use than fuels.
   - ✓ It is recommended for experience sharing where centres can visit each other and learn.
2. What are the implications of PPAs on reservoir management?

   One study conducted by FutureDAMS investigates different levels of Power Purchasing agreement between Eastern Nile countries on the operation of GERD (Grand Ethiopian Renaissance Dam). And the result shows that an increase in the level of power trade increases the availability in Sudan and Egypt, increases hydropower generation from GERD, reduces carbon emission from thermal power plants, and increases generation from existing hydropower plants in Egypt and Sudan.
3. What are the performance metrics to be assessed?
   - ✓ Operators need to be trained on why there should be power generation once they run the turbines. They need to avoid idling.
   - ✓ There is a need to protect the catchment to reduce sedimentation into the dams and also increase inflows.
   - ✓ Agricultural activities upstream of the dam impact the reservoir, and the dam
   - ✓ There has to be coordination or agreements to guarantee the farmers downstream.
   - ✓ Multipurpose development is always beneficial to all sectors.

Session 5. Proposals on strategic actions and associated targets to be included in the RBMP and suggestions on how these strategic actions could be achieved

Work in Groups.

BRAINSTORMING (see table on p.2)

1. Do the action areas and strategic actions cover what needs to be done at the strategic level?
2. What are the best measures of progress at the strategic action level?
3. We plan to have 15-18 high-level targets – the NBSTs. If we had 2 – 3 related to energy (electricity), what might they be? Bearing in mind that:
    - they should reflect progress towards Goal 2: "Enhance hydropower development in the basin and increase interconnectivity of electric grids and power trade".
    - And build (be aggregated from) progress towards the strategic actions
4. Suggestions on how to achieve these targets.

GROUP 1:

- Discuss and propose answers to questions 1 and 2 (an electronic version of the table can be provided).

GROUP 2

- Familiarise yourselves with the proposed action areas and strategic actions in the table overleaf, as well as Goal 2.
- Discuss and make proposals to answer Question 3.
- Ideas in terms of how to move towards these targets. What priority interventions?

Recommendations at plenary

- ✓ 2.1 Power Supply Strategic Planning----------2.1.1. and 2.1.2 indicative measure of progress (remove the word population).
- ✓ 2.2 Power Generation-------------2.2.1 (recast the action to read "investigate and assess the potential for renewables (taking into account complementarity)".
- ✓ 2.3 Power transmission----------2.3.2 indicative measure of progress (add the number of interconnections).
- ✓ 2.4 is okay.
- ✓ 2.5 Add a new action area as Power Trade and give strategic action and indicative measure of progress.

Session 6. Conclusions and next steps

The workshop participants requested feedback on the draft workshop report. The NBI suggest aiming to end up with a technical report type/quality document that can go on the website as a resource. Below are some suggestions/comments on the report:

1. Facts and figures:
    - Update the tables (and graphics) on interconnections (table structured by interconnection – capacity, year commissioning, status. Pls. Include who is the regional lead on the feasibility (NELSAP, EAPP, etc.).
    - Update the tables (and graphics) on power trade (see EAPP slides, Rusumo agreement, Uganda-Kenya agreement, etc.
    - "Figure A1: Existing and future water and energy infrastructure in the Nile Basin and EAPP member countries" include the data in a table in Annex – and is there a classification of the status as per text (existing, planned, financed, etc.)? Please include South Sudan and the planned interconnections.

2. Institutional arrangements:
    - Include a section at the beginning on the rough institutional setup of regional power planning (i.e. the EAPP its tasks and master plan, NELSAP and its roles).

3. Recommendations
    - A lot can be taken from the slides of EAPP and NELSAP in terms of recommendations/to-dos.
    - What is new beyond the agenda contained in EAPP and NELSAP presentations? On new topic could be an integration of solar and geothermal in the grid (with hydropower).

4. Examples in Textboxes
    - Rusumo Falls – I'm sure you can copy in some text box on the project highlighting it as a shared investment.
    - Reflect the FutureDAMS project/model and capacity development in a text box as an example of research NBI/EAPP cooperation.
    - Reflect in a text box or so the results of the PIK study on GERD, renewables and power trade (results) titled - "Linking solar and wind power in eastern Africa with operation of the Grand Ethiopian Renaissance Dam."

5. Annexes:

- Suggest to edit/layout the text/graphics in the power points of EAPP and NELSAP into two Annexes for the report on EAPP and NELSAP – contains a lot of useful information.

Session 7. Wrapping Up: Feedback and Recommendations

Next Steps/Recommendations

1. The Pre-Workshop report is to be updated and re-submitted by the end of January 2022.
2. The Presentations are to be shared with consultants/participants (immediate).
3. Participant's inputs to the report will be submitted to Mr. Tom Waako (email: twaako@nilebasin.org) by 24th January 2022.
4. Consultants to submit a final draft by 31st January 2022.
5. NBI and EAPP need to decide on access policies for the online Model (institutional management of the model access).
6. FutureDAMS continuation with NBI and EAPP - also seek alternative funding. This requires separate discussions among the Centre Heads.
7. Experience sharing/learning between NBI and EAPP in order to collaborate & coordinate in the power sector.
8. Preparation of collaborative plan between NBI and EAPP.
9. The integrated FutureDAMS model needs to be finalised and made accessible on the portal.
10. More workshops and interactions between NBI and EAPP going forward. It is proposed to have a follow-up virtual meeting in March 2022. NileSEC to coordinate.

