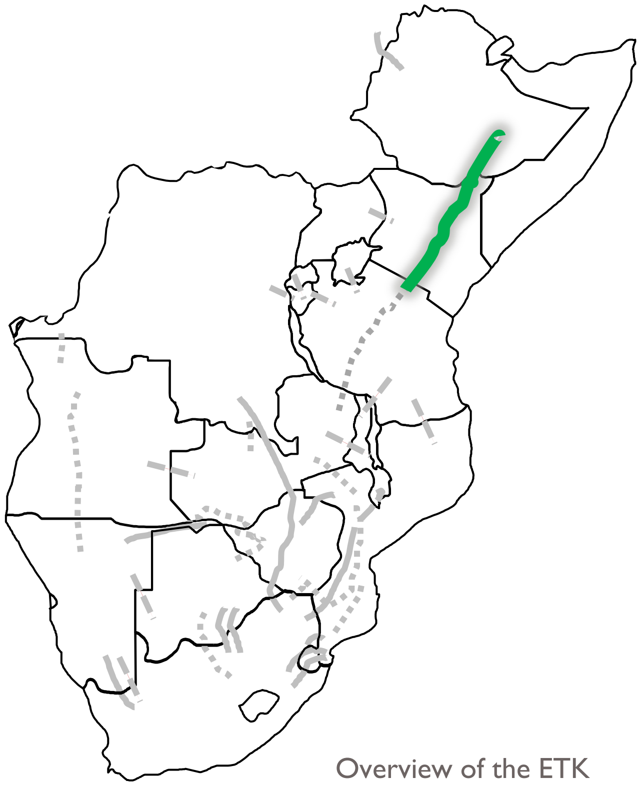
EAPP Wheeling Fee Modeling Strategy: The application to Ethiopia-Kenya-Tanzania power trade

Ron McNamara, PhD

September 1, 2021

OUTLINE OF PRESENTATION

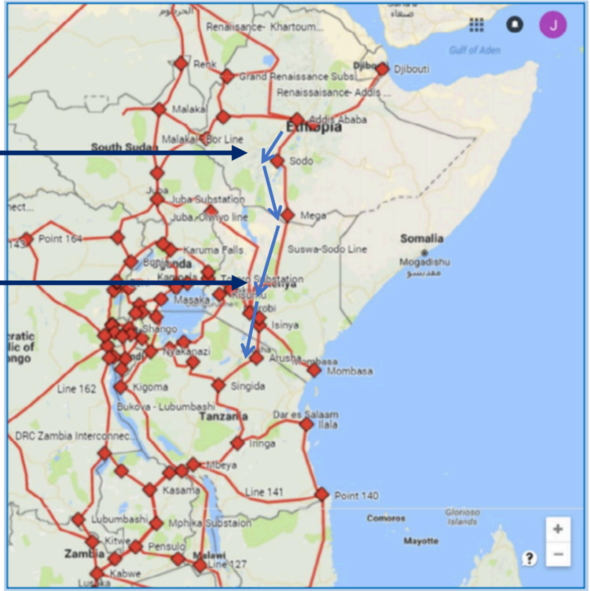
- Overview of the EKT Transmission Project
- The effect of the EKT on the EAPP
- ”Wheeling” of electricity
- The Foundation For The Recommended Wheeling Fee for Kenya
- Cost-of-Service Regulation
- Consistency of Cost-of-Service Regulation with Previous Work
- Distinguishing Between (1) the Modelling Strategy, (2) the Inputs, and (3) the Results
- The Structure of the Proposed Wheeling Fee Model
- The Results of the Proposed Wheeling Fee Model



Overview of the ETK

OVERVIEW OF THE EKT PROJECT

- The Ethiopia-Kenya-Tanzania (EKT) Transmission Project is comprised of two major power infrastructure projects.
  1. Construction of a 500 kV HVDC double circuit transmission line between Ethiopia and Kenya with a total length of 1 055 km, of which 433 km lies within Ethiopia and 622 km within Kenya. The transmission line capacity of this interconnection is 2,000 MW.
     - The originating HVDC inverter substation is at Sodo in Ethiopia, the other inverter is located at Suswa in Kenya. At this substation, HVDC will be inverted to HVAC.
  2. Construction of a 400 kV HVAC double circuit transmission line between Kenya and Tanzania with a total length of 507.5 km, of which about 414.4 km are in Tanzania and 93.1 km in Kenya.
     - In Tanzania, the project includes the construction of a 400 kV substation in Arusha and the extension of the existing Singida substation.
- When both components of project have been completed, they will become a crucial part of the *Eastern Africa Electricity Highway* with a capacity of 2,000 megawatts.
- This project provides the physical infrastructure that will enable the opportunity for the economic exchange of electricity not only between the three countries but also with other EAPP member countries, and finally between EAPP with SAPP.



