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Executive Summary

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REVISIONS HISTORY

Revision number	Date	Protocol	List of modifications and/or modified paragraphs
Rev.00	11 March 2025	C5003344	First emission

GLOSSARY

AC	Alternating Current
B/C	Benefit/Cost ratio
CAPEX	Capital Expenditure
CBA	Cost-Benefit Analysis
CCGT	Combined Cycle Gas Turbine
DSCR	Debt Service Cover Ratios
EHV	Extra High Voltage
ENS	Energy Not Supplied
ENTSO-E	European Network of Transmission System Operators for Electricity
FCFE	Free Cash Flows to Equity
FCFO	Free Cash Flows from Operations
GEP	Generation Expansion Plans
HSDG	High Speed Diesel Generator
IRR	Internal Rate of Return
LFO	Light Fuel Oil
MSDG	Medium Speed Diesel Generator
NCC	National Control Center
NPV	Net Present Value
O&M	Operation and Maintenance
OCGT	Open Cycle Gas Turbine
OPEX	Operational Expenditure
PSS	Power System Stabilizer
PV	Photovoltaic
RAP	Resettlement Action Plan
RES	Renewable Energy Source
S/S	Substation
SMO	System and Market Operator
STATCOM	STATic COMpensator
TEP	Transmission Expansion Plan

1 INTRODUCTION

This Report represents the Executive Summary of the Feasibility Study related to the "*Feasibility Study for the Ethiopia Somalia Electricity Transmission Line Interconnections*".
Aim of this report is to summarize the results of the Feasibility Study investigations.

2 THE ETHIOPIA – SOMALIA INTERCONNECTION PROJECTS

The realization of the Northern and Southern Power Interconnection Projects aims at contributing to the economic development of Northern and Southern line in particular, and regional integration of Ethiopia and Northern/Southern line to aid in power trade in general.
The proposed project will provide a medium-term prospect of supplying power to the Northern and Southern line, around Mogadishu, the capital city, which constitutes a big constraint to economic growth in this part of the region which has faced insecurity in the recent past. The project will, in addition, contribute towards poverty eradication and improvement of the standard of living and socio-political aspects in the project area by providing gainful employment opportunities. The project will later be linked to the planned interconnections to Ethiopia and Sudan as well as internal backbone transmission lines Ethiopia and Kenya, forming part of the interconnected grid of the EAPP region.

As a general description, the two interconnections objective of the present Consultancy service have the following characteristics:

- **the northern interconnection** consists of about 680 km of transmission line subdivided into three segments (Debre Zeit-Hurso 365 km, Jijiga-Hargesa 138 km and Hargesa-Berbera 176 km), with the involvement of 6 S/S (Debre Zeit, Hurso, Jijiga, Hargesa and Berbera and the upgrade to 400kV of existing Harar S/S on the segment Hurso-Jijiga);
- **the southern interconnection** consists of about 800 km of transmission line subdivided into four segments (Genale Dawa III Hydro power switch yard-Dolo Ado 359 km, Dolo Ado – Dollow a few kilometers, Dollow – Baidoa 220 km and Baidoa-Mogadishu 210 km), with the involvement of 5 S/S (Genale Dawa III Hydro power switch yard, Dolo Ado, Dollow, Baidoa and Mogadishu).

The characteristics of the Interconnection Project should be able to assure the following aspects:

- Provide transmission capacity to cater for grid interconnection between Ethiopia and Northern/Southern line and its neighboring countries,
- Promote regional cooperation through sharing of power generation resources i.e., cross-border electricity trading (promotion of electricity markets),
- Improve security in the project area by providing stable power supply,
- Facilitate of rural electrification and improvement in the standard of living for the population in the project areas,
- Provide a stable power supply to Northern/Southern line in order to improve businesses for social and economic development of the project area,
- Speed-up the realization of the transmission grid and promote the development of renewable energy sources in Northern/Southern line creating new opportunities for economic growth,
- Poverty reduction and Improvement in the standard of living by providing electricity needed for health, education, clean water and communication infrastructures,
- Reduce dependence of Northern/Southern line on diesel power thus reducing carbon emissions.

To reach the above-mentioned objectives, the detailed Feasibility Study has been conducted in close cooperation with EAPP, EEP, ME&WR and MoEM, and was supported by on-field investigations performed by the technical team of the Consultant with the fundamental collaboration of the Clients to directly verify on field the conditions for identifying the best solution of the new infrastructures.

The development of the interconnection between Ethiopia and Northern/Southern Line can be considered included in a wider project of EAPP to promote the energy trade between all countries in the region. At this purpose, many other interconnection projects have been already developed, are on-going or will be realized in the future, such as the Ethiopia – Kenya interconnection, the new interconnection between Ethiopia and Sudan, as well as the interconnections Ethiopia – Djibouti, Ethiopia – Eritrea, Djibouti – Northern Line, Uganda – Kenya, Tanzania – Kenya, Uganda – Tanzania and the possible future interconnections between South Sudan with Ethiopia and Kenya, as well as interconnections between Kenya, Uganda, Rwanda, Burundi and Eastern DR of Congo.

3 SYNTHESIS OF THE FEASIBILITY STUDY OUTCOMES

The Feasibility Study of the Ethiopia – Northern/Southern line Interconnection Project consists of the following main activities:

- Load demand forecast
- Generation Expansion Plan
- Transmission Expansion Plan
- Supply - Demand Analysis and expected energy flows on the interconnections
- Optimal Route Selection
- Power system analysis
- Recommendations for the secure operation of the interconnected power systems
- Project budgetary costs
- Project benefits
- Economic and Financial analysis, project viability
- Risk analysis
- Schedule of implementation

The summary of the obtained results is reported in the following paragraphs.

3.1 Load Demand forecast

The load demand forecast, having the objective to predict the expected electricity consumptions in Ethiopia, Northern line and Southern line in terms of peak and energy demand, has been performed for the whole planning period, i.e., up to the year 2048, on a yearly basis. For sake of clarity, just the results at the years objective of the power system analysis (i.e., 2028, 2033, 2038, 2043 and 2048) are reported.

Ethiopia

A Top-Down approach has been performed to update the already existing load forecast and the main results, in terms of energy supplied to the Country in three different scenarios, for same selected years, are reported in the table below.

Table 3-1 – Ethiopia load demand forecast results

Scenario	Electricity consumption	2028	2033	2038	2043	2048
Low	Gross Energy (GWh)	22,778	34,412	50,837	76,370	112,782
	Peak (MW)	4,194	6,336	9,360	14,061	20,766
Base	Gross Energy (GWh)	28,212	44,713	65,638	98,744	147,446
	Peak (MW)	5,194	8,233	12,085	18,181	27,148
High	Gross Energy (GWh)	31,875	52,862	79,310	118,206	173,303
	Peak (MW)	5,869	9,733	14,603	21,764	31,909

The amount of the electricity consumption reported in the table above is the one that will be required by the Ethiopian system just in terms of internal consumption, including losses, without considering the electricity exchanged with the neighbouring countries (exports and imports). The determination of the energy/power exchange with neighbouring countries is considered in the Demand-Supply analysis.

Northern Line

The estimation of the expected electricity consumption for the Northern Line has been based assuring the coordination with the transmission and generation expansion plans, since all of them are mutually impacting each other.

Based on that, a dedicated approach was performed making appropriate assumptions related to the electrification rate, development of the internal transmission grid and per-capita consumption. The resulting energy and peak values are reported in the table below.

Table 3-2 – Northern Line load demand forecast results

Scenario	Electricity consumption	2028	2033	2038	2043	2048
Low	Supplied Energy (GWh)	222	957	1,974	3,145	4,523
	Peak (MW)	39	168	347	552	794
Base	Supplied Energy (GWh)	226	1,011	2,143	3,501	5,159
	Peak (MW)	40	178	376	615	906
High	Supplied Energy (GWh)	229	1,067	2,324	3,892	5,876
	Peak (MW)	40	187	408	683	1,032

Southern Line

The same approach considering the mutual interdependence between the electricity consumption, the development of the transmission grid and generation facilities has been applied also for estimating the expected electricity consumption for the Southern Line.

Based on that, a dedicated approach was performed making appropriate assumptions related to the electrification rate, development of the internal transmission grid and per-capita consumption. The resulting energy and peak values are reported in the table below.

Table 3-3 – Southern Line load demand forecast results

Region	Scenario	Electricity consumption	2028	2033	2038	2043	2048
Mogadishu	Low	Supplied Energy (GWh)	221	892	1,992	3,425	5,302
		Peak (MW)	39	157	350	601	931
	Base	Supplied Energy (GWh)	225	942	2,162	3,808	6,041
		Peak (MW)	39	165	380	669	1,061
	High	Supplied Energy (GWh)	229	995	2,345	4,233	6,880
		Peak (MW)	40	175	412	743	1,208
Galmudug	Low	Supplied Energy (GWh)	26	69	305	643	1,071
		Peak (MW)	5	12	54	113	188
	Base	Supplied Energy (GWh)	26	72	331	714	1,221
		Peak (MW)	5	13	58	125	214
	High	Supplied Energy (GWh)	26	74	358	794	1,391
		Peak (MW)	5	13	63	139	244
Hirshabelle	Low	Supplied Energy (GWh)	8	51	117	213	340
		Peak (MW)	1	9	20	37	60
	Base	Supplied Energy (GWh)	8	54	126	237	388
		Peak (MW)	1	9	22	42	68
	High	Supplied Energy (GWh)	8	56	137	264	442
		Peak (MW)	1	10	24	46	78
Jubbaland	Low	Supplied Energy (GWh)	40	117	541	1,153	1,941
		Peak (MW)	7	21	95	203	341
	Base	Supplied Energy (GWh)	40	122	586	1,282	2,212
		Peak (MW)	7	21	103	225	388
	High	Supplied Energy (GWh)	40	127	635	1,425	2,519
		Peak (MW)	7	22	112	250	442
Southwest	Low	Supplied Energy (GWh)	20	128	293	537	857
		Peak (MW)	4	22	51	94	151
	Base	Supplied Energy (GWh)	20	135	318	597	977
		Peak (MW)	4	24	56	105	172
	High	Supplied Energy (GWh)	20	142	345	663	1,113
		Peak (MW)	4	25	61	117	195
Puntland	Low	Supplied Energy (GWh)	64	137	749	1,575	2,622
		Peak (MW)	11	24	131	277	460
	Base	Supplied Energy (GWh)	64	141	810	1,751	2,988
		Peak (MW)	11	25	142	307	525
	High	Supplied Energy (GWh)	64	146	877	1,945	3,403
		Peak (MW)	11	26	154	342	598
TOTAL Southern Line	Low	Supplied Energy (GWh)	379	1,394	3,997	7,546	12,133
		Peak (MW)	67	245	701	1,325	2,131
	Base	Supplied Energy (GWh)	383	1,466	4,333	8,389	13,827
		Peak (MW)	67	257	761	1,473	2,428
	High	Supplied Energy (GWh)	387	1540	4,697	9,324	15,748
		Peak (MW)	68	271	826	1,637	2,765