ANNEX 5. NBI AND EAPP INSTITUTIONAL SETUP

The main governance organs in the institutional structure of the NBI are three:

- **The Nile Council of Water Ministers (Nile-COM)**: comprised of Senior Ministers in charge of water affairs in the NBI member countries and is the highest policy and decision-making body of the Nile Basin Initiative.
- **The Nile Technical Advisory Committee (Nile-TAC)**: provides advisory services to the Nile Council of Ministers, follows up on implementation of Council decisions; oversees the technical work of the Initiative.
- **The Nile Basin Secretariat (Nile-SEC)**: is the executive organ of the Nile Basin Initiative (NBI). It serves to execute the programs and activities of the Nile Basin Initiative while supporting and facilitating the operations of the Nile Council of Ministers (Nile-COM) and the Nile Technical Advisory Committee (Nile-TAC) through the provision of general secretariat services.

Figure A3 presents the institutional structure of the NBI. The Eastern Nile Technical Regional Office (ENTRO) and Nile Equatorial Lakes Subsidiary Action Program Coordination Unit (NELSAP-CU) are the investment arms of the NBI for the Eastern Nile sub-basin and Nile Equatorial Lakes region, respectively. ENTRO and NELSAP-CU have their own council of ministers supported by a technical advisory committee and secretariat. ENTRO and NELSAP-CU have their council of ministers supported by a technical advisory committee and secretariat. In collaboration with the riparians, ENTRO and NELSAP-CU help to identify potential investments areas and prepare fesiblity and design documents. “Ethiopia-Sudan Interconnection” and “Eastern Nile Power Trade Program” under ENSAP and “Strategic/Sectoral Social and Environmental Assessment of Power Development Options”, “Regional Rusumo Falls Hydroelectric and Multipurpose Project” and “NELSAP Transmission Interconnection project” under NELSAP-CU are projects that contributed to the second strategic priority of NBI.

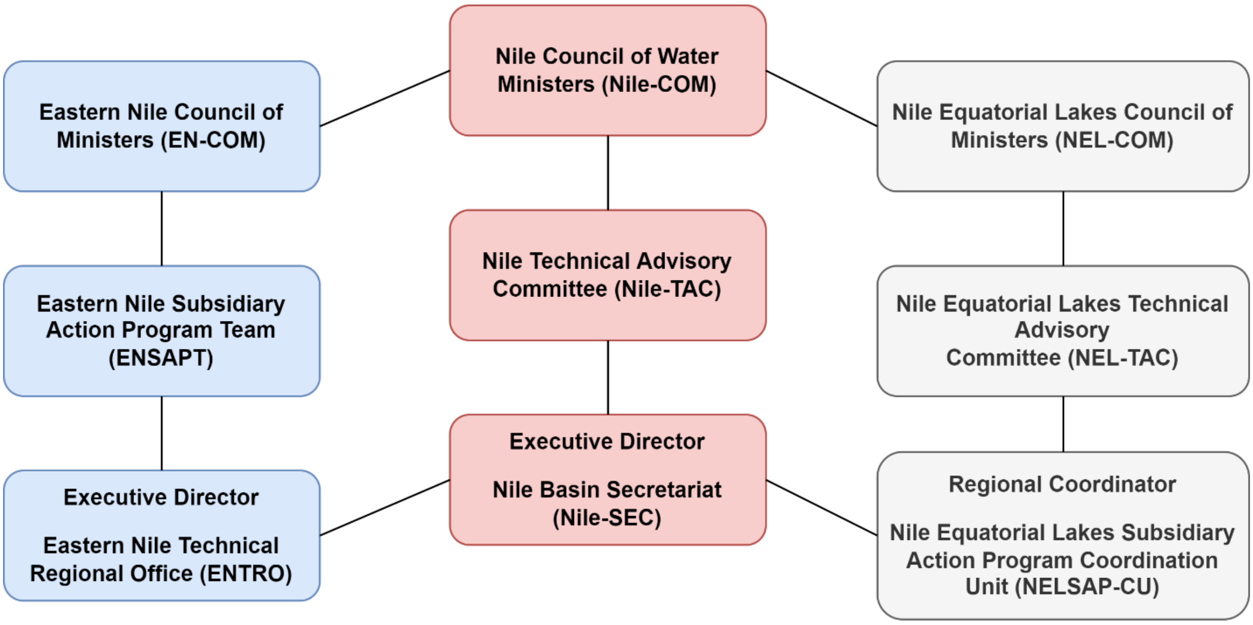


Figure A3: NBI organisational chart.

