



## **RESOLUTION N°006/ERERA/15**

### **Adoption of the Tariff Methodology for Regional Transmission Cost and Tariff**

The Regulatory Council,

Mindful of Article 18.5 of Regulation C/REG.27.12/07 of 15 December 2007, as amended, on the composition, organisation, functions and operations of ERERA, and

After the review of the Tariff Methodology for Regional Transmission Cost and Tariff for the West African Power Pool (WAPP) by ERERA's Consultative Committees,

#### **RESOLVE THAT:**

1. The Tariff Methodology for Regional Transmission Cost and Tariff for the West African Power Pool, hereby attached, is approved.
2. The Tariff Methodology for Regional Transmission Cost and Tariff for the West African Power Pool shall be published in the ERERA official Bulletin and Website.

**Done in Accra, GHANA, on August 18, 2015**

Mr. Alagi Basiru GAYE  
Council Member

Mrs. Ifeyinwa IKEONU  
Acting Chairperson

**AUTORIDADE REGIONAL  
REGULADORA DE ELETRICIDADE DA CEDEAO**

**ECOWAS REGIONAL  
ELECTRICITY  
REGULATORY AUTHORITY**



**AUTORITÉ DE RÉGULATION  
RÉGIONALE DU SECTEUR DE  
L'ÉLECTRICITÉ DE LA CEDEAO**

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# **TRANSMISSION TARIFF METHODOLOGY FOR THE WEST AFRICAN POWER POOL**

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**AUGUST 2015**

**ECOWAS REGIONAL ELECTRICITY REGULATORY AUTHORITY**

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## **ACRONYMS**

<b>ECOWAS</b>	: Economic Community of West African States
<b>ERERA</b>	: ECOWAS Regional Electricity Regulatory Authority
<b>kWh</b>	: Kilowatt hour
<b>PSSE</b>	: Power Transmission System Planning Software
<b>SMO</b>	: System and Market Operator
<b>SPV</b>	: Special Purpose Vehicle
<b>TSO</b>	: Transmission System Operator
<b>WACC</b>	: weighted average cost of capital
<b>WAPP</b>	: West African Power Pool

### 1- INTRODUCTION

The Transmission Tariff methodology for the West African Power Pool (WAPP) shall be used by the Regional System and Market Operator (SMO) to develop a clear, transparent and predictable model for the calculation of transmission prices.

It is intended to formulate steps to be followed and rules that shall govern transmission pricing between parties involved in cross-border power exchange transactions in the regional electricity market.

Only the tariffs submitted by the SMO within the framework of this Methodology shall be approved by the ECOWAS Regional Regulatory Authority (ERERA).

The regional tariff methodology is based on the principles agreed in the Workshop held in Accra, Ghana on 5 April 2013. At that technical workshop, various methodologies were presented and the workshop participants agreed on the appropriate methodology for ECOWAS. The methodology was validated by the third Meeting of the Consultative Committees of Regulators and Operators of ERERA held in Lome, Togo 6 to 12 May 2013.

### 2- LEGAL BASIS

ERERA has been vested, under Article 18.5 of Regulation C/REG.27/12/07 of 15 December 2007, as amended, with the mandate to set regulations on accounting rules for tariff structure and cost for transmission and ancillary services, and approve tariff proposals emanating from operators.

The Directive C/DIR/1/06/13 of 21 June 2013, on the Organization of the Regional Electricity Market requires ERERA to publish in accordance with its procedures and after consultation with stakeholders, transmission tariffs setting methodology for the regional electricity market.

The Regional Market Rules for the West African Power Pool provide that the approval by ERERA of the Regional Transmission Pricing Methodology shall be one of the conditions precedent for the commencement of Phase 1 of the regional electricity market.

### 3- TRANSMISSION PRICING

#### 3.1 Wheeling charges design

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The development of charges for wheeling power across transmission and distribution networks may be regarded as a special case of the more general requirement for transmission and distribution charges to enable network operators to recover the costs of their systems. The key difference lies in the proportion of the energy that is carried by the network to which the charges are applicable. The existence of a charging methodology for wheeling that has the potential to be applied to all electricity transactions is important to achieve in order to avoid distortions in pricing at a later stage.

