The 2017 Programme for Infrastructure Development in Africa (PIDA)

Ethiopia- Sudan Extra High Voltage Power System Interconnector Project

Blue Nile Energy Corridor (BNECO)

11-14 December 2017,
Namibia

Ethiopia-Sudan Power Interconnector (BNECO)

Project Location

Region of Eastren Africa Power Pool (Ethiopia & Sudan)

Owners & Project Sponsors

Government of Sudan

Government of Ethiopia

Implementing Partners

Sudanese Electricity Transmis sion Company (SETCO)

Ethiopian Electrical Power (EEP)

Regional Economic Community

Intergovernmental Authority on Development (**IGAD**)

Presentation Outlines

I. **Introduction.**

II. Feasibility Study

III. Main out comes

IV. Project Status

I. Introduction

❖ ***Back ground***

- Sudan and Ethiopia have already interconnected their transmission grids at **220 kV** voltage level. And now they are desirous to interconnect their power systems at Extra high voltage level.
- A contract signed in **2015** for conducting techno-economic Feasibility Study, technical specifications, Tender document and drafting of Interconnection Agreements with international consultant (CESI of Italy).
- The study was financed jointly by the two countries from their own resources about (*2.4 million Euro*).
- The final Feasibility Study report was submitted since Feb.2017.

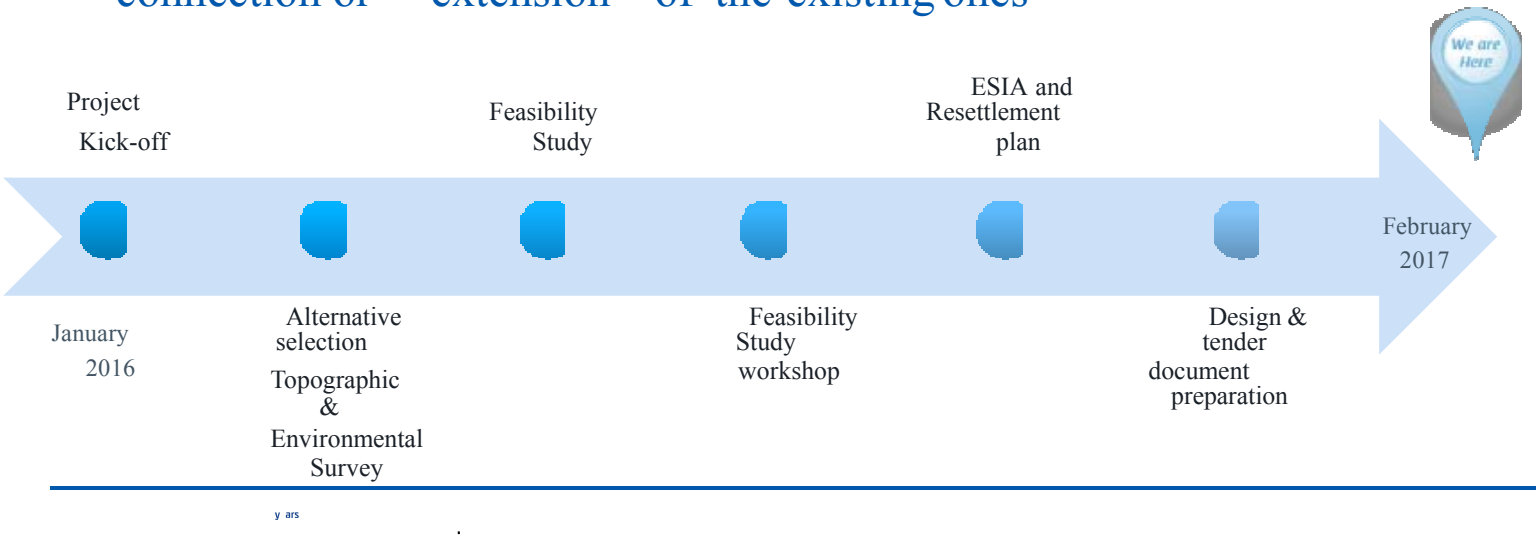
I. Introduction

❖ ***The Project***

- Techno-economic feasibility study for Extra High Voltage (EHV) Interconnection between Ethiopia and Sudan(completed)
- Different alternative options investigated
- Selection of the most technically, environmentally economically and financially feasible alternative.

❖ Challenges of the Project

- Selection of the best connecting points of the existing network
- Identification of the best route of the line
- Identification of the technology of the line
- Reinforcements of the existing electric grid
- Environmental and Social Impact Assessment (ESIA & RAP)
- Design & tender documents of the transmission line
- Design & tender documents of the new substations for the connection or extension of the existing ones



I. Introduction

❖ Main Benefits of the Project

The designed interconnection allows to get the Benefits from

Technical viewpoint

- Enhancement of the security of the system
- Improvement of the reliability of the system (sharp reduction power outages)
- Optimization of the generating resources in Ethiopia and Sudan
- Future power exchanges (power trade) with third Countries (e.g. with Egypt) i.e enhance regional economic integration.