3.2 Generation Expansion Plan

The overall objective of the Generation Expansion Plan is to simulate long-term operation of interconnected power systems and perform economic evaluation of the Interconnection Project. The study is conducted based on a comprehensive approach and methodology suitable for defining the

expansion plan of interconnection between the countries highlighting the benefits that can be attained by EEP, MoEM, ME&WR and EAPP to fulfil finance requirements estimating the power and economic energy exchanges deriving from variety of electricity production costs and generation capacities of interconnected countries.
In the study the estimation of the main benefits, the identification of potential deficit/surpluses of productions to be destined for economic exchange of electric energy between power systems and in the region is carried out using production cost-simulation, scenario analysis and other techniques suitable for economic analysis of viability of interconnection link. The horizon year of the analyses is 2048 and planning period is 2023-2048. Two approaches have been applied:

- For Ethiopia, the latest Generation Expansion Plan has been verified whether this plan is adequate to meet the reviewed expected demand, as well as to verify the margin available for power exchanges,
- For Northern/Southern line the Generation Expansion Plan has been developed based on the least-cost approach in order to minimize the sum of investment and expected production costs.

3.2.1 Revised Generation Expansion Plan for Ethiopia

The planning period of the present study is 2023-2048, thus beyond the planning period of the latest Generation Expansion Plan available up to the year 2040. During computational process some problems to cover the demand and scheduled export were found for the last years of the period. To overcome these problems the Consultant integrated the GEP adding three new power plants to be put in service beyond 2040. The Consultant proposes to use most advanced technology for thermal power plants as follows:

- new CCGT of 350MW natural gas firing in service in 2041
- new CCGT of 900MW natural gas firing in service in 2043
- new CCGT of 900MW natural gas firing in service in 2046

3.2.2 Generation Expansion Plan for Southern line: limited RES capacity scenario

Generation expansion of Southern line power system is performed assessing the ability of the corresponding Generation Expansion Plans (GEP) to supply the electricity demand over the planning period 2023-2048.
The demand forecast as capacity (MW) and energy (GWh) load is considered in the least-cost analysis, considering generation maintenance and outages of the power plants and reliability of renewable sources to meet the peak power load.
In the limited RES capacity scenario, the total installed capacity is increased from 44.3 MW in 2023 to 3,301.0 MW in 2048.
The following thermal power plants are included in generation investment plan:

- 38.5 MW HSDG power plants, diesel-burning, scheduled as follows:
  - 5.0 MW in 2024
  - 33.5 MW additional capacity up to 2028
  - No other HSDG are planned after the year 2029
- 240 MW MSDG power plants, diesel burning, scheduled as follows:
  - 170 MW in 2033
  - 70 MW additional capacity up to 2038
- 80 MW MSG power plants, LFO burning, up to 2031
- 285 MW Gas Turbine power plants, LFO burning, scheduled as follows:

- 45 MW capacity up to 2033
- 135 MW additional capacity up to 2038
- 60 MW additional capacity up to 2043
- 45 MW additional capacity up to 2048

- 6 new CCGT with rated power of 150 MW LFO burning. The construction of the combine cycles is assumed to be implemented in two phases. Each gas turbine is constructed and operated standalone in sequence the first years and then the steam turbine is constructed and connected to the gas turbine. Such practice allows the reduction of the investment costs and the operation follows the increment of load.
- 7 new CCGT with rated power of 240 MW LFO burning. As explained before their construction is assumed to be realized in phases, first the gas turbine is planned to operate standalone and then adding the steam turbine, in combined cycle. The 240 MW CCGT are schedules as follows:

The 150 MW and 240 MW CCGT are scheduled as follow, where "OCGT" means that the power plant starts its operation with gas turbine operated standalone, "CCGT" means that the steam turbine is constructed and connected to the gas turbine and the power plant is operated in the final configuration as combined cycle.

Table 3-4 – CCGT installation for Southern Line

#	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048
CCGT 150 MW																	
1		OCGT		CCGT													
2				OCGT		CCGT											
3								OCGT				CCGT					
4												OCGT				CCGT	
5														OCGT			CCGT
6																	OCGT
CCGT 240 MW																	
1					OCGT		CCGT										
2								OCGT		CCGT							
3									OCGT		CCGT						
4												OCGT		CCGT			
5													OCGT	CCGT			
6															OCGT		CCGT
7															OCGT		CCGT

The total installed capacity of renewable sources in Southern line is increased from 0 MW in 2023 to 404.0 MW in 2048. The following RES power plants are included generation investment plan:

- 48.5 MW PV power plants, in operation in 2033
- 117.0 MW PV power plants, in operation in 2038
- 224.0 MW PV power plants, in operation in 2043
- 404.0 MW PV power plants, in operation in 2048

Figure 3-1 shows the future evolution of total installed power capacity according to the capacity structure and peak power in Southern line.

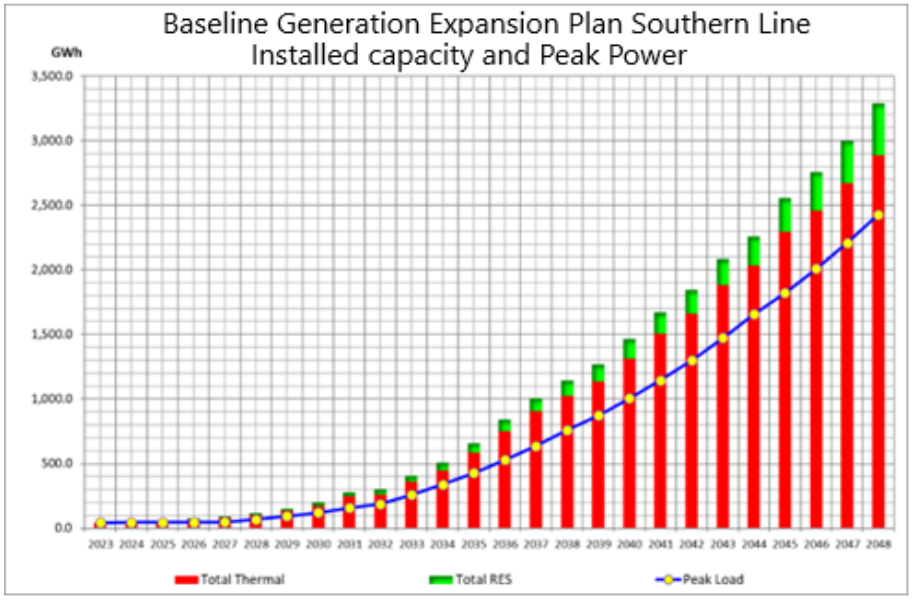

Figure 3-1 – Baseline Scenario - Development of Peak power and Installed Capacity for Southern line 2023 - 2048

The total Present Value of capital expenditure to implement the proposed generation expansion plan in Southern line relevant to the construction of new generation capacity during the planning period 2023-2048 is estimated 473.46 MUSD.

Including the operational costs and the fuel costs over the whole planning period 2023-2048, the expected generation costs are the following:

- The ***average*** short-term specific generation cost in Southern line relevant to the proposed generation plan during the first stage (2023-2031) is estimated 150.06 USD/MWh.
- The ***average*** short-term specific generation cost in Southern line during the second stage (2032-2048) is estimated 98.88 USD/MWh.

3.2.3 Generation Expansion Plan for Northern Line: limited RES capacity scenario

For the Northern line, in the limited RES capacity scenario, the total installed capacity is increased from 24.9 MW in 2023 to 1,159.2 MW in 2048.
The following thermal power plants are included in generation investment plan:

- 42.5 MW HSDG power plants, diesel-burning, scheduled as follows:
  - 14 MW in 2024
  - 28.5 MW additional capacity up to 2030
  - No other HSDG are planned after the year 2031
- 255 MW MSDG power plants, diesel burning, scheduled as follows:
  - 171 MW in 2033
  - 85 MW additional capacity up to 2038
- 690 MW Gas Turbine power plants, LFO burning, scheduled as follows:
  - 45 MW in 2033
  - 165 MW additional capacity up to 2038
  - 315 MW additional capacity up to 2043
  - 165 MW additional capacity up to 2048
- 250 MW Combined Cycle power plants, LFO burning, scheduled to be in operation in 2043.

The total installed capacity of renewable sources in Northern Line is increased from 3.2 MW in 2023 to 124.0 MW in 2048. The following RES power plants are included generation investment plan:

- 20.0 MW PV power plants, in operation in 2033
- 45.5 MW PV power plants, in operation in 2038
- 81.5 MW PV power plants, in operation in 2043
- 124.0 MW PV power plants, in operation in 2048

Figure 3-2 shows the future evolution of total installed power capacity according to the capacity structure and peak power in Northern Line.