Key aspects of wheeling charge design, and transmission pricing more generally, concern:

- the basis on which revenues are recovered, i.e. the size of the asset base and its associated valuation, and the possible inclusion of charges related to congestion and/or network losses;
- the way in which costs are allocated to the users of the transmission and distribution services, i.e. whether any distinction is drawn between charges faced by generators and consumers, or whether charges are differentiated on the basis of locational factors.

### 3.2 Transmission Pricing Principles

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The core principles of transmission pricing are to:

- **Promote efficiency** by providing appropriate price signals to generation and demand, giving incentives for appropriate investment and promoting competition. It is important to consider the link between transmission pricing and the associated electricity trading arrangements, particularly in relation to congestion charging.
- **Recover costs** by reflecting the actual cost of transmission services. Security in cost recovery lowers the risk of investment, and hence cost of capital.
- **Be transparent, fair and predictable** to encourage new market participants. The methodology should be easy to explain and should be stable in the long-term, avoiding “price shocks”.
- **Be non-discriminatory**, i.e. treat network users who have the same impact on the transmission network equally, and for example ensure that the recovery of any residual costs (where price signals do not recover the full costs required) is allocated in a fair way.

### 3.3 Cost recovery

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A number of cost components can be recovered through transmission prices, including:

- capital costs of network and equipment;
- operation and maintenance costs;
- losses; and
- congestion.

### **4- TARIFF METHODOLOGY FOR REGIONAL TRANSMISSION COST AND TARIFF**

The Regional Transmission Tariff Methodology selected is described as a point to point MW-Km load flow based Tariff methodology. The Tariff is calculated for each and every regional bilateral trade within ECOWAS.

#### **4.1 Regional Tariff Methodology Steps**

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The fundamental steps in the methodology are:

1. Determine regional transmission assets and asset value
2. Calculate annual revenue requirements for each Transmission System Operator (TSO) asset used for regional bilateral trading
3. Calculate use of transmission system and associated transmission losses for each regional bilateral trade
4. Calculate transmission revenue requirements for each TSO for regional bilateral trades
5. Calculate transmission tariff and transmission losses for the purchaser of each regional bilateral trade

The regional transmission revenue and losses is calculated annually.

The detailed methodology to determine Regional Transmission Tariff for all bilateral trades is described as follows.

##### **4.1.1 Step 1 - Determine Regional Transmission Assets and Asset Value**

The Regional Transmission Network is all interconnected assets whose service voltage are greater than 132 kV (or as agreed by EREDA) in the ECOWAS region.

Interconnected assets are all the assets that are regionally interconnected (between two or more countries) even if there are two or more synchronous areas. This does not include supplying a domestic demand from one country to another.

The interconnected assets in each TSO are all transmission elements with service voltage greater than 132 kV (or as agreed by EREDA) whether the elements are used for regional trading or not. The asset database will contain all assets per class and per TSO, physical data for each network branch, (including line lengths, numbers of circuits, line types, tower types, voltages, switchgear type and voltage, transformer rating and voltage, etc.) The commercial operating date of each asset shall be provided by the TSO.

The regional transmission asset database is kept by the SMO. The database is updated annually by the SMO from information provided by each TSO.

For each element in the regional transmission asset database, a replacement value shall be agreed upon by the WAPP Engineering and Operating Committee. The replacement values are updated every 5 years (or as agreed by EREDA).



#### **4.1.2 Step 2 - Calculate Annual Revenue Requirements for each Transmission System Operator (TSO) Asset used for Regional Bilateral Trading**

The two cost components to be recovered are:

- capital costs of network elements; and
- operation and maintenance costs;

##### **4.1.2.1 Calculation of asset value**

The method for calculating annual asset value is the Depreciated Replacement Cost. This method recognises that the replacement of specific parts of the transmission line (transformer, switch gear) will be at current asset value.

Typical values used for asset depreciation period are:

- Transmission lines, 50 years
- Substation equipment, 25 years;
- Substation civil works, 50 years; and
- Transformers, 25 years.

For simplicity a single asset value of 30 years can be chosen.