I. Introduction

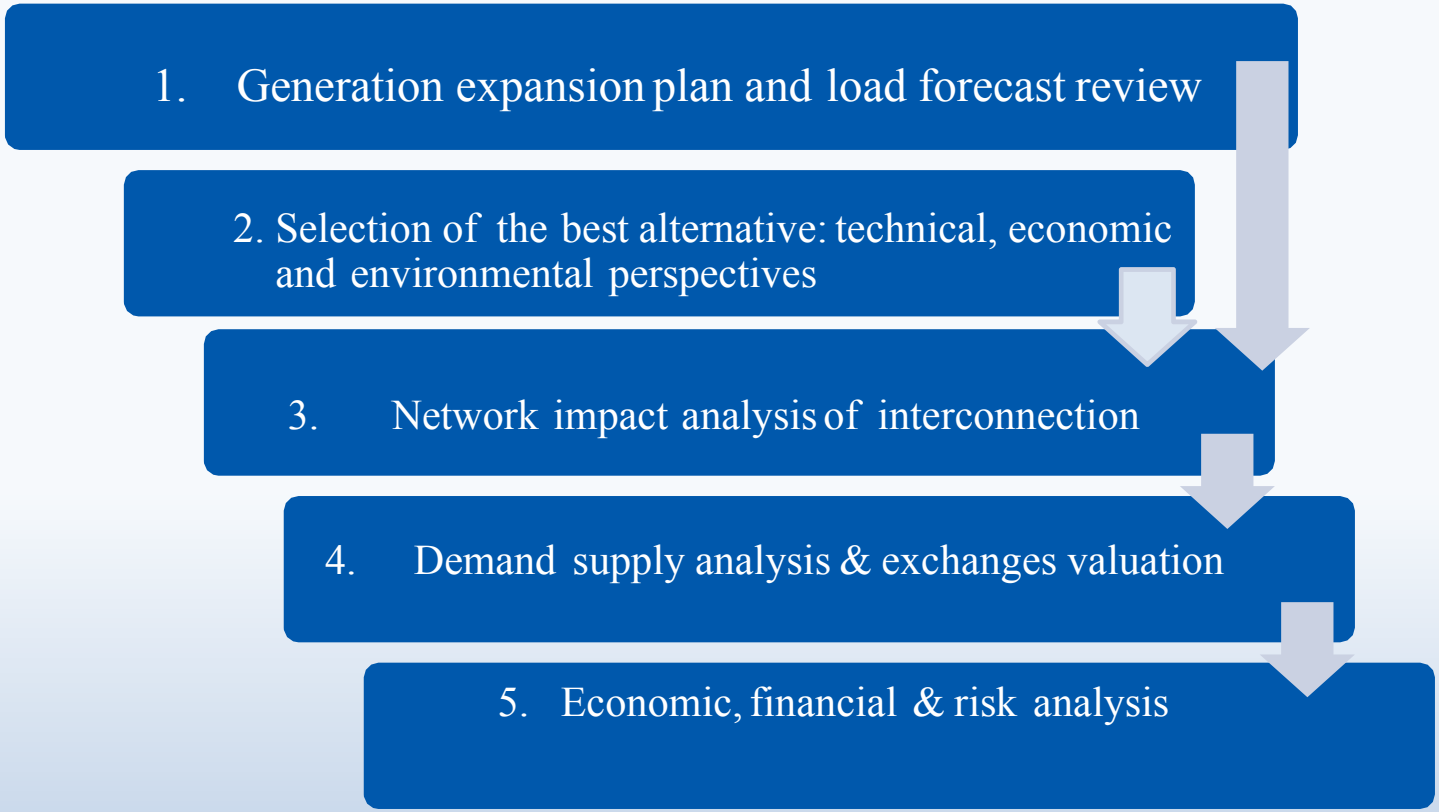
❖ Main Benefits of the Project

The designed interconnection allows to get the **Benefits** from

Economic and Financial viewpoints:

- Extremely positive economic impacts, robust to all sensitivity analyses.
- Sharp reduction in losses Expected Energy Not Supplied (EENS).
- Sharp reduction in system marginal prices.
- Sharp reduction of CO2 emissions.
- High levels of financial viability.
- Promote the economic development of both Countries.
- Attract investors to invest in agriculture sector in the region (land, water, energy). also will drive industrial sector in Sudan.
- Creates a lot of jobs direct and indirect.

II. Feasibility Study



II. Feasibility Study

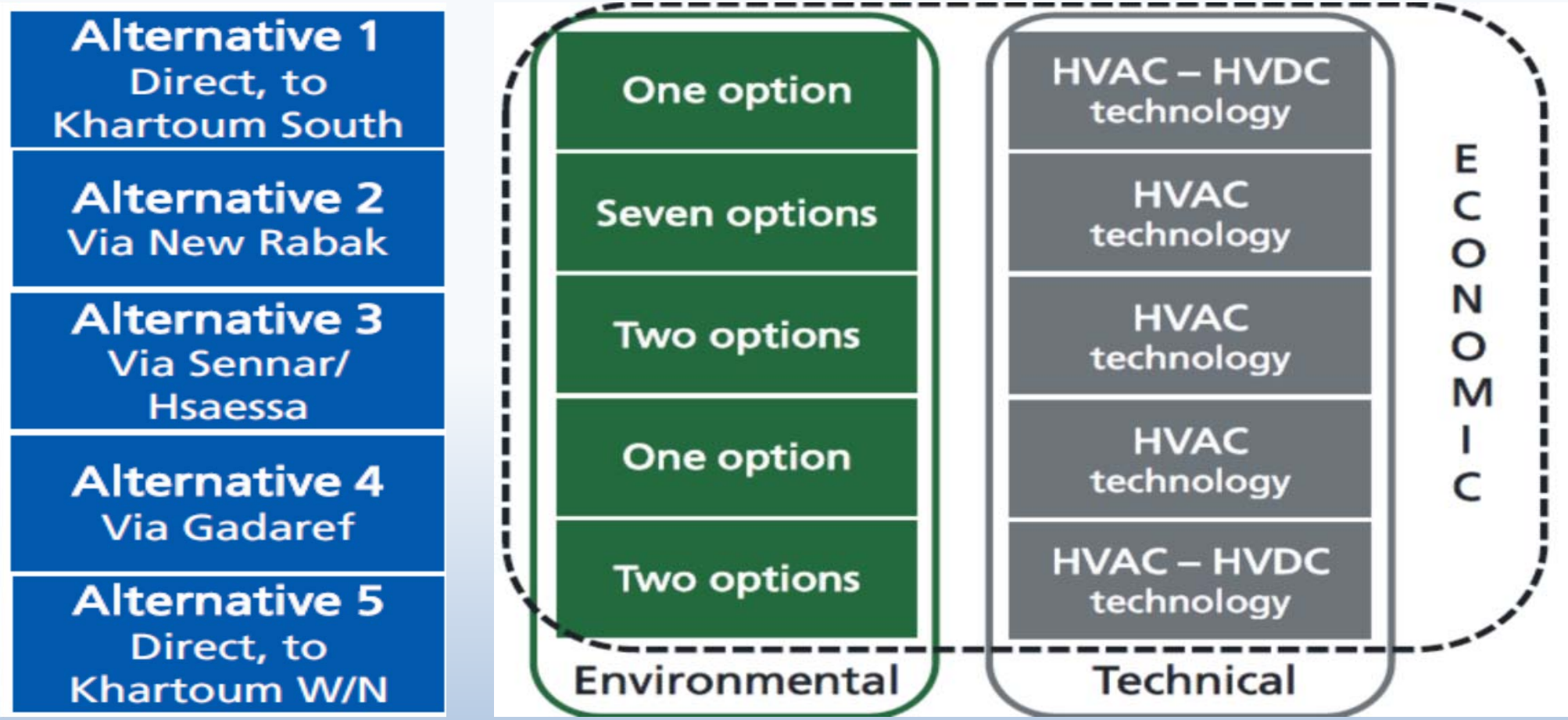
❖ *Alternative of Interconnection*

Five alternatives considered for the Ethiopian-Sudan UHV interconnection:

- Alternative 1: Renaissance Dam to Khartoum, *550 km*
- Alternative 2: Renaissence Dam to Khartoum, via Rabak , *580 km*
- Alternative 3: Renaissance Dam to Khartoum, via Sennar/Hsahessa , *550 km*
- Alternative 4: Renaissance Dam to Khartoum, via Gadaref , *650 km*
- Alternative 5: Renaissance Dam to Khartoum/Bagair or El-Kabashi , *615 km.*