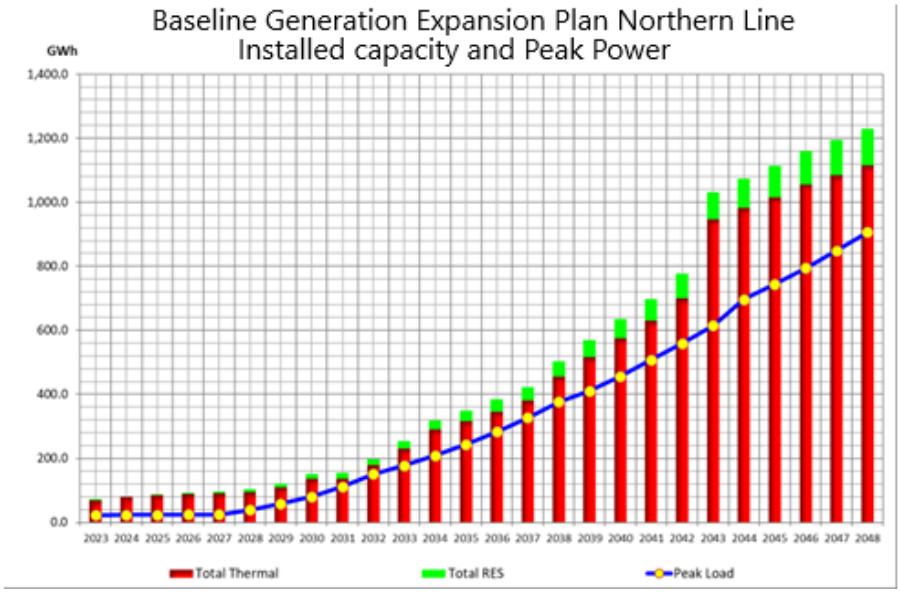

Figure 3-2 – Baseline Scenario - Development of Peak power and Installed Capacity for Northern Line 2023 - 2048

The total Present Value of capital expenditure to implement the proposed generation expansion plan in Northern Line relevant to the construction of new generation capacity during the planning period 2023-2048 is estimated 432.79 MUSD.

Including the operational costs and the fuel costs over the whole planning period 2023-2048, the expected generation costs are the following:

- The ***average*** short-term specific generation cost in Northern Line relevant to the proposed generation plan during the first stage (2023-2031) is estimated 272.57 USD/MWh.
- The ***average*** short-term specific generation cost in Northern Line during the second stage (2032-2048) is estimated 141.11 USD/MWh.

3.2.4 Generation Expansion Plan for Northern/Southern Line: enhanced RES capacity

In this scenario, in addition to the candidate conventional power plants of the previous scenario, the total installed capacity of renewable sources in Northern/Southern Line is increased from 3.3 MW in 2023 to 1600.0 MW in 2048.

The following PV Solar power plants are included generation investment plan:

- 70 MW PV power plants, in operation in 2033
- 130.0 MW PV power plants, in operation in 2038
- 350.0 MW PV power plants, in operation in 2043

- 942.0 MW PV power plants, in operation in 2048. Some of the new PV Solar power plant will be retired before the horizon year 2048

The following Wind Farm power plants are included generation investment plan:

- 25.0 MW WF power plants, in operation in 2033
- 145.0 MW WF power plants, in operation in 2038
- 315.0 MW WF power plants, in operation in 2043
- 640.0 MW WF power plants, in operation in 2048

Figure 3-3 shows the future evolution of total installed power capacity according to the capacity structure and peak power in Northern/Southern Line.

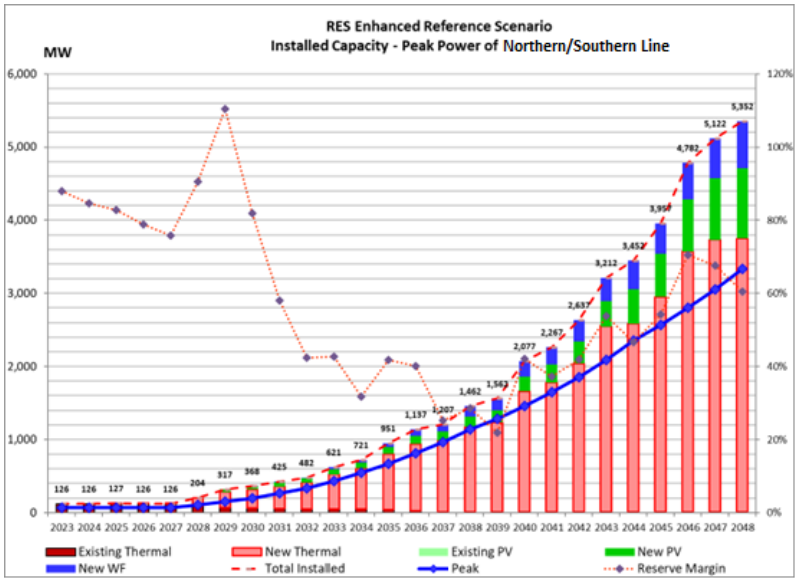

Figure 3-3 – RES enhanced scenario - Development of Peak power and Installed Capacity for Northern/Southern Line 2023 - 2048

The total Present Value of capital expenditure to implement the proposed generation expansion plan in Northern Line relevant to the construction of new generation capacity during the planning period 2023-2048 is estimated 464.06 MUSD.

The total Present Value of capital expenditure to implement the proposed generation expansion plan in Somalia relevant to the construction of new generation capacity during the planning period 2023-2048 is estimated 743.91 MUSD.

3.3 Transmission Expansion Plan

3.3.1 Ethiopian transmission system

Transmission adequacy of Ethiopia power system is performed assessing the ability of the corresponding Transmission Expansion Plan (TEP) to supply the electricity demand of internal consumption and to satisfy the obligation of power exchanges with other countries over the planning period 2023-2048.

Analysing the Ethiopian transmission plan included in the 25-year Master Plan, in the Rolling Plan 2022-2025 and the Eastern Ethiopia Electricity Grid Reinforcement Project, the Transmission Expansion Plan for Ethiopia is generally adequate to deal with the expected load increase and the expected power exchanges with neighboring countries. Two points need attention:

- At the year 2028, many voltage violations and some overloads already in normal conditions are present in the database. This is probably due to a delay in the realization of some projects, since

in the future the problems here detected disappear. Nevertheless, this situation needs attention in the operation of the power system in order to avoid possible criticalities, at least up to the realization of the required reinforcements.

- The backbones at which the interconnections with Somalia and Northern Line will be connected need attention. This is valid especially for the northern interconnection, for which the transmission lines from Debre Zeit to Jigjiga shall be operated at 400 kV voltage level, because of the length of the transmission lines.

3.3.2 Northern/Southern line transmission system

In coordination with the Generation Expansion Plan, the Transmission Expansion Plan of Southern/Northern Line has been been developed in order to identify the most appropriate national transmission grid for supplying the expected electricity consumption and for the development and the operation of the interconnections with Ethiopia. In synthesis, the main outcomes of the TEP of Southern/Northern Line includes:

- The transmission system internal to Northern/Southern Line shall be progressively developed starting from the S/S of the interconnections to electrify the Country and to progressively increase the utilization of the interconnections with Ethiopia,
- The creation of an Extra High Voltage (EHV) North-South backbone is important in the long-term period to transmit power from the interconnection and from the generation locations to the load centers, as well as to allow the development of renewable energy sources in Northern/Southern Line. The complete north-south backbone is expected not before 2048,
- The EHV North-South backbone can be realized in single-circuit configuration, on the contrary the interconnections with Ethiopia shall be realized in double circuit configuration. Specifically for the northern interconnection, also the segment Hargeisa – Berbera shall be in double-circuit configuration in order to assure the security of supply of Northern/Southern Line in case of contingencies,
- The adoption of the 500 kV voltage level internally to Northern/Southern Line increases the possibilities to transfer power from the generation facilities to the main load centers. More in detail, the adoption of the 500kV for the interconnections with Ethiopia increases the correspondent Net Transfer Capacity, particularly for the southern interconnection of about 30/40% in comparison with the solution “fully 400kV” solution,
- Considering that Ethiopia adopts the 400kV voltage level, the 400/500 kV transformation shall be realized, both for the northern and the southern interconnections. For the northern interconnection it has been agreed with stakeholders to realize the voltage transformation in Hargeisa S/S whilst for the southern interconnection, adopting the same approach, the 400/500kV transformation is placed in Dollow S/S,
- The transmission system in Northern/Southern Line is distributed on a wide geographical area. Therefore, its development shall be strictly coordinated with the development of generation facilities that cannot be totally switched-off: it means that part of the electricity demand in Northern/Southern line shall be necessarily supplied by local generation and the interconnections with Ethiopia cannot totally replace the generation in Northern/Southern lin,

Regarding the total investment costs in the electrical infrastructure for the period 2028-2048, they amount to the following figures:

- 3313 MUSD for Southern Line (500kV configuration)
- 1349 MUSD for Northern Line (500kV configuration)

3.4 Supply-demand analysis: expected energy flow on the interconnection

The estimation of production costs for energy and capacity in the Ethiopia and Northern/Southern Line in different operation conditions is simulated in order to determine the amount of energy and power that could be transmitted between two countries introducing new capacities of power transfer among them. The analysis is conducted using the SDDP software. The main inputs of the task are the Generation Expansion Plan and the Transmission Expansion Plan where the scheduled time of introduction of new units and new lines are defined.