In addition to the above methods, future approved investments are often included to allow the transmission network to build up equity for investment plans over the next 5 or so years. Future investments are also bankable as loan repayments are in the revenue base. Future investments requirements will be decided by ERERA on a case by case basis.

##### **4.1.2.2 Calculation of WACC**

The methodology used in Nigeria and Senegal for calculating the weighted average cost of capital (WACC) has been adopted.

The formula provides estimates of the appropriate return on equity and the returns to equity are measured in relation to the risk premium on the equity market as a whole. Thus:

$$R_e = R_f + \beta_e(R_m - R_f) \quad (1)$$

Where:

- $R_e$  is the return on equity
- $R_f$  is the risk free rate observed in the market
- $\beta_e$  is the correlation between the equity risk and overall market risk
- $R_m$  is the return on the market portfolio
- $R_m - R_f$  is the market risk premium



The WACC lies between the cost of equity and the cost of debt and is calculated as:

$$WACC = R_d \times D/(D + E) + R_e \times E/(D + E) \quad (2)$$

Where:

D is the total market value of debt  
E is the total market value of equity

R<sub>d</sub> is the nominal cost of debt; and  
R<sub>e</sub> is the nominal cost of equity.

This formulation does not include the effects of tax. The formulation of the WACC that allows for the effects of taxation (T<sub>c</sub>) and used extensively by regulators is as follows:

$$\text{Nominal post tax WACC (w)} = R_e \times E/V + R_d(1 - T_c) \times D/V \quad (2)$$

Where:

T<sub>c</sub> is the company tax rate,  
V is the total market value of the business, i.e. debt plus equity

A transformation is applied to derive an estimate of the real pre-tax WACC, as follows:

$$\text{Real pretax WACC (RW)} = \left[ \left( 1 + w/(1 - T_c) \right) / (1 + i) \right] - 1 \quad (4)$$

Where:

w is the nominal post tax WACC, as given by equation (3)  
i is the inflation rate

The WACC values allowed shall be approved by ERERA. All countries should use the same WACC values for regional interconnector asset value calculation. A common WACC for all countries in ECOWAS will depend on factors such as the differences in the risks of investing in individual countries and foreign exchange risk.

For dedicated interconnectors such as Special Purpose Vehicles (SPVs) or privately owned transmission assets, the WACC values could be actual WACC values in the agreement.

#### **4.1.2.3 Taxation on International Transmission Company Profits**

The formula for WACC allows for company taxation of the transmission companies' profits. The transmission company will be registered in one particular country and the taxation shall apply to that country only.

Intergovernmental agreements will have to be reached if an alternative taxation arrangement is required.

### 4.1.2.4 Operation and maintenance costs

Operation and maintenance costs are to be recovered by allowing a predetermined margin on the capital costs of equipment to cover an appropriate amount of the Operation and maintenance costs of each asset on an annual basis. This margin vary internationally and is typically in the range of 2% and 5% of the capital cost per annum for the system as a whole. The percentage allowed will be set by ERERA.

For dedicated interconnectors such as SPVs or privately owned transmission assets operating costs could be actual operating costs as approved by ERERA.

### 4.1.3 Step 3 - Calculate Use of Transmission System and associated Transmission Losses for Each Regional Bilateral Trade

Step 3 determines the transmission assets utilised and associated transmission losses for each regional bilateral trade. A load flow methodology has been adopted. A load flow, contingency analysis and dynamic stability study are required to be performed for each proposed regional bilateral trade to ensure there is sufficient transmission access for the regional bilateral trade before it is approved. Furthermore, each year a load flow is done for the forecast maximum generation hour for the next year and this is the load flow solution proposed for the method. The base case is the peak generation case for the following year.

The transmission pricing and losses studies will be performed annually by WAPP.