II. Feasibility Study

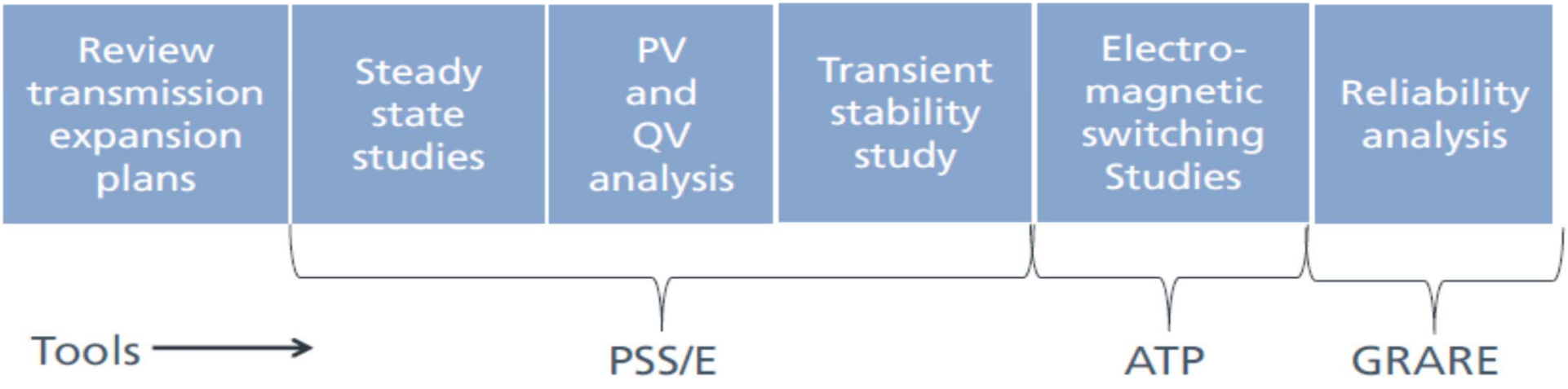
❖ **Several alternatives have been investigated between Grand Renaissance to Khartoum area.**



II. Feasibility Study

Network impact analysis of the interconnection

Set of detailed studies in order to evaluate the impact of the new interconnection on the Sudanese and Ethiopian networks



❖ Final Ranking

The AHP method has been applied using the following indicators: i) the Environmental and Socio-economic KPI, ii) the Total Technical Performance KPI and iii) the Total CAPEX KPI.

	RANKING	Environmental and socio-economic KPI	Total Techincal Performance KPI	Total CAPEX KPI	Final KPI
1	ALTERN 2 OPT 2	1.00	0.99	0.96	0.95
2	ALTERN 2 OPT 1	0.93	0.99	0.92	0.85
3	ALTERN 2 OPT 3	0.83	0.99	0.99	0.81
4	ALTERN 2 OPT 6	0.70	0.99	1.00	0.69
5	ALTERN 2 OPT 4	0.71	0.99	0.91	0.64
6	ALTERN 3 OPT 1	0.69	0.97	0.90	0.60
7	ALTERN 3 OPT 2	0.69	0.96	0.88	0.58
8	ALTERN 2 OPT 5	0.55	0.99	0.96	0.52
9	ALTERN 2 OPT 7	0.52	0.99	0.97	0.50
	ALTERN 5 OPT 2	Unfeasible	0.96	0.97	Unfeasible
	ALTERN 1	Unfeasible	0.94	0.91	Unfeasible
	ALTERN 5 OPT 1	Unfeasible	0.94	0.82	Unfeasible

The final ranking shows that the best interconnection solution is the Alternative 2, option 2 (via New Rabak)

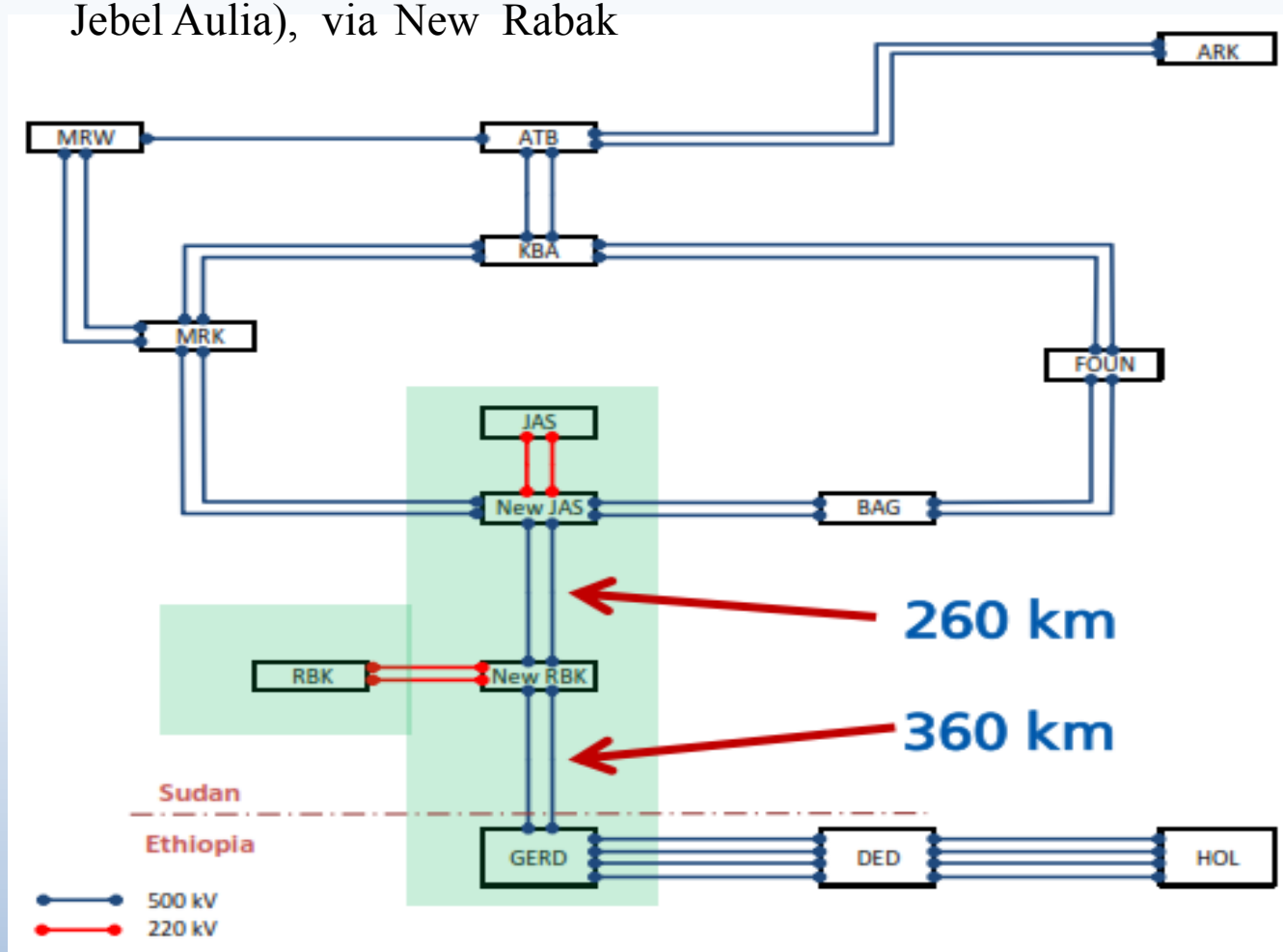
Location

Ethiopia-Sudan Power Interconnector

•The Project will connect the Grand Renaissance Dam in Ethiopia with Sudan and ultimately Egypt.

