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**14 – 18 April 2019**

**Cairo, Egypt**

**CONTINENTAL TRANSMISSION TARIFF METHODOLOGY FOR INTERNATIONAL BILATERAL TRANSACTIONS**

**THEME: DEVELOPING SMART INFRASTRUCTURE TO BOOST AFRICA’S CONTINENTAL TRANSFORMATION AND INTEGRATION**

**TECHNICAL PAPER**

1. **Background**

The African Union Commission’s Department of Infrastructure and Energy in collaboration with the EU Technical Assistance Facility (TAF), developed and validated the Strategy and Action Plan for a Harmonized Regulatory Framework for the Electricity Market in Africa. The Strategy and Action Plans were aimed at accelerating the process of integrating and harmonizing continental and regional electricity markets in Africa. Both documents went through extensive stakeholder consultation and validation processes. The Strategy and Action Plan were adopted by the Specialized Technical Committee (STC) on Transport, Transcontinental and Interregional Infrastructure, Energy and Tourism (STC-TTIIET) in Lomé, Togo on 17 March 2017 and by the Executive Council at its 31st Ordinary Session held on 27 June – 1 July 2017 in Addis Ababa, Ethiopia (Doc. EX.CL/1024(XXXI))

One of the key outcomes was the recommendation to *develop a Harmonized Transmission System Tariff Methodology to promote cross-border electricity trade in Africa.* TheAfrican Union Commission (AUC) in collaboration with EU TAF, in consultation with stakeholders, analyzed various transmission system tariff models applied in different parts of the world and ranked them for suitability in the African context. The Continental Transmission System Tariff Methodology, Guidelines and Monitoring Plan was subsequently developed and adopted by the Energy Sub-Committee of the STC-TTIIET at its meeting held on 21 - 23 March 2018 in Nouakchott, Mauritania. It was recommended that the adopted Transmission Tariff approach should be piloted in selected power pools, to test the robustness and efficacy of the methodology and the tariff model, before full scale implementation.

1. **Project Objective and Scope**

The overall objective is to develop a Continental Transmission Tariff Methodology that is expected to catalyze the establishment of a harmonized and integrated competitive electricity market, by ensuring the coordination of transmission tariff methodology and structures. It will also eliminates the problem of transmission tariff “pancaking” whereby cross border power exchanges are subjected to a number of tariffs which do not reflect the actual cost of assets used for the transmission transactions.

1. **Methodology for Selection of Continental Transmission Tariff Methodology**

Based on the review of standard transmission tariff models used in the industry, as well as stakeholders’ feedback from the **Technical Workshop held in Harare, Zimbabwe,** ***the point-to-point MW-Km (Load Flow-Based) methodology was adopted as the Continental Transmission Tariff Methodology.*** The point-to-point MW-km (Load Flow-Based) transmission tariff methodology presents a good balance in terms of recovery of *transmission cost,* simplicity and providing correct price signals. It takes account of network constraints and actual network flows

* 1. **Transmission Pricing Objectives**

A good transmission pricing approach must meet the following objectives: **Promote Economic Efficiency**, **Ensure Price Transparency and Non-discriminatory, Ensure Cost Recovery, Simple and Easy to Implement:** The methodology should be easy to understand and administer and **Promote Open-Access and Competition.** In practice, it is difficult to find a single tariff methodology that satisfies all the above objectives, since some of the tariff principles may be in conflict with others. Regulators therefore adopt a “second best” approach by finding a good balance among the above objectives, while taking account of practical issues which could affect the implementation of the tariff methodology.

1. **Transmission Tariff Model and Structure**

The transmission tariff model comprises separate but interconnected excel worksheets***. The tariff model is designed based on the “free” cash flow concept, where the tariff is determined by first setting the NPV of “free” cash flow to zero and then setting the NPV to be positive***. This approach will result in the determination of a transmission tariff that would enable the Transmission System Operator (TSO) to cover its incremental costs and earn a reasonable return on invested capital. The structure of the model is depicted in figure 1 and designed based on the following TSO revenue requirements formula.

**TSOARR,t = (RABt× WACC) + (WCt x WACC) + O&Mt + Dept + Taxt**

Where:

TSOARR,t  = 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”

The Model Structure is depicted in figure 1, showing the main elements.