The basic steps are:

- (a) Set up base case simulation model with the peak demands and generation in the region including all of the regional bilateral trades.
- (b) Remove a regional bilateral trade by decreasing the consumption by the trade volume at the transmission node associated with the demand. The order for the regional bilateral trades is the oldest trade is applied to the methodology first to be aligned with open access rules. The associated generator is set to be the swing bus. Solve the load flow.
- (c) Add the regional bilateral trade back by increasing the consumption by the trade volume at the transmission node associated with the demand. The associated generator is set to be the swing bus. Solve the load flow.
- (d) As the trade is added the transmission elements that increased by 1% or more are noted as the transmission assets utilised for the specific regional bilateral trade. Record the percentage change increase in flow for each transmission asset that increased by greater than or equal to 1%.
- (e) The change in transmission losses is calculated by subtracting generator (Gen.) increase from trade volume. If the result is positive then this is the expected transmission losses. If the value is negative then the bilateral trade reduces transmission losses

$$\text{Transm. Losses} = (\text{Gen. Final Value} - \text{Gen. Initial Value}) - \text{Regional Bilateral Trade}$$

The calculation of losses could be done for different periods of the day and year to obtain average losses. This will require accurate models for each period.

- (f) Repeat steps (b) to (e) for each regional bilateral trade in order from oldest trade first

It would be possible to develop indicative costs for future regional bilateral trades by using the load flow model and simulating generation and off take points throughout the network. Most load flow simulation software allow for macros to be written for multiple studies such as the one described in the above basic steps.

#### **4.1.4 Step 4 - Calculate Transmission Revenue requirements for each TSO for Regional Bilateral Trades**

The calculation of the revenue requirements to each TSO and to ensure they receive their full revenue requirement is to apportion the costs to each user of the system.

The apportioning is calculated based on the percentage use of each asset for regional trades of the transmission network as follows:

*TSO bilateral trades revenue for asset (i)*

$$= \sum_{j=1}^m \delta_{(i,j)} \times \text{TSO revenue requirement for asset (i)}$$

Where:

j is the regional bilateral trade

m is the total number of regional bilateral trades of the TSO

i is the transmission asset of the TSO used for regional bilateral trades

$\delta_{(i,j)}$  is the percentage use of asset (i) for the regional bilateral trade (j)

The TSO revenue requirements for assets (i) is determined in step 2. The percentage of use of each asset (i) for each regional bilateral trade (j) is determined in step 3.

This allocates for each TSO, the portion of each transmission asset utilised by all the regional bilateral trades.

When the bilateral agreement has a low power factor the relative annual load factor will have to be considered for the asset.

The sum of TSO revenue for all assets used for regional bilateral trades is the total revenue due to the TSO:

*TSO Total revenue for bilateral trades*

$$= \sum_{i=1}^n \text{TSO bilateral trade revenue for asset (i)}$$

Where

$n$  is the total of TSO assets used for regional bilateral trades.

The calculation is repeated for each TSO having at least one asset of interconnection.

For a transmission asset that is specifically built for a single regional trade the percentage of use will be 100%.

*The TSO regional bilateral trade assets revenue = TSO total revenue requirements for the asset.*

The full TSO costs are covered and revenue is guaranteed.

In the case where the whole transmission network is used for a regional bilateral trade then the portion paid by the TSO regional bilateral trade is in proportion of the energy flowing on each element.

The methodology will ensure no cross subsidisation for actual usage.

Transmission losses are paid as the TSO loss factor multiplied by the regional bilateral trade times the price for the energy lost. ERERA will determine the tariff for losses.

*TSO transmission losses revenue*

$$= \sum_{j=1}^m \text{transmission flow for bilateral trade (j)} \times \alpha(j) \times \text{Price for Losses}$$

Where

$\alpha(j)$  is the loss factor for bilateral trade (j)

$j$  is the regional bilateral trade

$m$  is the total number of regional bilateral trades of the TSO

#### **4.1.5 Step 5 - Calculate Transmission Tariff and Transmission Losses for the purchaser of each Regional Bilateral Trade**

The sum of the individual asset costs for each bilateral charge is paid by the purchaser of the regional bilateral trade.

*TSO Revenue for a bilateral trade (j)*

$$= \sum_{i=1}^p \delta_{(i,j)} \times \text{TSO revenue requirement for asset (i)}$$

Where:

$j$  is the regional bilateral trade

$i$  is the transmission asset of the TSO used for regional bilateral trades

$p$  is the total transmission assets of the TSO used for the regional bilateral trade (j)

$\delta_{(i,j)}$  is the percentage use of asset (i) for the regional bilateral trade (j)

The costs are charged at rate per kWh based on hourly scheduled (contracted) energy. The transmission losses is paid by the purchaser of the regional bilateral trade. The price payable for the energy losses is determined by ERERA.