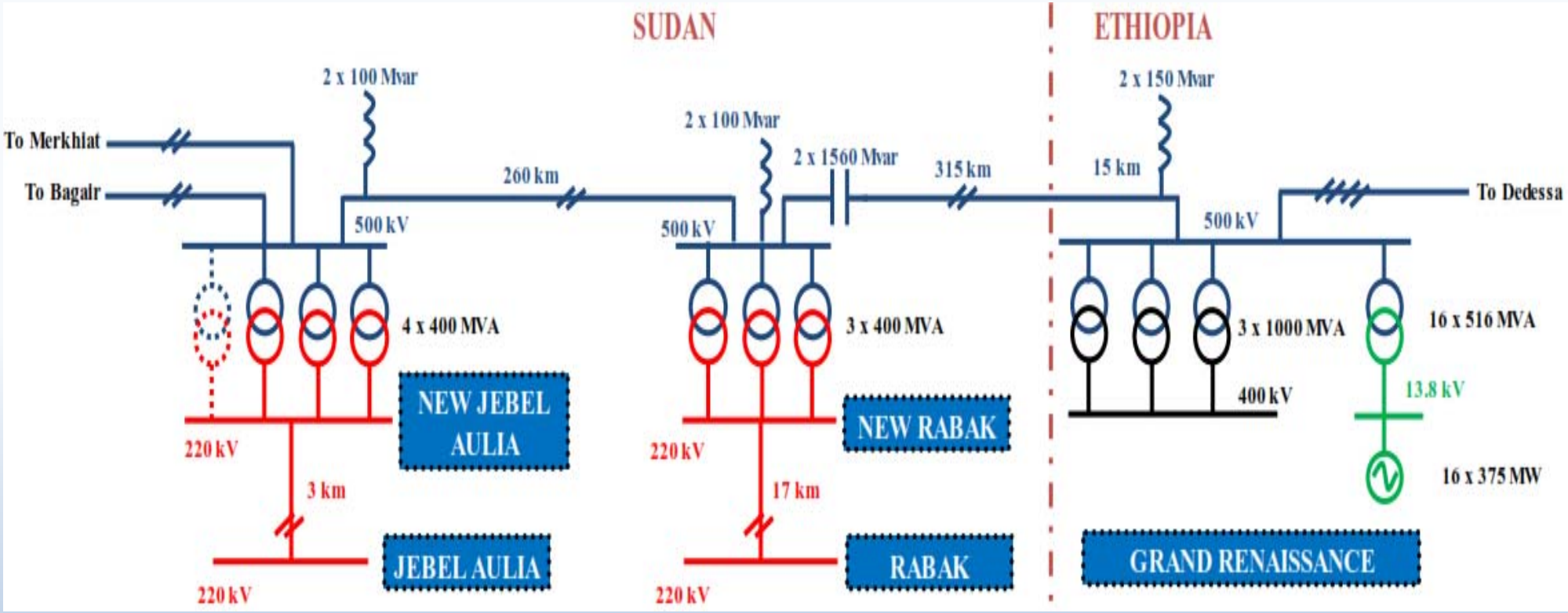
The selective alterative, alternative2 Option2

Interconnection between Grand Renaissance and the Khartoum area (New Jebel Aulia), via New Rabak



Configuration of the interconnection after the technical analyses

- **Project Component:**

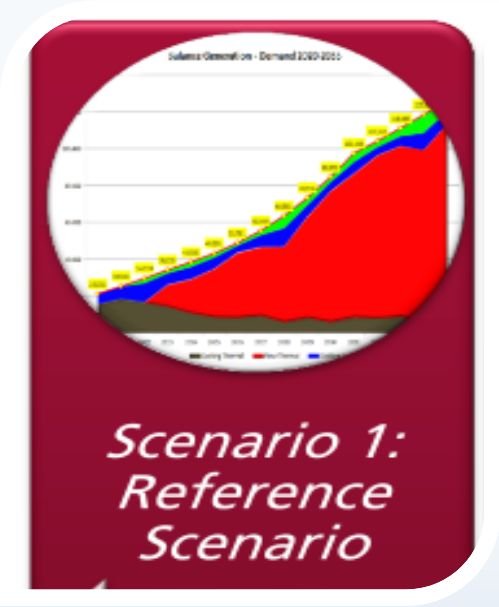


Main features of the selected interconnector

- On the basis of the analyses performed in the Feasibility Study, the best alternative is the interconnection *Grand Renaissance — New Jebel Aulia substation with intermediate substation in New Rabak.*

- The main technical characteristics;
  - Double circuit AC line.
  - Voltage level: 500 kV.
  - The capacity of the interconnection (3000 MW)
  - Length *Grand Renaissance – New Rabak 330 km* and
  - *New Rabak – New Jebel Aulia 260 km*,

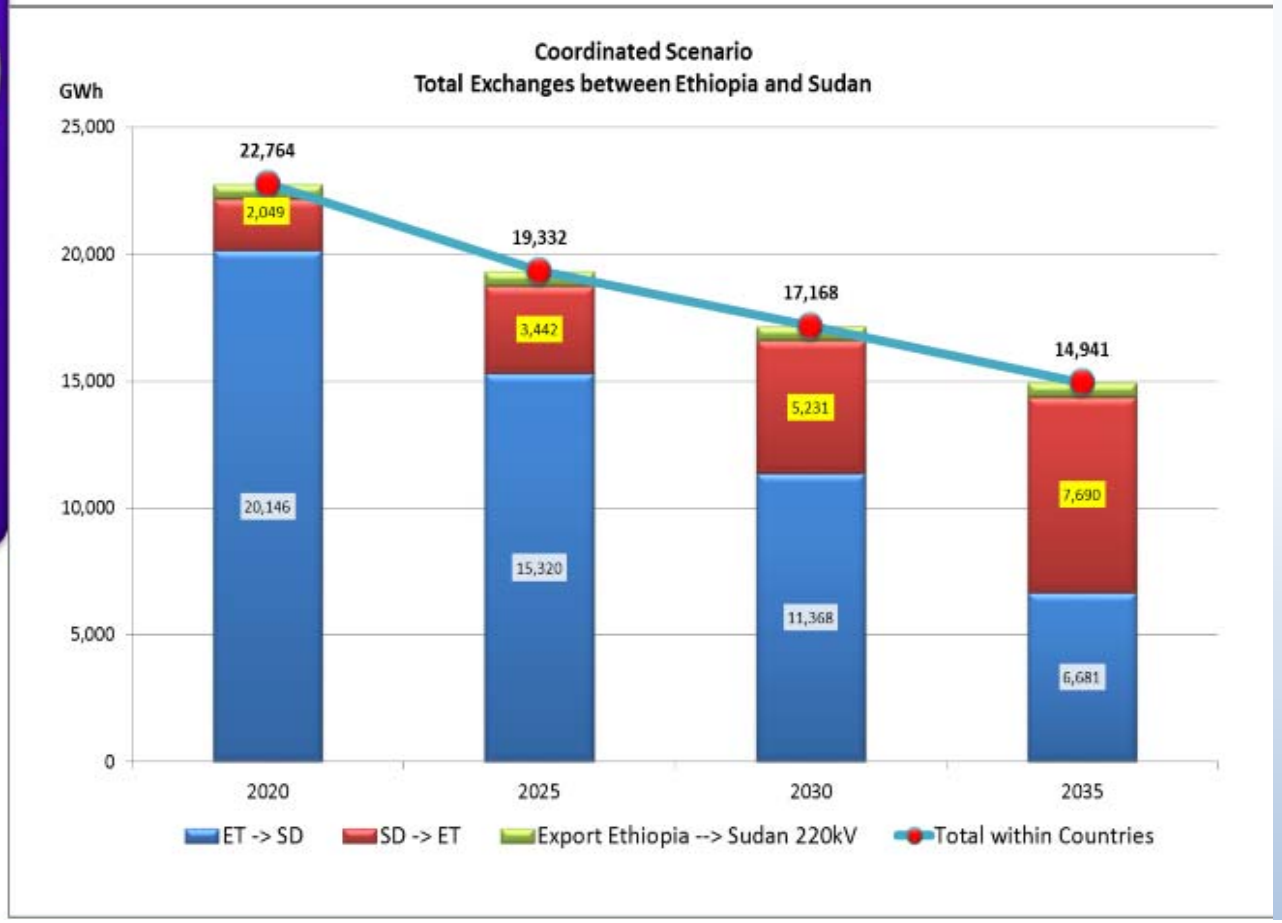
Demand supply analysis & exchanges evaluation