Main steps of Supply –Demand Analysis of Ethiopia and Northern/Southern Line power systems are:

- **Preliminary step**: Creation of a multi-year (2023-2048) and multi-country Integrated Generation and Transmission Model as a transmission-constrained generation scheduling model. The optimal dispatches of generation resources (thermal, hydro and renewable) are constrained by the transfer capacity of the elements of HV transmission network and new Interconnection Projects.
- **First step**: Definition of the Reference Scenario and simulation of long-term operation of the Ethiopia and Northern/Southern Line power systems without the Interconnection Projects.
- **Second step**: Simulation of long-term (2023-2048) operation of power systems in the presence of Interconnection Projects (both of them) considering the bi-directional transfer capacities of interconnections. Conduct a supply-demand balance and production cost analyses for Ethiopia and Northern/Southern Line.

In order to assess the benefits that could be directly attributed to Interconnection Projects, the simulation results are compared identifying the economic benefits from power and economic energy exchanges. The following Operation Scenarios are simulated:

- **Reference Scenario:** The revised GEP of Ethiopia and the GEP of Northern/Southern Line is used for the supply –demand balance suitable to meet the demand of each system, including hydroelectric and thermal sources operating without the interconnections objective of the analysis. New generation capacities will be put into service according to the chronology defined in the GEP.
- **Interconnected Scenario**: Ethiopian and Northern/Southern Line power systems in Interconnected Scenario are considered as one interconnected system scheduling their annually hydro-thermal renewable generation and coordinating operation to minimize their operating costs and having as objective covering their electricity demand with daily power exchanges. Interconnected Scenario is analyzed assuming that the new interconnections assure the possibility to exchange power in both directions, in compliance with the capacity of the interconnections and the internal transmission lines.

3.4.1 Summary of the results of Supply-Demand, Production Cost and electricity transfers

Table 3-5 and Table 3-6 respectively reports the total electricity supply-demand balance for all the period 2023-2048 in Ethiopia and Southern/Northern Line for both scenarios considered in the Generation Expansion Plan, i.e.: limited RES capacity and enhanced RES capacity in Northern/Southern Line. For each country are reported the demand, production, energy losses and exchanges. In case of Southern Line, the exchanges include the energy exchanges between areas. During the planning period Ethiopia exports to Southern/Northern Line and imports just a small amount of electricity. The electricity losses are the losses on the interconnections.

The total electricity exchanges in the interconnected scenario over the planning period between two countries are:

- 78,048 GWh in the scenario without significant RES capacity in Northern/Southern Line
- 75,826 GWh in the enhanced RES capacity in Northern/Southern Line

Table 3-5 – Interconnected scenario – Electricity Balance of Ethiopia over the period 2023-2048

Total Electricity Balance 2023-2048		
Ethiopia	Limited RES	Enhanced RES
	GWh	GWh
Total Demand	**1,654,394**	**1,654,394**
TOTAL Supply	**1,611,501**	**1,610,896**
Total Production	1,947,895	1,941,584
Total Export to N/S Line and other countries	350,344	346,200
Total imports from N/S Line	13,950	15,512
Exchange Losses	180	204
Total ENS	43,100	43,709

Table 3-6 – Interconnected scenario – Electricity Balance of Southern/Northern Line over the period 2023-2048

Total Electricity Balance 2023-2048		
Southern/Northern Line	Limited RES	Enhanced RES
	GWh	GWh
Total Demand	**161,864**	**161,864**
TOTAL Supply	**161,690**	**161,957**
Total Production	112,013	117,151
Total Export between areas and Ethiopia	50,052	50,964
Total imports between areas and from Ethiopia	99,729	95,770
Exchange Losses	1,114	1,086
Total ENS	1,322	1,006

3.4.2 Cost of Electricity Supply

The electricity supply costs for the national demand are estimated for both countries. The supply cost considers not only the cost of electricity production but also the cost of imports/export of electricity. For imports of electricity the prices per MWh are assumed equal to the marginal system cost of the Ethiopia and for export of electricity, the marginal cost of the area in Northern and Southern Line. No other additional price due to other economic and commercial reasons are considered.

Figure 3-4 illustrates the evolution of the short-term average specific cost of electricity supply for Ethiopia in both scenarios: limited and enhanced RES capacity in Northern/Southern Line. The average specific cost of load remains at low level up to the year 2042 and the values are very similar in both scenarios. By the end of planning period, due to the shortage of electricity production, the more costly units are dispatched and import of electricity from Northern/Southern Line occurs, so the electricity cost is rapidly increased.

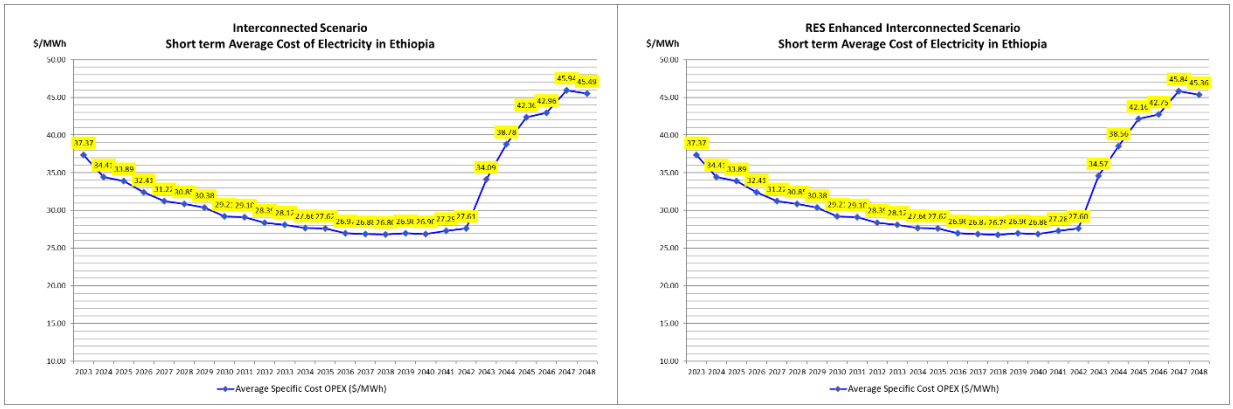

Figure 3-4 – Average Specific Cost of Electricity Supply in Ethiopia. Left: limited RES capacity in Northern/Southern Line, Right: enhanced RES capacity in Northern/Southern Line.

Figure 3-5 illustrates the evolution of the short-term average specific cost of electricity supply for Northern/Southern Line in both scenarios: limited and enhanced RES capacity in Northern/Southern Line. The components of supply cost are the operation and maintenance cost, fuel cost of power system and the cost for import of electricity. The specific supply cost ($/MWh) are estimated referring to the internal demand of Northern/Southern Line, and they have a similar behavior in both scenarios, even though with small differences in the values. The supply cost considers the expenses for electricity imports and the revenues from export of electricity.

The values in Northern/Southern Line drastically decreased when the interconnections are put in operation and import of electricity from Ethiopia occurs, substituting all the production of costly unit in Northern/Southern Line. By the end of planning period, due to the shortage of electricity production, these units are dispatched so the electricity cost is rapidly increased.

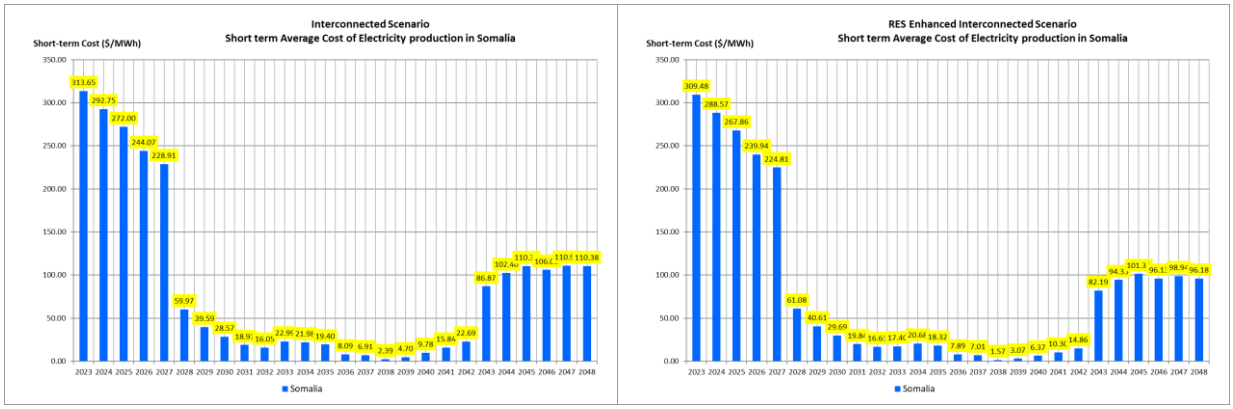

Figure 3-5 – Average Specific Cost of Electricity Supply in Northern/Southern Line. Left: limited RES capacity in Northern/Southern Line, Right: enhanced RES capacity in Northern/Southern Line.

3.4.3 Summary of the results of electricity Transfers

The total electricity that Northern/Southern Line import from Ethiopia by the interconnection line Mogadishu – Ethiopia is 36,619 GWh for the whole period in the limited RES capacity scenario, it reaches 35,284 GWh in the enhanced RES scenario. Figure 3-6 shows graphically the development of the annual energy transfer on the southern interconnection and the annual balance of the electricity economic exchanges over the 2023 - 2048 period.