THE EKT PROJECT AND THE EAPP

Once completed, the EKT Interconnector will allow the East Africa Power Pool ("EAPP") to truly become a regional electricity market with integrated operations across 10 separate countries. While the current East African electricity market is in its early stages, the completion of the EKT Interconnector will provide a potentially significant impetus for the growth of the market. And, in so doing will allow the EAPP to fulfill their stated objectives:

- *The mission of the EAPP is to make available for the Eastern Africa region, by the pooling of electrical energy resources in coordinated and optimized manner, an affordable, sustainable and reliable electricity in order to increase the rate of access to electricity by the population of the Region and thereby promote regional integration.*

- *Specific objectives include optimization of the usage of energy resources available in the COMESA region, increase power supply in the region, reduction of electricity production cost and creation of an environment that is conducive for investment.*

In trying to meet these objectives, EAPP has recognized that the lack of transmission capacity for "wheeling" and the lack of interconnectors in the region are key issues and challenges. Completion of the EKT will not only increase the opportunity for "wheeling" in the region but will eventually facilitate direct integration of EAPP with both the South African Power Pool and the Central African Power Pool. Thereby creating a very large electricity market.

"WHEELING" ELECTRICITY

"Wheeling" is the act of transporting electricity that is generated in a location or region that is different from where the electricity is consumed. Wheeling can be between utilities in the same country ore region or between separate countries.

Accordingly, there are three types of electricity "wheeling" – "through", "in" and "out".

- *"Wheeling through"* refers to power that is produced in Region A (e.g., Ethiopia) and is wheeled through Region B (e.g., Kenya) to Region C (e.g., Tanzania) where it is consumed.
- *"Wheeling in"* refers to power that is produced in Region A (e.g., Ethiopia) and is wheeled into an adjacent Region B (e.g., Kenya) where it is consumed.
- Lastly, *"wheeling out"* refers to electricity that is produced in Region B (e.g., Kenya) and is wheeled out to an adjacent Region C (e.g., Tanzania) where it is consumed.

For many regions, "wheeling" is the first concrete step in introducing (non-discriminatory) open access to the transmission system and the eventual success or failure of the regional electricity market will closely depend on the details associated with implementing fair and non-discriminatory open access to the transmission system.

The "wheeling fee" is simply the cost of using the interconnector to "wheel", i.e., transport, the electricity. There are three important aspects to the fee;

1. the precise definition of the services provided to the wheeling parties by the transmission assets,
2. the methodology used to determine the costs of those services, and
3. the allocation methodology used to recover the costs of the appropriate services.

FOUNDATION FOR THE RECOMMENDED WHEELING FEE FOR KENYA

The current exercise was focused on validating previous work with respect to the wheeling fee model for assets within Kenya that will be built, owned and operated by either the Kenya Electric Transmission Company (KETRACO) or the Kenya Power & Light Company (KPLC).

The modeling strategy put forth is a draft recommendation for the wheeling fee model that should be adopted by the East Africa Power Pool ("EAPP") to be used for all wheeling transactions across the footprint of the EAPP.

The wheeling fee(s) for the eventual EKT Transmission path will be the combined regulated fee(s) for using all or part of the transmission path to wheel power in, out, or through each region of the EAPP.

However, the model in presented here relates only to the assets within Kenya that will be built, owned, and operated by either the Kenya Electric Transmission Company (KETRACO) or the Kenya Power & Lighting Company (KPLC).

Determination of the exact wheeling fee will be a regulatory exercise.

That is, the wheeling fee will be a rate determined through regulatory processes.

In particular the wheeling fee will be determined through the application of a "cost-of-service" regulatory paradigm/process by each of the individual national regulators

COST OF SERVICE REGULATION

Cost-of-service regulation is based on dis-aggregating the services provided by a monopolist into individual services. The cost of providing these individual services is then determined and the required revenue necessary for the monopolist to provide the services is calculated from these costs.

With open access, different participants will use different bundles of "transmission services", for different periods of times and for differing amounts. As a result, the services being sold must be defined and priced.

The revenue requirement for each individual service is then allocated in some manner to the users of the service. The generic equation for the revenue requirement is:

$$RR_t = (RB_t) * R_t + OC_t + D_t + T_t + F_t$$

Where:

RB_t	=	Rate base,
R_t	=	Rate of return,
OC_t	=	Operating (and maintenance) costs,
D_t	=	Depreciation,
T_t	=	Taxes,
F_t	=	Franchise fees (not applicable here), and
t	=	The base year.

The Rate Base is generally understood to be the Capital Asset Base. There are several accepted methodologies that are used by regulators around the world to value the assets in question.