Scenario 1 – Reference Scenario

Under the Reference Scenario Ethiopian and Sudanese power systems are developed and operated independently from each other's and schedule their generations annually to meet their electricity demand and long term trade contracts

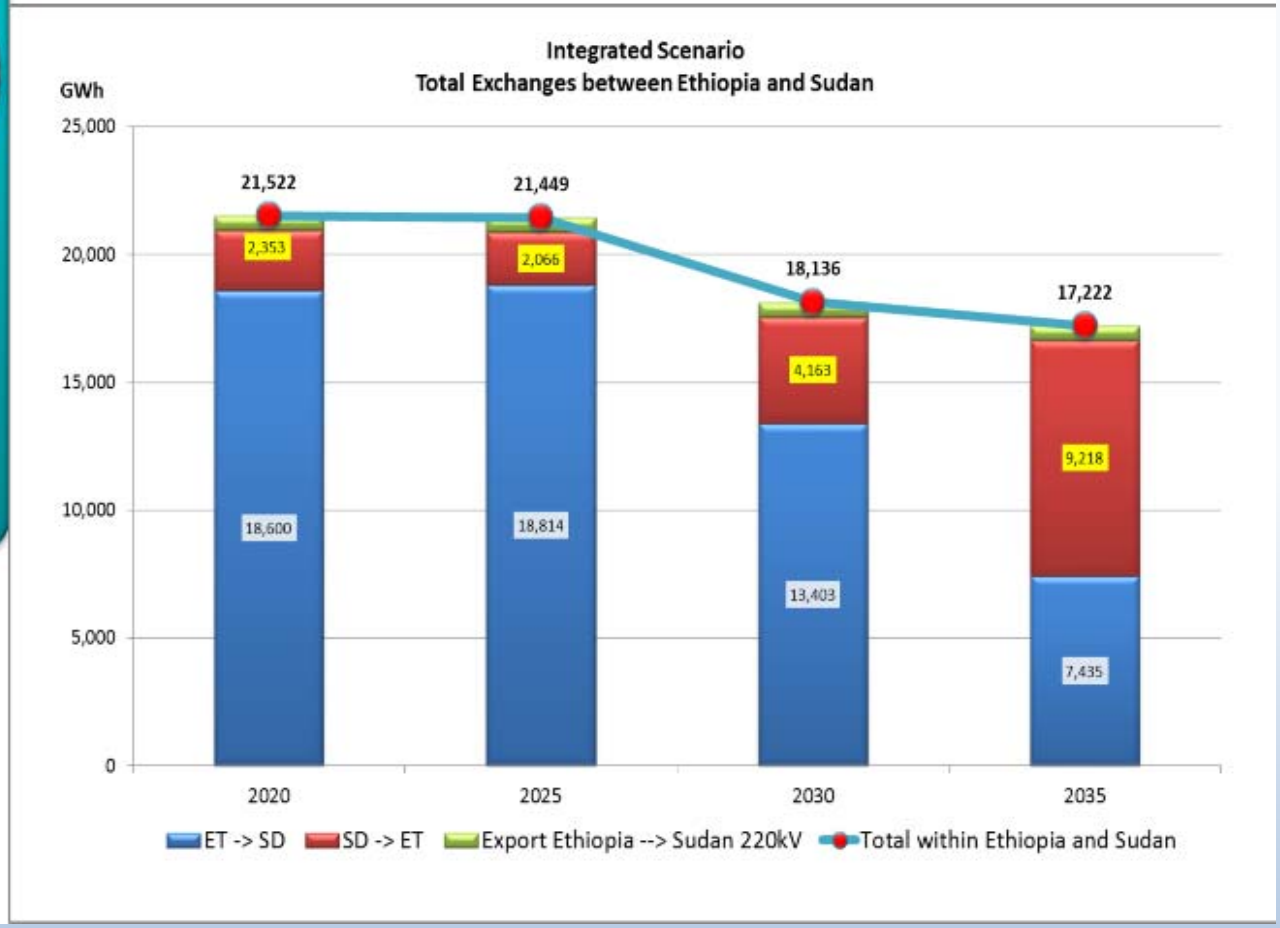
Demand supply analysis & exchanges evaluation -



Scenario 2: Coordinated Scenario

Ethiopian and Sudanese power systems in the Coordinated Scenario are considered as **two** interconnected systems scheduling their annually hydro-thermal generation and **coordinating operation** to minimize their operating costs having as objective covering their electricity demand with daily power exchanges.