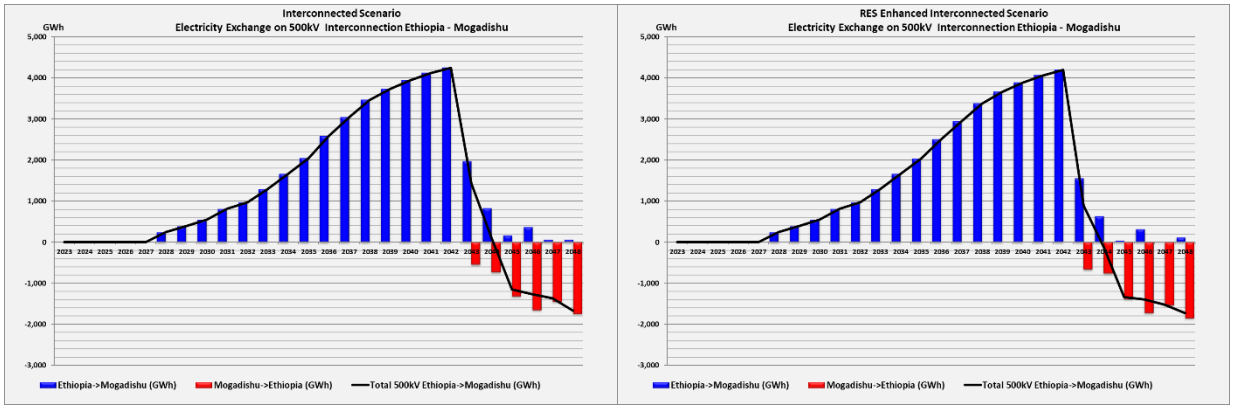

Figure 3-6 – Interconnected scenario - Electricity Exchanges in the interconnection Mogadishu – Ethiopia. Left: limited RES capacity in Northern/Southern Line, Right: enhanced RES capacity in Northern/Southern Line.

The total electricity that Northern/Southern Line import from Ethiopia by the interconnection line Hargeisa/Berbera – Ethiopia during the planning period is 27,480 GWh in the limited RES capacity scenario, it reaches 25,031 GWh in the enhanced RES scenario.

Figure 3-7 shows graphically the development of the annual energy transfer on the northern interconnection and the annual balance of the electricity economic exchanges over the 2023 - 2048 period.

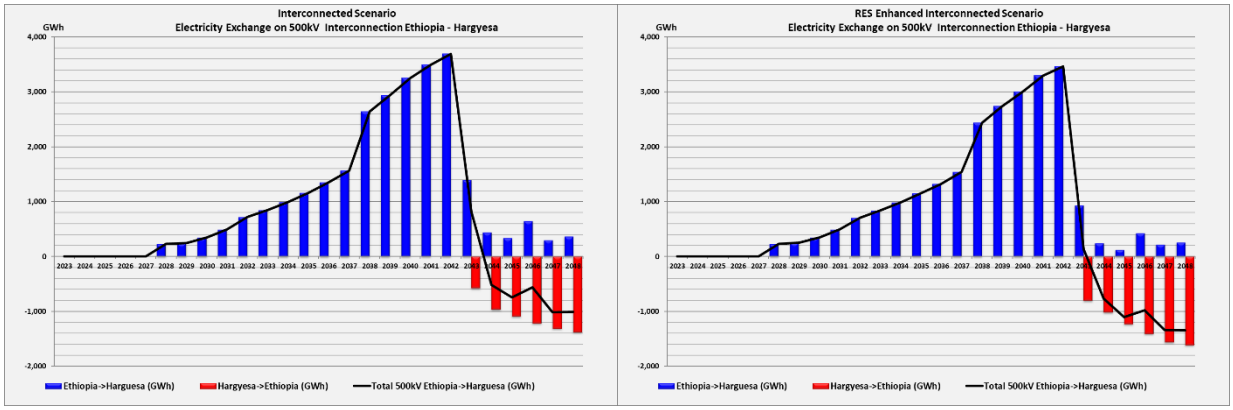

Figure 3-7 – Interconnected scenario - Electricity Exchanges in the 500kV interconnection Ethiopia - Hargeisa

In conclusion, the analyses reported in this document clearly shown that there are the conditions, in terms of expected energy exchange and in terms of expected evolution of average costs of electricity, to justify the realization of the new interconnections between Ethiopia and Northern/Southern Line.

3.4.4 Avoided installed thermal capacity due to the interconnections

Compared with Reference Scenario, the reduction of Installed Capacities in Northern/Southern Line in the interconnected scenario with limited RES capacity amounts to about 295.5 MW, which represents about 6.9% of the total thermal installed capacity in the reference (isolated) scenario, for a total of avoided investment cost of 443.8 MUSD. The avoided generation capacity is subdivided between Northern and Southern Line as follow:

- 165.0MW in Northern Line, for a total avoided investment costs of 248.0 MUSD
- 130.5MW in Southern Line, for a total avoided investment costs of 195.8 MUSD

In the RES enhanced scenario, the reduction of Installed Capacities in Northern/Southern Line amounts to 475.5 MW, for a total of avoided investment cost of 659.7 MUSD. This value represents about 11.1% of the total thermal installed capacity in the Reference Enhanced (isolated) scenario. The avoided generation capacity is subdivided between Northern and Southern Line as follow:

- 270.0MW in Northern Line, for a total avoided investment costs of 373.9 MUSD
- 205.5MW in Southern Line, for a total avoided investment costs of 285.8 MUSD

The avoided installed capacity can be associated to the interconnections as follow:

- The thermal capacity avoided in the Northern Line, but also the one in Southern Line (Puntland region) can be associated to the Northern Interconnection, for a total avoided investment costs of 249.7 MUSD
- The thermal capacity avoided in the Southern Line, except for the Puntland region can be associated to the Southern Interconnection, for a total avoided investment costs of 194.1 MUSD

Finally, the ratio between the avoided additional thermal capacity (180 MW) and the additional RES installed capacity (1072 MW) can be interpreted as the "capacity credit" of the RES additional generation mix under the interconnected operating condition. The ratio between the additional unused thermal capacities with the total additional RES capacities considered in the analysis is about 16.8%.

3.5 Optimal Route Selection for the interconnections

3.5.1 Northern Interconnection

For the Northern interconnection, three alternatives for each segment Debre Zeit – Hurso and Jigjiga – Hargeisa – Berbera have been detailed investigated through on-site visits. The main characteristics of such alternatives are listed in the following tables.

Table 3-7 – Different lengths of the interconnection alternatives – segment Debre Zeit - Hurso

Line Route	Length of Line Route
Option I (EEP option)	365.1 km
Option 2	364.5 km
Option 3	375.5 km

Table 3-8 – Different lengths of the interconnection alternatives – segment Jigjiga – Hargeisa – Berbera

Line Route	Length of Line Route
Option I	320.0 km
Option 2	315.5 km
Option 3	314.0 km

According to the investigations, considering both on-field investigations, technical, economic and environmental criteria, the best alternatives are:

- Option 1, for the segment Debre Zeit – Hurso
- Option 3, for the segment Jigjiga – Hargeisa – Berbera

The details of each segment are presented here below.

Segment Debre Zeit – Hurso

The first alternative route runs from the Debre Zeit Substation to Hurso Substations. The track articulates for the first 365.1 km on the east side of Ethiopia, which is pass closer to Adama Wind Farm. From there,

the proposed route follows the existing track of the existing 132kV and 230 kV lines alongside the main road from Adama to Awash and Meiso, Afdem and finally Hurso. The closeness of the line route to the access road and the existing transmission line is very helpful for the accessibility of the route during construction and operation/maintenance works.
Due to the Debre Zeit master plan expansion and settlements around substations areas, the alternative line passes away from the existing 132kV and 230kV lines until Back of Modjo and Senyo Gebya and joins the existing line.

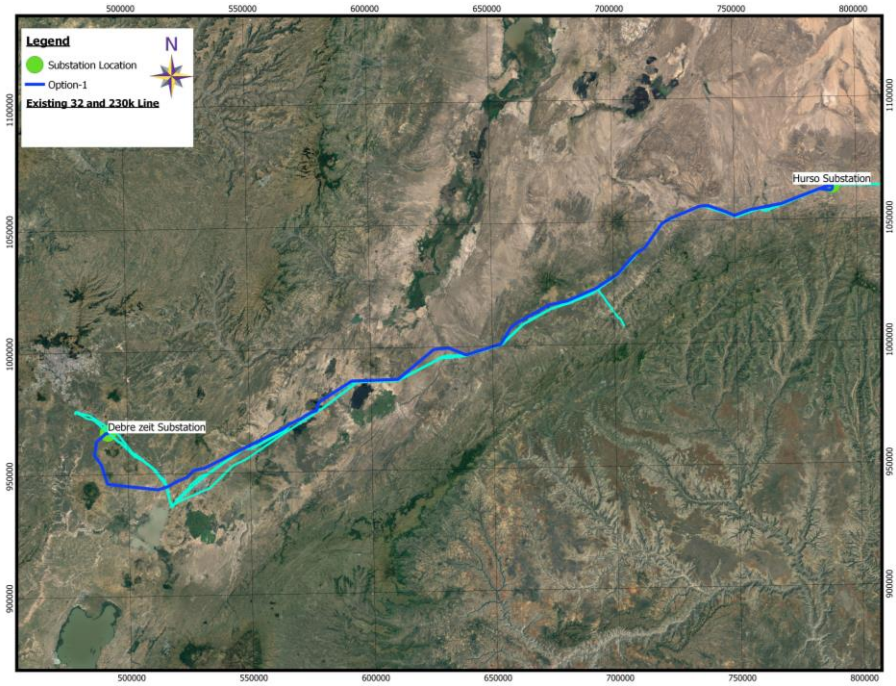

Figure 3-8 – Alternative-1 relative to the existing transmission lines (segment Debre Zeit – Hurso)

Segment Jigjiga – Hargeisa – Berbera

The third option of the interconnection, having a nominal voltage of 400 kV in the part Jigjiga – Hargeisa and 500 kV in the part Hargeisa – Berbera, has a total length of 313.96 km, of which approximately 73 km in Ethiopia and the rest in the Northern Line.