**Figure 1. Structure of Transmission Tariff Model**

**Load Flow Analysis**

**Depreciation Expense**

**Model Output and Results: Transmission Tariff, Wheeling Charge, NPV, IRR, RoR, Debt Service Coverage**

**Gross Replacement Asset Value, Net Replacement Asset Value, Cost of Capital**

**Operation and Maintenance Expense, Working Capital, Tax**

**Network Loss Compensation, Reactive Power Charge**

1. **Principles Underlying Determination of Main Tariff Cost Components**
	1. **Asset Value**

The depreciated or net replacement cost has been used to calculate the transmission system asset value by taking into account data submitted by the TSOs, as well as well-researched international benchmark prices. ***The depreciated or net replacement cost seeks to estimate what it would cost to replace the existing stock of transmission assets with identical assets in the same condition.*** The **Regulatory Asset Base (RAB) is the Net Replacement Asset Value (NRAV)** and is calculated as the ***Gross Replacement Asset Value (GRAV)*** *less the accumulated depreciation.*

* 1. **Determination of Fixed Asset Lives**

Stakeholders agreed that the regulatory principles of ***“used and useful” and “reasonableness and prudency”,*** should be used to determine the Regulatory Asset Value.

* 1. **Depreciation**

The purpose of depreciation is to allocate the cost of an asset over the useful life of the asset. At the first technical workshop, stakeholders/experts suggested that the straight-line depreciation method which is considered to be the standard regulatory approach, should be used to calculate the depreciation expense.

* 1. **Working Capital Determination**

Working capital measures a company’s ability to pay off its current liabilities with current assets. Working capital shows how a firm’s short-term liquidity and assets are managed and therefore maintaining the right amount of working capital is important. It is a common regulatory practice to make allowance for working capital in the revenue requirements determination and this has been taken into account in the transmission tariff calculation.

* 1. **Cost of Capital**

Although the actual cost of capital may differ for the various countries involved in the international bilateral power transactions, for the sake of simplicity and as suggested by stakeholders at all the technical workshops, a single WACC has been used to calculate the transmission tariff. In calculating the transmission tariff, the **Vanilla WACC**, which is the weighted average of the post-tax nominal return on equity and the pre-tax nominal return on debt has been used. With this approach, the post-tax cost of equity is not adjusted, but rather the assessment of ***likely tax liabilities is treated as a cash-flow item and added to the operating costs***.

* 1. **Operation and Maintenance Cost**

The level of operation and maintenance (O&M) cost has been benchmarked as a percentage of the Gross Replacement Asset Value (GRAV). Taking cognizance of the range of values used in international electricity markets, ***the O&M expense could be benchmarked between 2% and 5% of the Gross Asset Replacement Value of transmission assets for the tariff calculation.***

1. **Load Flow Analysis and Implications for Determination of Transmission Tariff**

The aim of carrying out the load flow analysis is to ensure that each TSO receives its fair share of the revenue requirement, ***based on the transaction participation of each asset used for the transmission or wheeling services***. The effective Regulatory Asset Base (RABT) for calculating the TSO’s revenue requirements is determined as follows:

**RABT = {RABTransformer + RABSwitchbay + RABTransmission Line) x Load Flow Results**

*RABT = {(RABTransformer x % of capacity used) + (RABSwitchbay x % of rating used) + (Transmission Line Cost per km x Line length x % of capacity used)}*

The annual depreciation (DepreciationT) for calculating the TSO revenue requirements is determined as follows

**DepreciationT = {Depreciation Transformer + Depreciation Switchbay + Depreciation Transmission Line) x Load Flow Results**

*Depreciation= {(Depreciation Transformer x % of capacity used) + (Depreciation Switchbay x % of rating used) + (Depreciation of Line Cost per km x Line length x % of capacity used)}*

The effective Operation and Maintenance (O&MT) expense is calculated as follows:

**O&MT = O&M Cost Factor x Gross Replacement Value of Asset**

1. **Network Loss Compensation**

The principle of using incremental losses associated with specific wheeling transactions to determine the network losses, implies that the utilities would be compensated for any increases in network losses from the wheeling transaction. The cost of network loss is determined based on the incremental effect of generation and demand at specific locations, *using load flow analysis.* The simulation is carried out for **Peak, Medium and Low loading** conditions. The approach for determining the network loss compensation is as follows:

**CTnLoss,t, = WACG X (∆MW)hTransm Loss,i**

Where:

CTnLoss,t, = Cost of Transmission Loss during period “t”

WACG = Weighted Average Cost of Generation

(∆MW)hTransm Loss,i = Incremental Amount of Generation to cover transmission network loss