### 4.2 SMO's role in revenue collection, payments and ERERA funding

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The System and Market Operator (SMO) will collect the revenue from purchasers of bilateral trades for transmission tariff and transmission losses. ERERA and the SMO revenue requirements will be determined by applying a rate per kWh traded. The rates will be determined by ECOWAS's regulation on the levies for the operation of the Regional electricity market.

The SMO will pay TSOs their allocated transmission tariff and losses revenue.

Billing and settlements is based on energy schedules and schedules will be provided by the purchaser of the regional bilateral trade.

Billing and settlements will be done monthly.

### 4.3 Other issues

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- **Congestion management:** Congestion is managed on a "first come first serve" basis. . The latest signed regional bilateral trade will be the first to be curtailed.
- **Ancillary Services Costs:** Any specialised transmission device deemed an ancillary service will be settled by the trading parties directly.

## **5- APPLICATION OF THE METHODOLOGY**

### **5.1 Development of the detailed transmission pricing model and procedures**

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The final regional transmission pricing model is to be developed. This is the implementation of the software to ensure an easy to use, auditable and repeatable pricing methodology. This entails setting up of the asset database, writing scripts to transfer data to the financial model, the Siemens PSSE model and settlements processes. The writing of scripts for Siemens PSSE model to automatically perform step 3 of the methodology is adopted to avoid unnecessary repetitive tasks. The calculation of the final prices could be done in an Excel spreadsheet or a database type programme with this capability. The setting up of the financial settlements, currency to be used and timeframes for payment should be in these procedures. Billing and Settlement software is required to perform these functions.

The transmission pricing procedures will need to detail:

- the information required from TSOs in relation with the bilateral agreements;
- timeframes for submission of data to the SMO to ensure there is sufficient time to calculate the following year's revenue and tariff;
- the detailed procedure of how the model is run by the SMO;
- the approval process for the final transmission pricing and losses values; and
- what information is required to be provided to TSO's and regional bilateral traders and when it has to be provided.

### **5.2 Trial of the pricing Model on Existing ECOWAS Bilateral Arrangements**

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The pricing Model shall be tried on the existing regional bilateral trades.

This entails following steps 1 to 5 in the Methodology and using assets data base for the determination of asset values.

In essence, this trial run of the transmission pricing methodology will provide vital information to ERERA, WAPP, TSOs and the existing bilateral traders for the adoption of the pricing Model.

The results of the trial run in the step above should be presented to stakeholders. Key information is the impact on existing regional bilateral trades.

The information provided will enable stakeholders to refine the detailed transmission pricing model and final decisions on the handling of issues such as negative losses, approve no pricing for trades that reduce power flows on an asset etc.



### **5.3 Approval of the transmission pricing model and procedures**

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The detailed transmission pricing model and procedures developed by the SMO shall be approved by ERERA.

The transmission prices of all the contracts coming into effect after the enforcement of the Regional Market Rules shall be calculated each year according to this Pricing Model and submitted to the approval of ERERA.

For the contracts existing before the enforcement of the Regional Market Rules, the transmission pricing may be agreed between parties.

## **6- REVIEW AND MODIFICATION OF THE TARIFF METHODOLOGY**

- 6.1 ERERA will conduct a review of the Methodology before the end of the first Market Phase to ensure that the contents of the Methodology reflect the regulatory circumstances existing at the time of the review.
- 6.2 Special circumstances may arise that may necessitate changes to be effected, perhaps sooner than the envisaged formal review of the end of Phase 1 of the market.
- 6.3 ERERA will make decisions on the interpretation of the various clauses of the Methodology, but any party will be entitled at any stage to request ERERA's review or appeal a decision of review according to ERERA's enabling regulation.

## **7- EFFECTIVENESS**

This Transmission Tariff Methodology was approved by the ERERA Regulatory Council on the 18<sup>th</sup> of August 2015 and is effective from the said date.

**DONE IN ACCRA, GHANA, ON AUGUST 18, 2015**

By Order of the Regulatory Council



Mrs. Ifeyinwa IKEONU  
Acting Chairperson