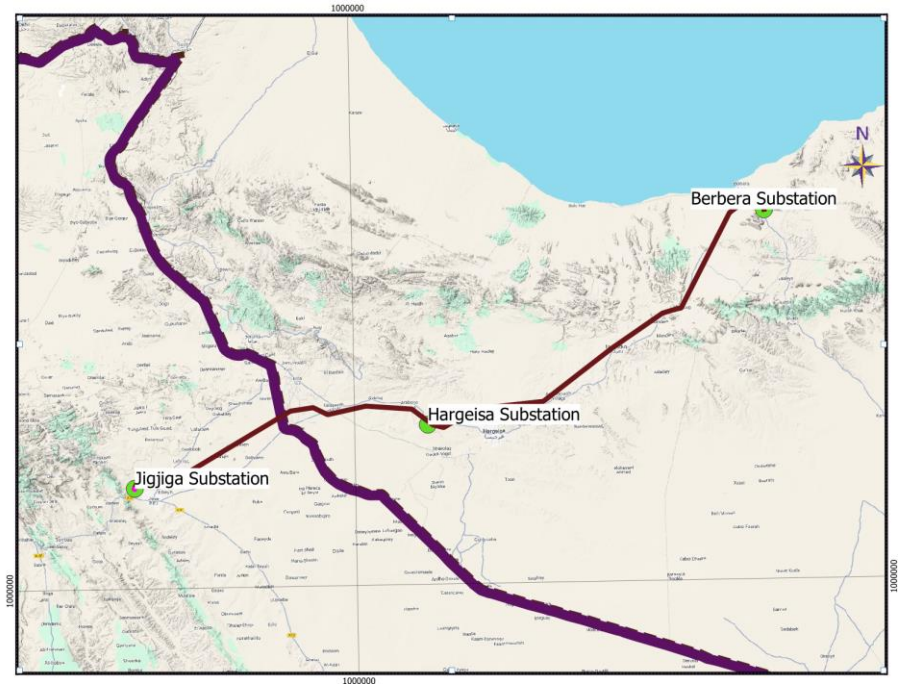

Figure 3-9 – Alternative-3 (segment Jigjiga – Hargeisa – Berbera)

3.5.2 Southern Interconnection

For the southern interconnection, three alternatives for each segment Genale Dawa III HPP – Dolo Ado – Southern Line border and Ethiopia border – Dollow – Baidoa – Mogadishu have been detailed investigated through on-site visits. The main characteristics of such alternatives are listed in the following tables.

Table 3-9 – Different lengths of the interconnection alternatives – segment Genale Dawa III HPP – Dolo Ado – Southern Line border

Line Route	Length of Line Route
Option I	359.4 km
Option 2	359.6 km
Option 3	356.5 km

Table 3-10 – Different lengths of the interconnection alternatives – segment Ethiopia border – Dollow – Baidoa – Mogadishu

Line Route	Length of Line Route
Option I	433.7 km
Option 2	431.4 km
Option 3	441.7 km

According to the investigations, considering both on-field investigations, technical, economic and environmental criteria, the best alternatives are:

- Option 1, for the segment Genale Dawa III HPP – Dolo Ado – Southern Line border
- Option 2, for the segment Ethiopia border – Dollow – Baidoa – Mogadishu

The details of each segment are presented here below.

Segment Genale Dawa III HPP – Dolo Ado – Southern Line border

In Ethiopia, the first alternative route runs from Genale Dawa III substation to Dolo Ado newly proposed substation and then up to the Ethiopia – Southern Line border. The total length of the first option is

359km and it follows the existing Genale Dawa III to Yirgalem for the first 10 km. From there, the proposed route runs alongside the road from Negele to Dolo Ado, passing Negele, Filtu, Bokolmayo, and Melka Dida towns.

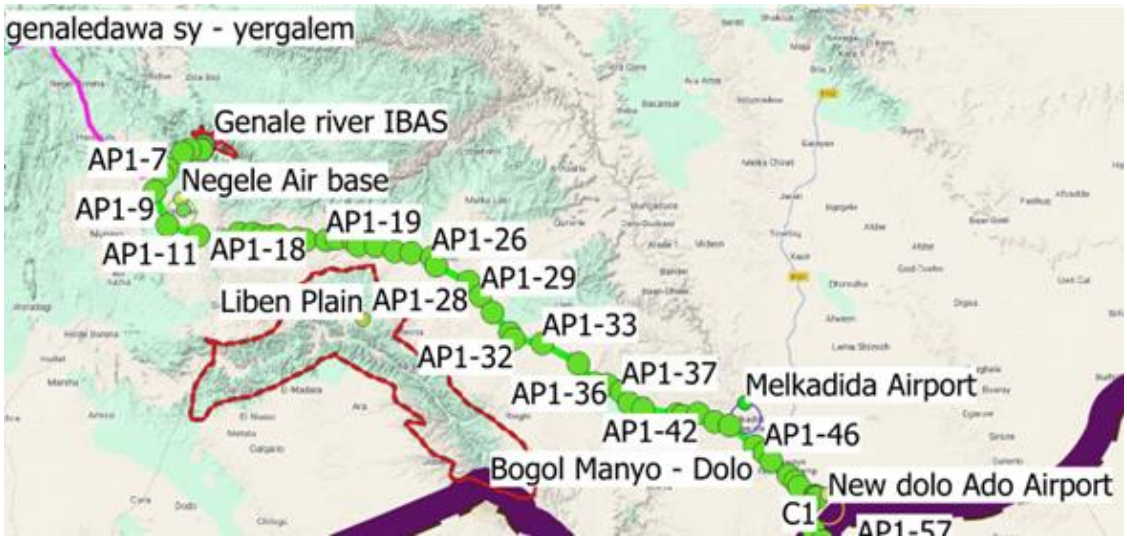

Figure 3-10 – Alternative-1 (segment Genale Dawa III HPP – Dolo Ado – Southern Line border)

Segment Ethiopia border – Dollow – Baidoa – Mogadishu

In Southern Line, the second alternative route runs from the border with Ethiopia up to. Dollow, luuk, Yurkud, Berdaale, Baidoa, Afgoye (see the figure below) and from Ethiopian Border until end Mogadishu covers 431 km.

Figure 3-11 – Alternative-2 (segment Ethiopia border – Dollow – Baidoa – Mogadishu)

3.6 Results of power system analysis

Based on the results of the power system analysis, the structure of the Northern Interconnection between Ethiopia and Northern Line is schematically shown in the following figure.

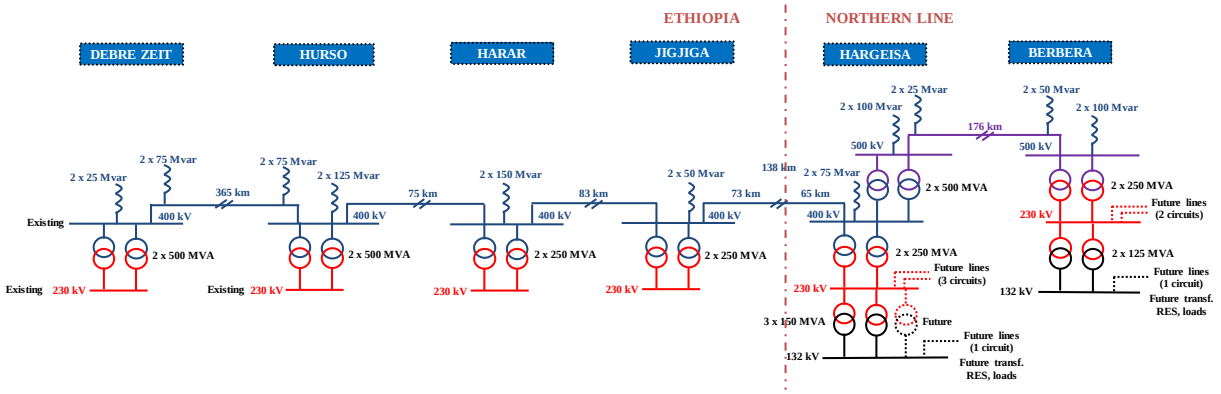

Figure 3-12 – Scheme of the Northern interconnection

More in detail, the characteristics of the Northern Interconnection are the following:

- Components that are part of the projects:
  - Transmission lines for segments Debre Zeit – Hurso, Jigjiga – Hargeisa and Hargeisa – Berbera
  - Substations of Debre Zeit (extension), Hurso (extension), Harar (extension), Jigjiga (extension), Hargeisa (new S/S), Berbera (new S/S)
- Technology: Alternating Current
- Nominal voltage: 400 kV in Ethiopia, up to the substation of Hargeisa in Northern Line, 500 kV in Northern Line for the segment Hargeisa - Berbera
- Configuration: double circuit
- Rated capacity: up to 1000 MW (in both directions) in N and N-1 conditions.
- 500/400kV transformation located in Hargeisa S/S

The structure of the Northern Interconnection between Ethiopia and Southern Line is schematically shown in the following figure.