1. **Ancillary Services**

Ancillary services are required to ensure that the interconnected power system is operated in a stable and reliable manner with acceptable levels of voltage and frequency. The basic principle underlying the recovery of cost of ancillary services is that, if the TSO purchases ancillary services from generators or installs specific equipment to produce reactive power*, these costs should be recovered from the specific load(s) who directly benefit from the purchase* of the ancillary services or the installation of the ancillary service equipment. In order to ensure that transmission voltages are maintained within acceptable limits, generation facilities, capacitors and other power correction devices under the control of the System Market Operator (SMO), must be operated to produce (or absorb) reactive power. The total reactive power revenue collected from the transmission customer is a pass through to the TSO for the service provided. Purchasers of reactive power would be charged for such service in accordance with the following formula*:*

$$Reactive Factor Charge (US\$=MVAR\_{TARIFF} x \frac{MVAR\_{ACTUAL }x PF\_{BENCHMARK} }{PF\_{ACTUAL}}- MVAR\_{TARIFF }x MVA\_{ACTUAL}$$

$$Reactive Factor Charge (US\$)= MVAR\_{TARIFF} x MVAR\_{ACTUAL }\left[\frac{PF\_{BENCHMARK}}{ PF\_{ACTUAL}}-1\right]$$

Where:

MVARTARIFF = Reactive Power Tariff (US$/MVAR/Month), as determined by the regional regulatory authority;

MVARACTUAL = Average Reactive Power Consumption of transmission network user (MVAR);

PFACTUAL = Average Power Factor of transmission network user recorded during the billing period.

PFBENCHMARK = Benchmark Power Factor as defined by the Technical/Grid Code or TSO/SMO.

1. **Transmission Tariff Determination**

The transmission tariff is expected to recover infrastructure or network costs and will be denominated as ***per KWh (i.e. cents/kWh)*** based on ***reserved capacities (MW), which would be used to determine the associated energy.*** The SMO will monitor all bilateral trades for the transmission tariff and the cost of transmission losses and pay each TSO *its portion of allocated transmission network revenue as well as revenue from network losses.* The SMO will also pay the power utilities their revenue for reactive power compensation. The payment for *scheduled firm quantities* is calculated based on the transmission customer’s*reserved capacity (MW) multiplied by the applicable tariff**rate*as follows:

***Tariff Revenue (US$) = Tariff (US$/MWh) x Reserved Capacity (MW) x Number of hours (h)***

1. **Results from Computational Model**

A tariff computational model was developed based on the tariff methodology. The tariff results are presented below for the following international transactions in tables 1 and 2: **i.** **Cote d’Ivoire-Burkina Faso and Mali Transactions** **ii**. **Nigeria – CEB (Benin and Togo) Transaction iii. Republic of Congo–Democratic Republic of Congo (DRC) Transaction**

1. **Tariff Results from Tariff Computational Model**

The cost reflective tariff should enable the TSO to recover the full cost of its participating assets, such that the transmission tariff will generate adequate cash flow by satisfying the following conditions:

***Net Present Value (NPV)>0; Rate of Return (RoR) = Cost of Capital; and Internal Rate of Return > Cost of Capital.***

1. **Results from Tariff Model for the condition NPV= 0**

The table presents a summary of the results for the selected international transactions for NPV=0*. At a cost of capital of 10%, the Rate of Return (RoR) earned on the regulated asset base (RAB) for each of the transactions, is less than the WACC (10%).* This means the indicated tariffs in the table will not yield ***a financially viable transaction.***

**Table 1. Results from Tariff Model: NPV = 0; WACC=10%.**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Transaction** | **Wheeled Power (MW)** | **Tariff** **US cents/kWh** | **RoR** **%** | **NPV****US$** | **IRR****%** | **Average Incremental Losses- MW/day** | **Network Loss- cents/kWh** | **Network Loss per Month****(US$)** | **Average Reactive Power- MVAR/day** | **Reactive Factor-** **U$/ Month** |
| Cote d'Ivoire-Burkina Faso | 81 | **2.396** | **8.31** | **0.00** | **8.59** | 3.912 | 0.0151 | 8,919.84 | 1.65 | 1,426.47 |
| Cote d'Ivoire-Mali | 82 | **2.136** | **6.92** | **0.00** | **8.55** | 4.166 | 0.0159 | 9,498.33 | -11.25 | -10,158.65 |
| Nigeria-CEB (Benin) | 121 | **0.551** | **8.22** | **0.00** | **8.59** | 1.884 | 0.0023 | 3,970.53 | 30.08 | 27,155.84 |
| Congo Republic – DRC | 50 | **1.953** | **7.08** | **0.00** | **8.55%** | 1.213 | 0.0075 | 2,765.31 | -5.83 | -5,053.04 |

1. **Results from Tariff Model for NPV > 0**

The table presents a summary of the results for the selected international transactions for NPV>0*. At a cost of capital of 10%, the Rate of Return (RoR) earned on the regulated asset base (RAB), is equal to the WACC, while the IRR is greater than WACC. This implies that the tariffs indicated in the table will result in a financially viable transaction.*