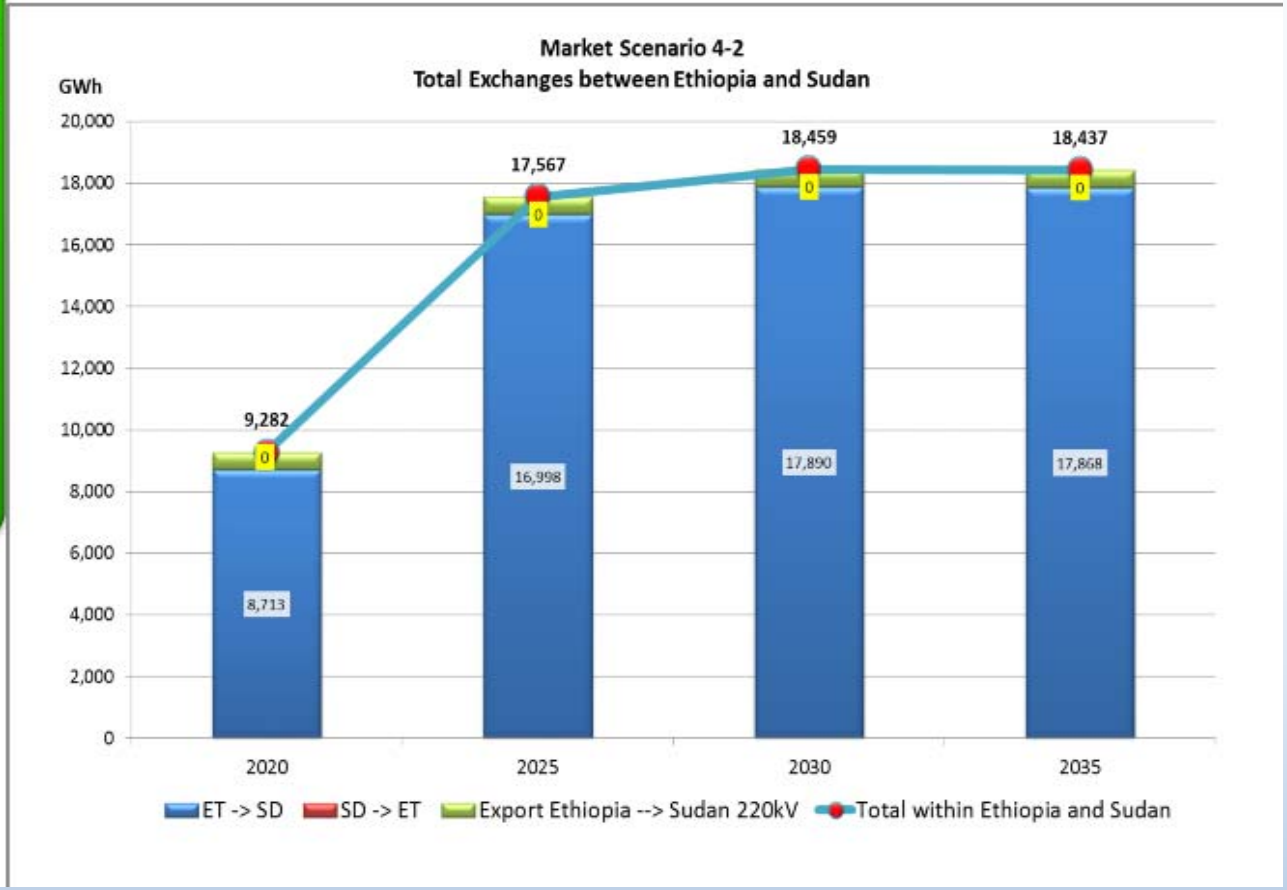
Demand supply analysis & exchanges evaluation – Scenario 3



Scenario 3 Integrated Scenario

Ethiopian & Sudanese power systems are considered as **one interconnected system (Integrated system)** scheduling their annually hydro-thermal generation to minimize their operating costs and having as objective covering their electricity demand with daily power exchanges.

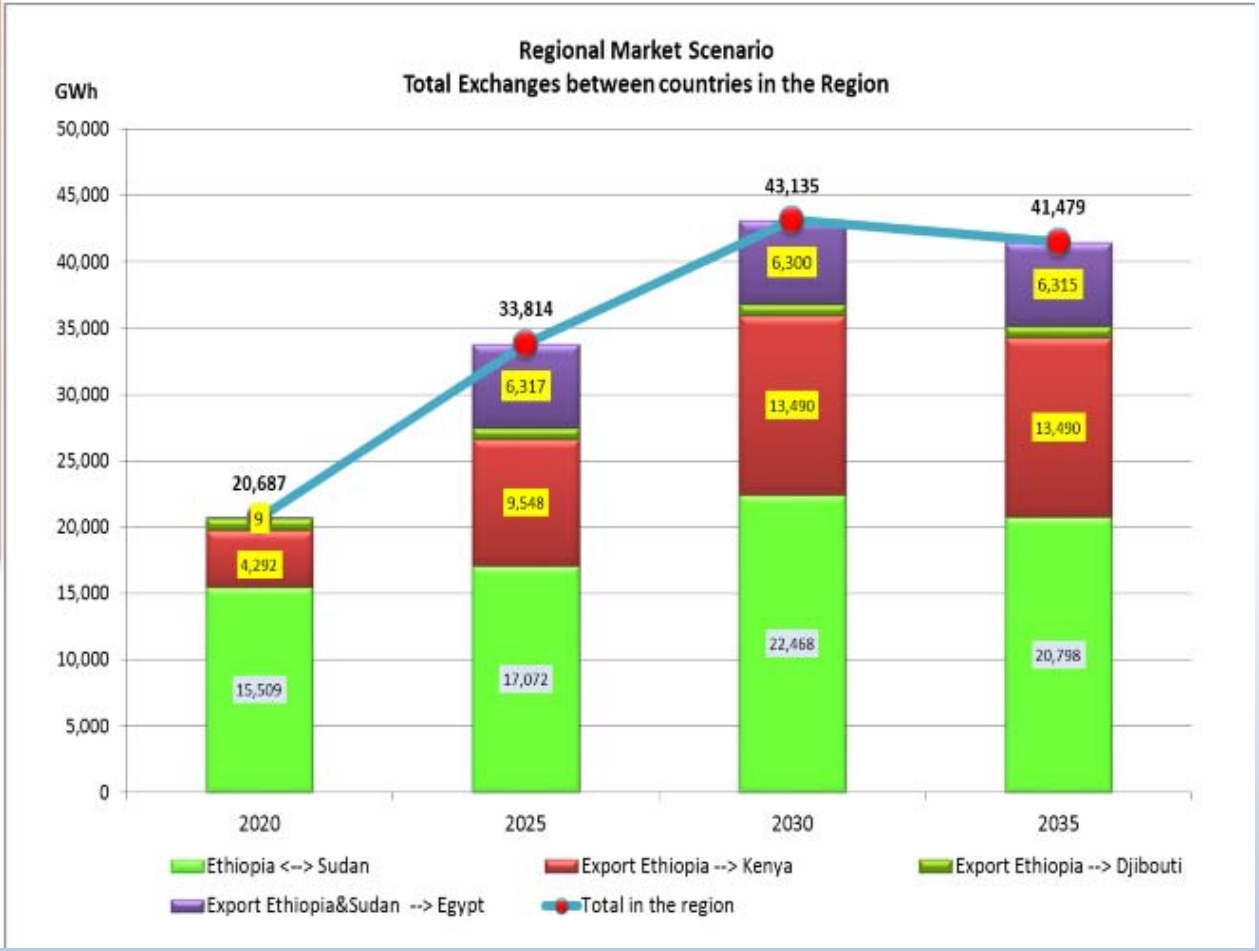
Demand supply analysis & exchanges evaluation – Scenario 4



Scenario 4 : Market Scenario

Ethiopia and Sudan are member of the Eastern Africa Power Pool (EAPP) whose main objective in long-term, is the development of an **electricity market** using the planned pool interconnectors in order **to optimize the use of energy resources available in the region**.

Demand supply analysis & exchanges evaluation - Scenario 5



Scenario 5: Regional Scenario

The long term vision of Regional Electricity Market (REM) is a competitive whole sale market at the regional level comprising a range of bilateral contracts and a spot market to determine a common clearing price. In considering the development of a **regional electricity market**, the most difficult contractual issue is likely to be related to the new contractual framework and pricing.

III. Main out comes

- ***Project Cost***

The total estimated cost is USD **566.01 *million USD*** according to the Feasibility Study.

- Sudan portion is **536.980 *million USD*** and
- Ethiopia portion is **29.030 *million USD***

III. Main out comes

- The economic analysis was done to determine whether the proposed project has economic benefit for both Ethiopia and Sudan or not?.

Below we present the results of the economic analysis of all five scenarios and then we compare the four interconnected scenarios with the reference scenario in order to test whether the interconnector has a net positive impact in terms of welfare. The details of each scenario can be found in the demand and supply analysis.