The highest authority in the EAPP is the "Conference of Ministers" and is followed by the Independent Regulatory Board, Steering Committee and General Secretariat. The Conference of Ministers is the political body that takes high-level decisions and provides policy guidelines. Figure A4 shows the general organisation.

Council of Ministers: is the decision-making authority for policy, strategy and membership. It is made up of ministers responsible for electricity in the EAPP Member States.

Steering Committee: recommends policies and strategic issues for approval by the Council of Ministers and oversees the execution of approved EAPP policies and strategies. It is made up of the chief executives of the national power utilities of the EAPP Member States.

Technical Sub-Committees: responsible to the Steering Sub-Committee, comprise of senior officials with relevant knowledge and expertise drawn from the EAPP Member Utilities. Three Technical Sub-Committees are:

- Planning Sub-Committee: responsible for coordination of master plans and development of programs of the member utilities.
- Operations Sub-Committee: responsible for drafting the operation and maintenance rules of power plants and networks.
- Environment Sub-Committee: responsible for environmental impact assessment, and the mitigation measures.
- **Governance and Human Resources**: responsible for managing the organization’s governance and human resources.

The Independent Regulatory Board: oversees the harmonisation and implementation of cross-border trade regulations. Its mandate includes the resolution of disputes among member utilities on power trade.

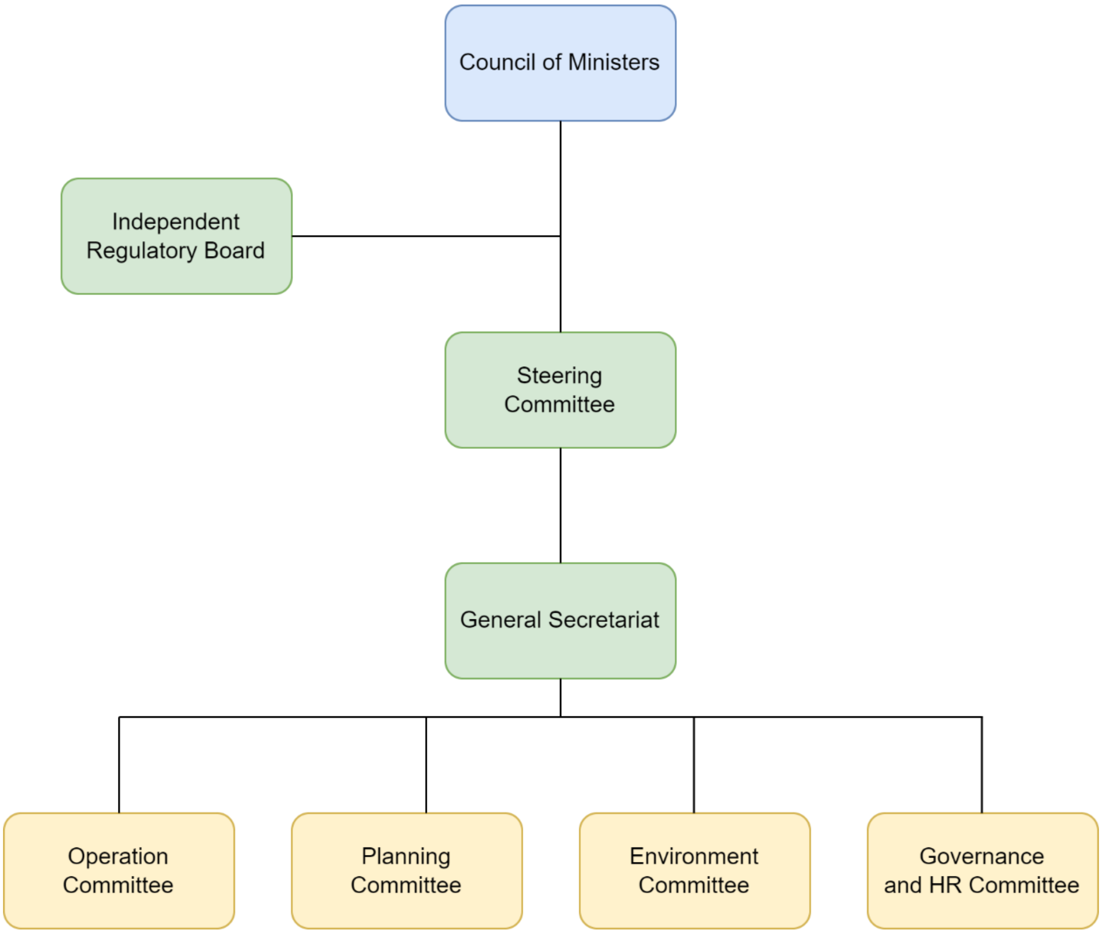


Figure A4: EAPP organisational chart (Source: EAPP presentation slide 12).

ONE RIVER

ONE PEOPLE

ONE VISION

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