**Table 2. Results from Tariff Model: NPV > 0; WACC=10%.**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Transaction** | **Wheeled Power (MW)** | **Tariff****US cents/kWh** | **NPV****US$** | **RoR-****%** | **IRR-****%** | **Average Incremental Losses- MW/day** | **Network Loss- cents/kWh** | **Network Loss-US$/Mth.** | **Average Reactive Power-MVAR/day** | **Reactive Factor- US$/Month** |
| Cote d'Ivoire-Burkina Faso | 81 | 2.714 | 8,294,319 | 10.0 | 10.14 | 3.912 | 0.0151 | 8,919.84 | **1.65** | 1,426.47 |
| Cote d'Ivoire-Mali | 82 | 2.717 | 15,271,141 | 10.0 | 11.47 | 4.166 | 0.0159 | 9,498.33 | -11.25 | -10,158.65 |
| Nigeria-CEB (Benin/Togo) | 121 Each | 0.628 | 3,006,723 | 10.0 | 10.22 | 1.884 | 0.0023 | 3,970.53 | **30.08** | 27,155.84 |
| Congo Republic - DRC |  50 | 2.446 | 7,996,649 | 10.00 |  11.31 |  1.213 |  0.0075 |  2,765.31 |  -5.83 |  -5,053.04 |

1. **Recommendations: Policy, Regulatory and Technical**
* **Benchmarks**

Based on the review of international practice, it is recommended that the following benchmarks could be used as a guide by the regulatory authorities and power pools for the transmission tariff calculations:

**Recommended Asset Lives and O&M Cost Factor**

|  |  |  |
| --- | --- | --- |
| **Parameter** | **High Value** | **Low Value** |
| **Depreciation:** 1. Transmission Lines
2. Transformers
3. Switch bays
 | 50 years50 Years50 years | 30 years30 years30 years |
| O&M Cost Factor | 2% | 5% |

* **Recovery of Transmission Tariff Components**

In operationalizing the Transmission Tariff Methodology, the following transmission costs should at a minimum, be recovered by the TSOs: i. **Reserved capacity (MW) and the associated energy (MWh) ii. Reactive Power iii. Transmission network losses**. In addition, the regional regulatory authorities and power pools, should undertake studies with the view to determine how to calculate the compensation for the following ancillary services: ***Regulation and Frequency Control, Operating Reserves and Black Start Capability.***

* **Rules for Capacity Allocation, Pricing and Congestion Management**

The regional regulatory authorities and power pools should develop **Guidelines and Rules for Capacity Allocation and Congestion Management (CACM)**. These Rules and Guidelines will define the method to be used by the SMO to among others, price capacity and award the usage right to available transmission capacity.

* **Guidelines and Strategies for Maintaining Efficient Transmission Network Loss Levels**

The regional regulatory authorities, in collaboration with the power pools should cap the transmission loss levels for all participating TSOs. In addition, **Energy Audits can be commissioned,** *and Guidelines and Strategies can be developed, for reducing reactive absorption/injection and improving power factor.*

* **Monitoring of Implementation of a Harmonized Transmission Tariff Methodology**

The monitoring of implementation of a Harmonized Transmission System Tariff Methodology could be under the purview of the AUC’s Department of Infrastructure of Energy,through its Coordination Unit known as the *Electricity Regulatory Framework Unit (ERFU).*ERFU would be expected to *ascertain if the transmission tariffs are determined and implemented in accordance with the principles set out in the Transmission Tariff Methodology, as agreed between the regional regulatory authorities and the power pools.*

* **Capacity Building on Tariff Computational Model**

A comprehensive training programme should be implemented for all key stakeholders, on the principles of the transmission tariff methodology, and operationalization of the computational tariff model. A high level capacity building programme should also be organized for policy makers and technical directors from the Energy Sector Ministry, on the principles of the tariff methodology. Additionally, since the results of the load flow studies are key inputs for the calculation of the transmission tariff, *it is important that each participating TSO acquires a load flow software and train its engineers on how to carry out a load flow simulation for the tariff calculation.*

1. **Expected STC Decision (14 – 18 April 2019)**

The STC is requested to adopt the Continental Transmission System Tariff Methodology and urge the AUC, in collaboration with relevant stakeholders, to:

1. undertake a comprehensive training programme for all key stakeholders, on the principles of the transmission tariff methodology, and operationalization of the computational tariff model; and
2. support power pools, regulatory bodies, Transmission System Operators (TSOs) and System Market Operators (SMOs) to implement the transmission tariff methodology; and
3. continue implementation of the Strategy and Action Plan for a Harmonized Regulatory Framework of Electricity Market in Africa