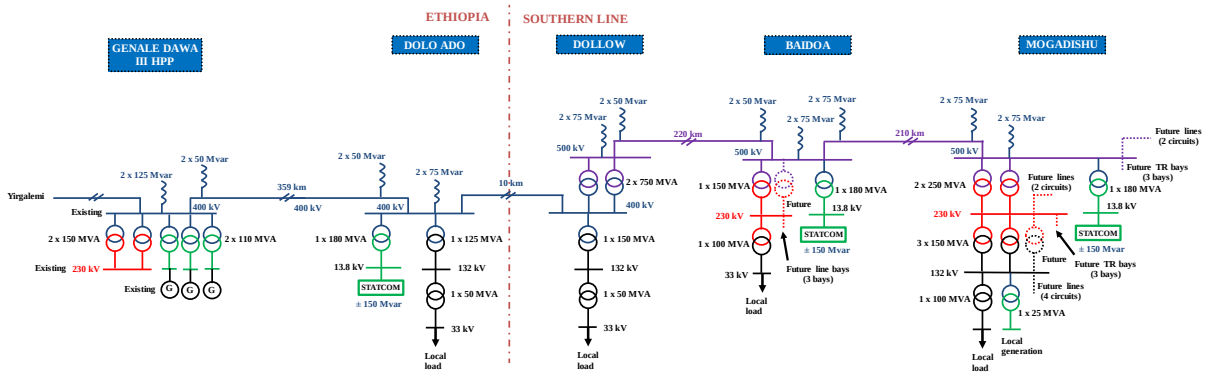

Figure 3-13 – Scheme of the Southern interconnection

More in detail, the characteristics of the Southern Interconnection are the following:

- Components that are part of the projects:
  - Transmission lines for segments Genale Dawa III HPP – Dolo Ado, Dolo Ado – Dollow, Dollow – Baidoa and Baidoa - Mogadishu
  - Substations of Genale Dawa III HPP (extension), Dolo Ado (new S/S), Dollow (new S/S), Baidoa (new S/S), Mogadishu (new S/S)
- Technology: Alternating Current

- Nominal voltage: 400 kV in Ethiopia, up to the substation of Dollow in Southern Line, 500 kV in Southern Line for the segments Dollow – Baidoa and Baidoa – Mogadishu
- Configuration: double circuit
- Rated capacity: up to 1000 MW (in both directions) in N and N-1 conditions.
- 500/400kV transformation located in Dollow S/S
- STATCOM required in the substations of Dolo Ado, Baidoa and Mogadishu

With reference to power system analysis, the interconnections as per the configurations reported in the previous figures are feasible, with the following remarks:

- The development of the interconnections must be performed in parallel with the development of the internal transmission grids in Northern and Southern Line in order to allow the power exchanges on the new infrastructures,
- The reactive power compensation plays a fundamental role for both interconnections, but especially for the Southern Interconnection, for which three STATCOM have been identified,
- Both interconnections, but especially the Southern one, are characterized by very long transmission segments: this implies that the power transfer on both interconnection is limited to 600/700 MW for both infrastructures in both directions,
- The impact on the transmission system of Ethiopia is not very huge, and no particular reinforcements have been identified,
- The short circuit currents, for the S/S of both interconnections, are quite limited, especially for the southern interconnection. This implies that no problems are expected for the selection of the circuit breaker interrupting duty but, as already mentioned, the voltage profiles shall be carefully controlled with the installation of adequate reactive power compensation devices,
- The complete redundancy of the first step protection system is recommended for both interconnections to solve the problem of some Critical Clearing Time lower than the first time of intervention of the line protections,
- To improve the dynamic behaviour of the interconnected systems and to avoid problems of inter-area oscillations, it is recommended to equip some power plants in Somalia and some power plant in Ethiopia with Power System Stabilizers:
    - PSS device in Northern/Southern Line are required in most of its power plants, for sure for all conventional power plants connected to the National Grid having a nominal capacity starting from some tens of MW. The need of such PSS devices is required because the Somali system is expected to be developed radially inside Northern/Southern Line and to be connected to the Ethiopian system through two long interconnections: this is the typical scenario that can cause poor-damped oscillations in the grid
    - also for some generators in Ethiopia the installation of PSS devices seems required, not only for the development of the interconnections with Northern and Southern Line, but also for the development of interconnections with other countries, which will significantly increase the dimensions of the interconnected power system
- The installation of some batteries in Northern and Southern Line improves in a significant way the stability of both power system, since batteries are able to provide fast-response reserve, contribute to frequency and voltage regulation,
- An appropriate coordination between Ethiopia, Northern and Southern Line must be assured for the secure and reliable operation of the interconnected power systems,
- For the long line Dollow – Mogadishu (about 430 km) both energization and single-pole reclosing are not feasible: thus, the Baidoa substation shall be realized since the beginning and the control

of the voltage profiles requires the installation of STATCOMs on the backbone of the southern interconnection
- The operation at 230 kV level of the Northern interconnection is feasible limiting the power transfer to 150 MW, but not recommended; on the contrary, the operation of the Southern Interconnection at 230 kV level is not feasible.

3.7 Recommendations for the secure operation of the interconnected power systems

The operation of different power systems interconnected between them implies the adoption of common procedures and operating rules aimed to assure the security of all electrical systems not only in normal conditions, but especially in case of contingencies.

In general, the basic procedures for realizing the synchronization of different power systems are:
- Before implementing the synchronous Cross-Border Interconnection, the National Grid Codes and the on-field practices of the Grid Operators shall have been harmonized and adapted to the requirements of the EAPP Grid Code. Part of the assessment is the selection of rules, obligations and procedures that are mandatory to be conformed since the beginning and the timeline to complete the compliance path.
- In addition to the neighboring Grid Operators, a devoted team of Grid Operators led by SMO (System and Market Operator) should be part of the process with the main tasks of guaranteeing the Grid Operators of the involved areas on the correct application of the principles of the EAPP Grid Code. SMO is also supervisor of the programs and the time schedules.
- In addition to the technical matters, Grid Operators shall sign a series of contracts and agreements on the market rules, which are not part of the Grid Codes.
- The harmonization process shall be concluded before the first commercial Operation of the first Cross-Border Interconnection of the Power Systems.
- Final decision for synchronization and connection shall be taken at the unanimity by all Grid Operators involved in the Synchronous Areas based on the proposal of SMO.

The common operational rules cover several aspects, which are mainly the following:
- The frequency control,
- The voltage and the reactive power control,
- The load shedding schemes,
- The frequency limits,
- The protection systems,
- The procedures to be adopted for the synchronization,
- The trial period,
- Criteria for the operation and for the disconnection of the interconnections.

Since Northern/Southern Line does not have a national grid code, the recommendation is to proceed with the development of a National Grid Code based on the guidelines included in the EAPP regional code, which remains in any case the reference for the operation of Northern/Southern Line power system until the formal adoption of national grid codes and operational policies.

3.8 Project budgetary costs

3.8.1 Northern Interconnection

The subdivision of the Project costs for all infrastructures necessary for the full operation of the new Ethiopia – Northern Line interconnection between countries is reported here below. In summary:

- The total project investment costs amount to about USD 700 million, of which:
  - USD 395 million in Ethiopia (56.4% of the total)
  - USD 305 million in Northern Line (43.6% of the total)

The subdivision among components is expected to be the following:

- About USD 396 million are expected for the transmission line (about 57% of the total), for a total of 680 km, including both 400kV and 500kV transmission lines,
- About USD 189 million are expected for the substations (about 27% of the total), for a total of 6 substations,
- About USD 114 million include supervision, coordination, monitoring and contingencies (including environmental, social and RAP costs), about 16% of the total.

Table 3-11 – Cost estimation - Total CAPEX for country – Northern interconnection

Project costs	Ethiopia	Northern Line
AC Double circuit line	245,280	150,800
Extension of Debre Zeit S/S	4,160	-
Extension of Hurso S/S	37,100	-
Extension of Harar S/S	23,660	-
Extension of Jigjiga S/S	21,020	-
Hargeisa S/S	-	67,200
Berbera S/S	-	36,100
Rural electrification	1200	2,800
Consultancy Supervision Services	11318	8682
Regional coordination & monitoring	1415	1085
Contingencies	49683	38115
Total	394,835	304,783
TOTAL PROJECT	**699,618**	

Focusing the attention on the fixed operational and maintenance (O&M) costs, Table 3-12 reports the quantification of this costs for each Country assuming a total value of 1%/year of the total CAPEX.

Table 3-12 – Cost estimation - Total fixed O&M costs for country – Northern interconnection

Project costs	Ethiopia	Northern Line
AC Double circuit line	2,453	1,508
Extension of Debre Zeit S/S	42	-
Extension of Hurso S/S	371	-
Extension of Harar S/S	237	-
Extension of Jigjiga S/S	210	-

Project costs	Ethiopia	Northern Line
Hargeisa S/S	-	672
Berbera S/S	-	361
Rural electrification	12	28
Total	3,324	2,569
TOTAL PROJECT	**5,893**	

In total, about US$ 5.9 million of O&M costs are expected for each year of the project lifetime.

3.8.2 Southern Interconnection

The subdivision of the Project costs for all infrastructures necessary for the full operation of the new Ethiopia – Southern Line interconnection between countries is reported here below. In summary:

- The total project investment costs amount to about USD 758 million, of which:
  - USD 274 million in Ethiopia (36.2% of the total)
  - USD 484 million in Northern Line (63.8% of the total)

The subdivision among components is expected to be the following:

- About USD 486 million are expected for the transmission line (about 64% of the total), for a total of 790 km, including both 400kV and 500kV transmission lines,
- About USD 155 million are expected for the substations (about 20% of the total), for a total of 5 substations,
- About USD 117 million include supervision, coordination, monitoring and contingencies (including environmental, social and RAP costs), about 16% of the total.

Table 3-13 – Cost estimation - Total CAPEX for country – Southern interconnection

Project costs	Ethiopia	Southern Line
AC Double circuit line	203,840	282,300
Extension of Genale Dawa III HPP S/S	6,340	-
Dolo Ado S/S	21,200	-
Dollow S/S	-	52,450
Baidoa S/S	-	28,400
Mogadishu S/S	-	46,540
Rural electrification	2,000	2,000
Consultancy Supervision Services	7,219	12,781
Regional coordination & monitoring	902	1,598
Contingencies	32,632	57,779
Total	274,133	483,848
TOTAL PROJECT	**757,981**	

Focusing the attention on the fixed operational and maintenance (O&M) costs, Table 3-14 reports the quantification of this costs for each Country assuming a total value of 1%/year of the total CAPEX.

Table 3-14 – Cost estimation - Total fixed O&M costs for country – Southern interconnection

Operational costs	Ethiopia	Southern Line
AC Double circuit line	2,038	2,823
Extension of Genale Dawa III HPP S/S	63	-
Dolo Ado S/S	212	-
Dollow S/S	-	525
Baidoa S/S	-	284
Mogadishu S/S	-	465
Rural electrification	20	20
Total	2,334	4,117
TOTAL PROJECT	**6,451**	

In total, about US$ 6.4 million of O&M costs are expected for each year of the project lifetime.