CONSISTENT WITH PREVIOUS RECOMMENDATION (1)

Cost-of-Service regulation as a modeling strategy is consistent with earlier work related to deriving the regulated wheeling fee for the EFT transmission line. The recommended modeling strategy provided in the *EU Technical Assistance Facility for the "Sustainable Energy All" Initiative (SE4ALL) – Eastern and Southern Africa.*

TSOARRt = (RABt× WACC) + (WCt x WACC) + O&Mt + Dept + Taxt

Where:		
	TSOARRt	= TSO Annual Revenue Requirement for period "t"
	RABt	= Regulatory Asset Base for period "t"
	WACC	= Weighted Average Cost of Capital
	WCt	= Working Capital for period "t"
	O&Mt	= Operating and Maintenance Expense for period "t"
	Dept	= Regulatory Depreciation for period "t"
	Taxt	= Corporate Tax for period "t"

Which is the exact same formulation as was given on the previous slide.

CONSISTENT WITH PREVIOUS RECOMMENDATION (2)

We now compare our recommended modeling methodology given in Eq. 1 with the recommendation given in *Proposed Principles for Long Term Wheeling Service:*

C_{Total} = R+D

Where: R = return on capital; return on Wheeling Service Asset Base

D = depreciation of fixed assets and amortization of other assets

R = B*r

Where: R = return on the Wheeling Service Asset Base

B = Wheeling Service Asset Base at the end of the base year

r = allowable rate of return on the Wheeling Service Asset Base including an allowance for profit taxes.

Coperating = Cmaintenance + Csalaries + Coutsource + Csocial tax + Cproperty tax

Where: Cmaintenance = spare parts, supplies, vehicles, fuel, and other main. costs

Csalaries = salaries, wages, medical insurance, and costs (other than taxes)

Coutsource = expenditures for professional services (excluding expenses included in salaries and wages)

Csocial tax = all taxes related to salaries, such as pension taxes.

Cproperty tax = property tax on buildings, facilities and land owned by the TSP

Putting these equations together and rearranging we get: Revenue Requirement = (Base*r) + Coperating+taxes + Depreciation…which is identical to the recommended Revenue Requirement equation above. The only difference in this approach is that the allocation mechanism has been included in the revenue requirement equation.

DISTINGUISHING BETWEEN THE MODEL, THE INPUTS, AND THE RESULTS

The modeling strategy shown above, i.e., cost-of-service, is the standard approach used around the world and, as shown, is entirely consistent with the previous recommendations.

It is important, to distinguish between (1) *the modeling strategy* and (2) *the results of the model.* A "good" model does not guarantee "good" results. *While the model itself is independent of input data, the results are not.*

Thus, while the modeling strategy can be perfect, the results depend on the inputs to the model.

- There are two types of inputs, (1) the raw data and (2) data that has been transformed before being used in the model. Examples of the former include capital expenditures, operations and maintenance costs, depreciation, taxes and working capital. Examples of the latter include the correct application of tax rates, the correct application of approved valuation methodologies for capital assets, etc.

The objective of our analysis was to recommend the appropriate modeling strategy independent of the input data that was provided.

STRUCTURE/OUTPUT OF PROPOSED WHEELING FEE MODEL

USAID FROM THE AMERICAN PEOPLE

POWER AFRICA A U.S. GOVERNMENT-LED PARTNERSHIP

$$RR_t = (RB_t) * R_t + OC_t + D_t + T_t + F_t$$

Where:
- RB_t = Rate base,
- R_t = Rate of return,
- OC_t = Operating (and maintenance) costs,
- D_t = Depreciation,
- T_t = Taxes,
- F_t = Franchise fees, and
- t = The base year.

Note: this is the generic formulataion for a Revenue RequirementEquation. The last term, Ft, does not apply in the current situation. As such, it is not part of any calculation.

Note: The Rate Base (RBt) is defined as [(Cumulative Capex - Cumulative Depreciation) + Working Capital] and "R", the rate of return, is the weighted average cost of capital (WACC). Since Scenario 1 is based on the complete buildout (i.e., completion) of 140 (of the 144) projects, all construction expenses incurred are (or should be) Included in the CAPEX.