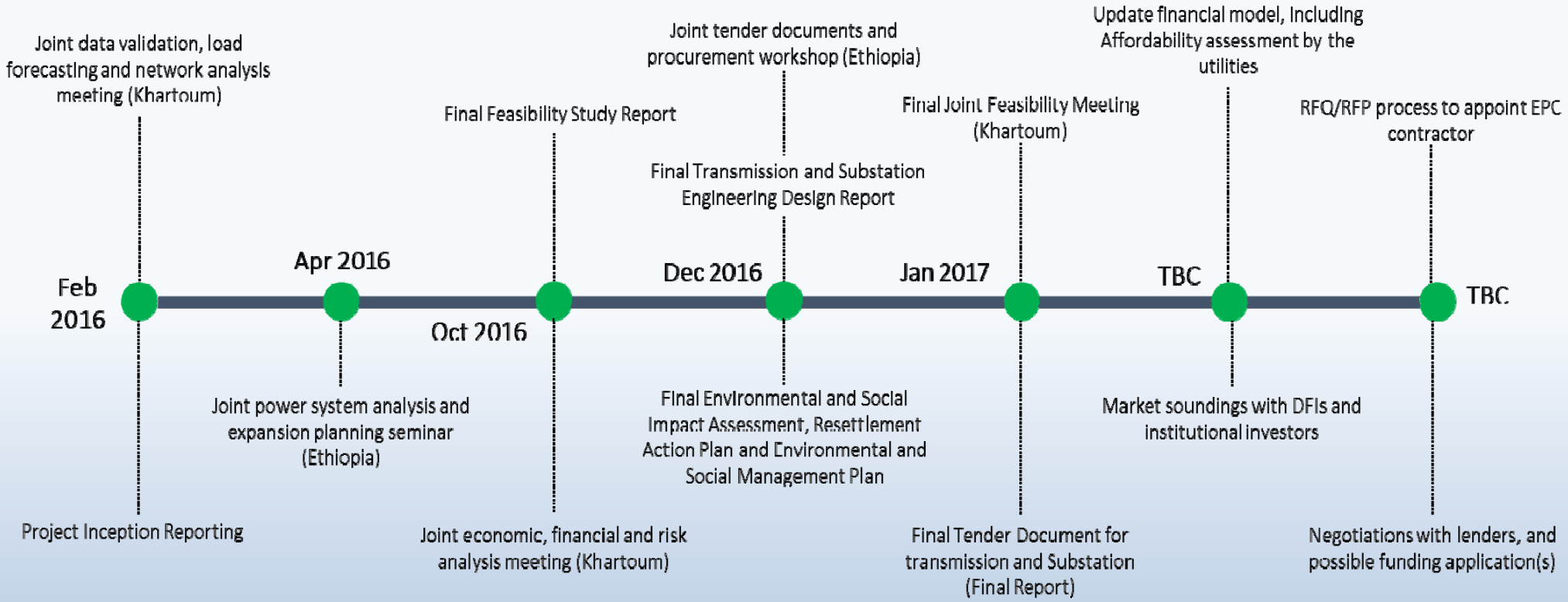
	Coordinated	Integrated	Market	Regional
NPV (kilo$)	10,209,305	41,080,515	39,665,209	38,999,634
IRR	169%	186%	168%	171%
Benefit/Cost Ratio	20.56	79.70	13.27	12.30

IV. **Project Status**

- Feasibility Study, Environmental and Social Impact Assessment (ESIA), Resettlement Action Plan & (RAP), Engineering Design and Tender documents had been finalized.
- **Interconnection Agreements** documents are under negotiations. and will be finalized and singing in Dec, 2017.
- The two countries seeking for finance to the project, a Joints letter of requested finance was issued by the two finance Ministers to the African Development Bank AfDB. The two governments of Ethiopia and Sudan was full committed to this project.
- The project proposed to be commissioned in year 2021 as agreed in Road Map.

IV. **Project Status**

Way Forward



Financial Analysis & Revenue Model

Ethiopia-Sudan Power Interconnector

- The Feasibility Study assumed that the two utilities will finance the Project with a combination of equity (20%) and debt (80%) whilst recovering costs and returns through tariffs.
- The tariffs required by EEP and SETCO to undertake the Project were calculated using a rate of return calculation.
- The Feasibility Study assumed that EEP will be able to raise long term corporate debt at 6% and SETCO at an effective interest rate 6.5%* (in US$ terms).
- US$ based project IRRs of 10.2% (Ethiopia) and 13.8% (Sudan) are forecast in the Feasibility Study – based on the tariffs calculated, debt assumptions, capex and opex.

* 6% corporate debt, 8% for SUKUK

Funding Opportunities

Ethiopia-Sudan Power Interconnector

•GCF funding could be explored, due to the Project's strong CO2 reduction potential, to unlock a mixture of concessionary loans, grants and guarantees for SETCO.

• A Sukuk funding opportunity exists for local/regional institutional investors, however the assumed funding costs will need to be market tested.

• Both utilities should conduct market soundings with DFIs to understand their appetite and return requirements.

DESCRIPTION	ETHIOPIA		SUDAN		TOTAL
Equity	5,806	20%	107,400	20%	-
Senior Debt	23,224	80%	322,200	60%	-
Zero-Coupon Bond	-	-	107,400	20%	-
Latest Capex (Excl. Vat)	**29,030**	**100%**	**537,000**	**100%**	**566,030**

JOB CREATION
ANNEX

The Ethopian Sudan Power Interconnector Will Create an Estimated 717,000 Job Years over Its Useful Life of 35 Years