3.9 Economic & Financial analysis, project viability

3.9.1 Economic and CBA analysis

The project aims to enhance power trade, integrate Somalia into the East African Power Pool (EAPP), mitigate supply risks, and foster optimal use of energy resources by leveraging both conventional and renewable generation. The analysis follows the ENTSO-E Guidelines for grid development projects, employing a total surplus approach to quantify the economic gains in terms of producer and consumer benefits, as well as environmental and security-of-supply improvements.

The key objectives are to:

- Increase market efficiency by enabling the exchange of cheaper power from Ethiopian hydropower,
- Reduce the need for investment in expensive peak thermal generation, particularly in Somalia,
- Enhance energy reliability and supply security, thereby supporting socio-economic growth in both countries.

The analysis considers both a reference scenario (current market conditions) and an enhanced renewable energy (RES) scenario. The CBA reveals robust economic viability for the project in both scenarios:

Table 3-15 – Results for the reference case.

	NPV	IRR	B/C RATIO
ETHIOPIA	5.883.877.548	23%	13.8
SOMALIA	8.799.349.176	26%	16.7
TOTAL	14.683.226.724	25%	15.4

Table 3-16 – Results for the enhanced RES case.

	NPV	IRR	B/C RATIO
ETHIOPIA	5.884.176.627	23%	13.8
SOMALIA	11.508.186.148	30%	21.7
TOTAL	17.392.362.775	27%	18.1

These results highlight that the interconnection not only yields significant economic benefits overall but that Somalia stands to gain from lower-cost power imports and the avoidance of costly thermal generation investments. The enhanced RES scenario further amplifies these benefits, underpinning the value of integrating higher levels of renewable energy.

In terms of benefit breakdown for the interconnection projects, the following table reports the subdivision between Northern and Southern Line in both reference and enhanced RES scenario.

Table 3-17: Breakdown for Somalia benefits in the reference case.

	NPV	IRR	B/C RATIO
NORTHERN LINE	3,686,066,834	26%	73.0
SOUTHERN LINE	5,113,282,341	25%	11.0
SOMALIA	8,799,349,176	26%	16.7

Table 3-18: Breakdown for Somalia benefits in the Enhanced RES case.

	NPV	IRR	B/C RATIO
NORTHERN LINE	4,769,601,623	31%	95.0
SOUTHERN LINE	6,738,584,525	30%	14.4
SOMALIA	11,508,186,148	30%	21.7

Based on these findings, decision-makers are encouraged to advance the project with confidence. The interconnection is not only a strategic investment to modernize regional power infrastructure but also a catalyst for broader socio-economic development and environmental sustainability. Further detailed planning and stakeholder engagement are recommended to secure necessary investments and ensure successful project implementation.

3.9.2 Financial and Risk analysis

The financial analysis of bot interconnections is grounded in a regulated revenue model using a cost-plus (Rate-of-Return) approach, while also discussing the merchant alternative. The core purpose is to evaluate project viability by comparing cash flow profiles, risk-adjusted returns, and debt service capabilities. Overall, the projects are structured with an 80:20 debt-to-equity ratio and are financed with highly concessional loans at an interest rate of 2.24%, under an annuity repayment scheme over a repayment period of 15 years.

Key elements of the analysis include:

- **Funding Structure**: The projects are financed with an 80:20 debt-to-equity ratio. Total funding encompasses construction costs, DSRA contributions, and financing expenses (approximately 13% of total costs).
- **Revenue Model**: The regulated (cost-plus) revenue approach ensures full cost recovery while delivering a steady revenue stream via pre-set tariffs. This is contrasted with the merchant model, where revenues depend on congestion rents and market-based mechanisms.
- **Risk & Coverage**: Robust cash flow calculations—distinguishing between Free Cash Flows from Operations (FCFO) and Free Cash Flows to Equity (FCFE)—are used alongside sensitivity analyses.

Debt Service Cover Ratios (DSCRs) ranging from 1.43x to 1.65x reinforce the projects' resilience against market fluctuations.

The analysis delivers clear financial metrics across the four interconnection segments:

Table 3-19 – Project comparison.

	Northern Interconnection		Southern Interconnection	
	Ethiopia	Northern Line	Ethiopia	Southern Line
NPV m$	239	168	150	299
Project IRR	18.97%	15.44%	10.11%	10.14%
Equity IRR	11.19%	9.61%	16.54%	16.64%
Tariff c$/kWh	20	15	12	22
Min DSCR	1.65	1.43	1.51	1.5

The financial analysis confirms that the interconnection projects are economically viable and strategically beneficial for enhancing regional energy connectivity. Key conclusions include:

- The projects exhibit positive NPVs and robust IRRs, underpinning their potential to generate stable returns while meeting investor and public sector requirements.
- The regulated revenue model ensures predictable revenue streams and risk-adjusted returns, whereas the merchant model could offer upside potential in dynamic market conditions.
- Strong DSCRs and prudent funding structures (with low financing costs) mitigate the inherent risks of large-scale infrastructure investments.

Overall, the report makes a compelling case for the further development of these interconnection projects. With carefully structured financial models, rigorous risk assessments, and attractive performance metrics, the initiatives are well-positioned to contribute significantly to regional energy efficiency and market integration.

3.10 Project Implementation Plan

The implementation plan of the interconnection projects is estimated to be about 26 months starting from the date of the tender invitation.
This means that, for assuring the operation at the beginning of 2029, the tender invitation shall be launched at the end of 2025, in any case not later than January 2026.

More in detail, two lots are foreseen both for Ethiopia, Northern Line and Southern Line referred to Northern and Southern Interconnections:

- Lot 1: Construction of the transmission line
- Lot 2: Construction/upgrade of substations

The provisional timetable for both lots for Ethiopia – Northern interconnection is the following:

Project Description	Tender/ Invitation	Contract/ Award	Contract/ Completion
Ethiopia			
Transmission Lines			
Lot 1 - Transmission Line Debre Zeit – Hurso and Jigjiga - up to Northern Line border	N	N+10 Months	N+10+26 Months
Substations			
Lot 2 - Substation Debre Zeit (extension), Substation Hurso (upgrade), Substation Jigjiga (upgrade) and Substation Harar (upgrade)	N	N+10 Months	N+10+26 Months

The provisional timetable for both lots for Northern Line – Northern interconnection is the following:

Project Description	Tender/ Invitation	Contract/ Award	Contract/ Completion
Northern Line			
Transmission Lines			
Lot 1 – 400kV Transmission Line from the border with Ethiopia to Hargeisa S/S + 500kV Transmission Line from Hargeisa S/S to Berbera S/S	N	N+10 Months	N+10+26 Months
Substations			
Lot 2 - Substation Hargeisa (new), Substation Berbera (new)	N	N+10 Months	N+10+26 Months

The provisional timetable for both lots for Ethiopia – Southern interconnection is the following:

Project Description	Tender/ Invitation	Contract/ Award	Contract/ Completion
Ethiopia			
Transmission Lines			
Lot 1 – 400kV Transmission Line Genale Dawa III HPP – Dolo Ado - up to Southern Line border	N	N+10 Months	N+10+26 Months
Substations			
Lot 2 - Substation Genale Dawa III HPP (extension), Substation Dolo Ado (new)	N	N+10 Months	N+10+26 Months

The provisional timetable for both lots for Southern Line – Southern interconnection is the following:

Project Description	Tender/ Invitation	Contract/ Award	Contract/ Completion
Southern Line			
Transmission Lines			
Lot 1 – 400kV Transmission Line from the border with Ethiopia to Dollow S/S + 500kV Transmission line from Dollow S/S to Baidoa S/S to Mogadishu S/S	N	N+10 Months	N+10+26 Months
Substations			
Lot 2 - Substation Dollow (new), Substation Baidoa (new), Substation Mogadishu (new)	N	N+10 Months	N+10+26 Months

The period of 10 months between the tender invitation and the contract award includes the following phases: contractors pre-bid meetings/site visits, contractor clarifications to tender documents, tender submission/opening, evaluation phase, financier approval, contact negotiation and finalization.

4 RECOMMENDATIONS AND NEXT STEPS

The development of the interconnection projects between Ethiopia and Northern/Southern Line shall be intended as a coordinated process involving different factors and different aspects of both power systems of Ethiopia and Norther/Southern Line.
First, the construction and the operation of both interconnections shall be coordinated with the contemporaneous development of the electric system inside Northern/Southern Line: only in this way, in fact, the interconnections can be exploited in the optimal way bringing the expected benefits in terms of economic and social welfare growth in Northern/Southern Line thanks to the availability of significant amount of electricity.

Second, several other steps shall be addressed, including (but not limiting to):

- Definition of an Interconnection Operation Agreements between Ethiopia and Northern/Southern Line for the operation of the interconnections,
- Develop a National Grid Code in Northern/Southern Line for the operation of the power system and the two interconnections with Ethiopia, starting from the regional guidelines already defined by EAPP,
- Create and adequately train personnel dedicated to the development and operation of the electrical system in Northern/Southern Line, including the interconnections, based on approach adopted on international levels and in agreement with the EAPP guidelines and procedures.

Lastly, but not the least, a series of other studies and updates on the existing procedures and plans shall be performed, such as (but not limiting to):

- Before the operation of the interconnections, make a detailed protection setting analysis for each component of each interconnection and, for Ethiopia, update/control the protection settings of the network components directly impacted by the interconnections, whose operation will be affected by the presence of the new link
- Develop a National Control Center (NCC) for the control, monitoring and operation of the national power system and the interconnections with neighbouring countries

- Update the defense plan in Ethiopia, also considering the interconnections and the expected power flow towards Northern/Southern Line
- Reoptimize the Power System Stabilizers (PSS) already installed in Ethiopia, considering the modified transmission grid topology, as well as install and set the PSS also on the new generating units.