Key Assumptions Pertaining to Scenario 1

		Starting or Default Value	User Defined Value
1	Import/Export Capacity at Completion	2000	2000
2	Amount of Capacity Used	1600	1600
3	Income Tax (Kenya)	30%	30%
4	Cost of Equity (Working Capital)	11.08%	11.08%
5	Depreciation - straight line depreciation in years		
	Transmission Lines	50	50
	Substations	25	25
	National Dispatch Center	10	10
6	Weighted Average Cost of Capital	5.57%	5.57%

Users can change the values in these cells

Description of Capital Projects

Breakdown of the 144 transmission projects by year and type. / Control Center

	Projects by year	Transission Lines by Year	Transformers by Year	National Load & Dispatch Center
2014	3	3	0	0
2015	0	0	0	0
2016	11	11	0	0
2017	17	17	0	0
2018	13	11	2	1
2019	22	17	5	0
2020	31	21	10	0
2021	28	23	5	0
2022	2	2	0	0
2023	2	2	0	0
2024	0	0	0	0
2025	11	11	0	0
2031	1	1	0	0
2099	3	3	0	0
Total	144	122	22	1

Note: we ignore the 4 four projects with commissioning dates after after 2025. Furthermore, we assume that the projects commissioned on or before 2018 have been commissioned and are in actual operation. Thus, we assume all projects after 2018 have not been built or commissioned.

Total Revenue Requirement as at 2025

Rate Base as at 2025	$ 2,768,275,597.81
WACC	5.57%
RBt * Rt as at 2025	$ 154,192,950.80
Current O&M Expenditures as at 2025	$147,886,346.81
Current Depreciation as at 2025	$7,940,000.00
Current Taxes as at 2025	$51,006,882.16
Total Revenue Requirement per Year as at 2025	$361,026,179.77

Determination of the Wheeling Fee

Allocation of the Annual Revenue Requirement:

Per MW of assumed usage	$225,641.36
Per MWh of assumed usage	$25.76
Per kWh of assumed usaage	$0.0258

THE RESULTS OF THE WHEELING FEE MODEL

To use the model to derive hypothetical results we used the input data provided and made the following assumptions:

- We assumed that we were in year 2025 and 140 (of the 144) projects had been built, commissioned and were in operation.
- We further assumed that every project from 2014 to 2018 was in operation.
- We applied straight line depreciation to determine the cumulative depreciation for the capital expenditures for all 140 projects.
- We assumed that all of the costs for the added capacity from the 140 projects was assignable to wheeling transactions.

Given these assumptions, the table on the right provides the annual Total Revenue Requirement as of 2025. Based on the data that we were provided, the model shows that the regulated rate base as of 2025 will be US$2,768,275,598 i.e., slightly less than US$2.8 billion.

The total annual revenue requirement for these 140 projects will be approximately $361 million, or roughly US$0.026 per kWh.

Total Revenue Requirement as at 2025		
Rate Base as at 2025	$ 2,768,275,597.81	
WACC	5.57%	
RBt * Rt as at 2025		$ 154,192,950.80
Current O&M Expenditures as at 2025		$147,886,346.81
Current Depreciation as at 2025		$7,940,000.00
Current Taxes as at 2025		$51,006,882.16
Total Revenue Requirement per Year as at 2025		$361,026,179.77

Determination of the Wheeling Fee	
Allocation of the Annual Revenue Requirement:	
Per MW of assumed usage	$225,641.36
Per MWh of assumed usage	$25.76
Per kWh of assumed usaage	$0.0258

THANK YOU

Kenya--Tanzania Interconnection Line
CNSTRUCTIONREVIEWONLINE.COM

APPENDIX

Source Material Used To Develop The Wheeling Fee Model:

- Proposed Principles For Long Term Wheeling Service (Revision 3), August 28, 2014 (USAID & Power Africa)
- EU Technical Assistance Facility for the "Sustainable Energy for All" Initiaitve (SE4ALL) - Eastern and Southern Africa Final Guidelines and Monitoring Plan for Continental Transmission Tariff Methodology, April 2018*
- EU Technical Assistance Facility for the "Sustainable Energy for All" Initiative (SE4All) - Eastern and Southern Africa Pilot Phase Implementation of Continental Transmission Tariff Methodology for International Bilateral Transactions: Tariff Computational Model - Final Report*
- Loss Factor Study for the Ethiopia-Kenya-Tanzania (EKT) Transaction, December 15, 2017 (USEA, EAPP, Power Africa)
- Total Transfer Capacity (TTC) and Reliability Reserved Capacity (RRC) Study for the Ethiopia-Kenya-Tanzania (EKT) Transactions, September 2017, (Power Africa, United States Energy Association, Electricity Coordinating Center).
- Power Africa Transactions and Reforms Program (PATRP), Ethiopia Kenya Tanzania Wheeling Charges Model User Manual, November 2019, (Nexant).
- Power Africa Transmission Roadmap to 2030: A Practical Approach To Unlocking Electricity Trade, Nov. 2018 (Power Africa)

* We note that both of these documents refer to a "TSO" or Transmission System Operator which, while consistent with the electricity market model used in Europe, is inconsistent with the electricity market model in North America, Central America, South America, Mexico, Canada, New Zealand, Singapore, Australia, and the Philippines. Nevertheless, the general regulatory (but not the electricity market) principles/strategy are the same, albeit with different services being provided by different entities.