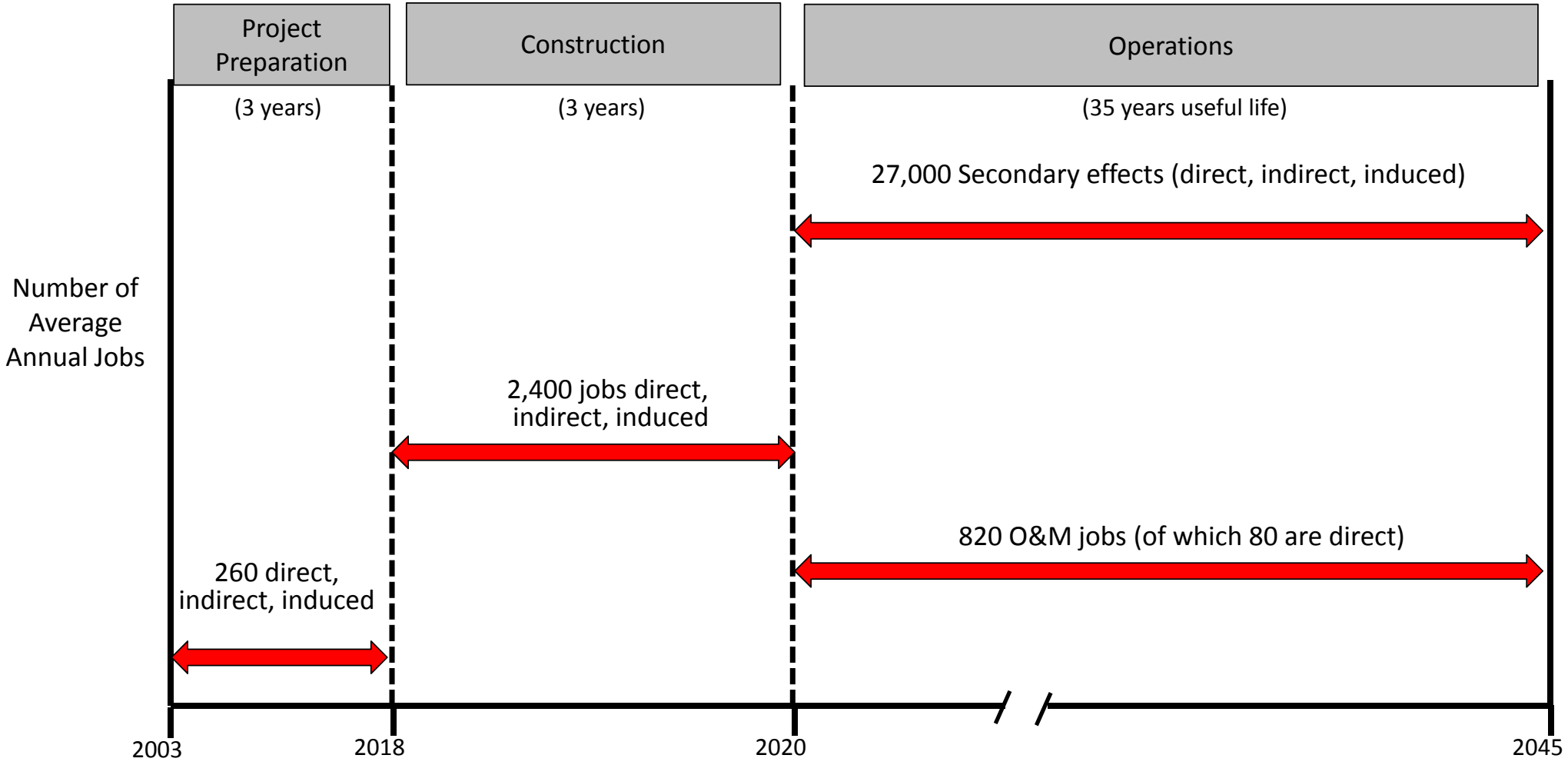
37,000 JOB YEARS FROM PROJECT DEVELOPMENT, CONSTRUCTION, AND OPERATION

PHASE	Ethiopia			Sudan			TOTAL			
	Direct	Indirect	Induced	Direct	Indirect	Induced	Direct	Indirect	Induced	Total
Project Preparation	172	48	359	103	21	17	275	69	376	720
Construction	220	108	440	4,407	894	1,259	4,627	1,002	1,699	7,328
Total One-Time	392	156	799	4,510	915	1,276	4,902	1,071	2,075	8,048
O&M (over 35 years)	805	385	1575	17640	3570	4830	18,445	3,955	6,405	28,805
Total Primary effects	1,197	541	2,374	22,150	4,485	6,106	23,347	5,026	8,480	36,853

680,000 JOB YEARS FROM SECONDARY SPILL OVER EFFECTS ON THE ECONOMY

Country	Annual Electricity Supply (million US$)	Annual				Over Useful Life (35 years)			
		Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
Sudan	$315,887,060	6,793	4,838	5,150	16,781	169,825	120,950	128,750	419,525
Kenya	$160,310,920	3,282	502	297	4,080	82,050	12,550	7,425	102,000
Djibouti	$14,708,040	316	225	240	781	7,900	5,625	6,000	19,525
Ethiopia	$34,688,140	4,507	351	548	5,407	112,675	8,775	13,700	135,175
Total		14,898	5,916	6,235	27,049	372,450	147,900	155,875	676,225

The Ethopian Sudan Interconnector will Create an Estimated 30,500 Average Annual Jobs (based on preliminary assumptions)



Source: GlobalDF analysis

METHODOLOGY FOR ESTIMATING JOB CREATION
IN ELECTRICITY GENERATION AND TRANSMISSION INFRASTRUCTURE

PRIMARY EFFECT (jobs created as a result of infrastructure deployment)

DIRECT JOBS (actual jobs required for project development, construction, operation phases over project's useful life)

INDIRECT JOBS (employment generated by businesses providing inputs for project preparation (studies, etc.), construction, operation (e.g., raw materials, equipment, etc.)

INDUCED JOBS (Employment generated by household spending based on the income earned by direct and indirect workers engaged in project)

SECONDARY EFFECT (jobs created from the economic spillover of infrastructure once it is deployed)

DIRECT, INDIRECT & INDUCED JOBS (employment resulting from new businesss creation and existing enterprises expanding as the result of additional power supply)

BEST PRACTICE: INPUT-OUTPUT ANALYSIS (used worldwide based on subsectorial economic national data)

- Estimate cost of inputs by country source
  - Project preparation (studies, project staff & experts)
  - Construction (labour, supervision, equipment, raw materials, etc.)
  - Operations & Maintenance
- Enter inputs in Input-Output Tables (developed from GTAP data base for all African countries)
- Tables estimate jobs

INPUT-OUTPUT ANALYSIS (based on IFC approach)

- Estimate incremental energy generated by new infrastructure
- Convert to Kw$
- Split power by destination country
- Enter incremental power in National Input-Output Tables

TO GENERATE THE DATA REQUIRED FOR ESTIMATING JOBS, MAJOR ASSUMPTIONS WERE MADE

Phases	Assumptions	Impact
Project preparation	Considering that CESI, an Italian consultancy, conducted most of the preparation studies (Feasibility, ESIA) it was assumed this component to generate out-of-Africa jobs	If some tasks were provided by African firms, it would result in a higher job creation potential
	The organization of a Power Coordination Unit depending from the local utilities (*Ethiopia-Sudan Interconnector PIM, pp. 6-7)*, was assumed to generate local jobs; Project preparation costs of Power Coordination Unit were assumed to be equally split between Ethiopia and Sudan	While PIM was clear about co-sponsorship of utilities, information of responsibilities for each was missing
Construction	Engineering, administration, and supervisory costs were assumed to be provided by an out of Africa EPC firm, and consequently jobs created were not included in construction related estimates; It was assumed that all substation and line equipment would be imported from out-of-Africa sources	Could result in under estimation of jobs
	Labor costs were not included in project documents; consequently a benchmark ratio (labor costs as percent of total investment of transmission lines) provided by the ZTK Feasibility Study was utilized	If labor costs in Ethiopia-Sudan are different, the benchmark ratio could result in either under or overestimation of construction effects
O&M	The Feasibility Study provides a ratio of O&M annual costs to project capital costs (1%) but does not break it down between labor and spare parts; the estimates assume all of it to be labor; O&M Supervisory costs was assumed to be 10% of total O&M costs	This could be an overestimation of O&M jobs

Opportunities to unlock projects

DFIs / ICPs	• Unlock climate financing (GCF guarantees/ concessionary loans/grants) • Extend concessionary loans • Guarantee debt
Institutional Investors Commercial Banks & Developers	• Invest in Sukuk /zero coupon bond
Governments	• Guarantee debt
NEPAD/RECs	• Coordinate technical teams between countries • Market projects to funders • Provide political support

Thank you