
Office of Utilities Regulation

**Electricity Wheeling
Methodologies**

Consultation Document



OFFICE OF UTILITIES REGULATION

December 31, 2012

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Abstract

This Consultation Document sets out and invites comments on the various methodologies available to the Office of Utilities Regulation (“OUR”) for consideration in the setting of prices in the soon-to-be implemented Electricity Wheeling Framework in keeping with the provisions of the *Amended and Restated All-Island Electric Licence, 2011* (the “Licence”).

Condition 12 of the Licence stipulates that the Jamaica Public Service Company Limited (“JPS”) should within a 12-month period, which ended in August 2012, submit to the OUR proposed wheeling charges for approval. According to the Licence these wheeling charges should be based on a cost of service study conducted by the company within the 12-month period prior to the stipulated date for the submission of the wheeling tariffs for approval.

In addition to the stipulated cost of service study, the setting of wheeling rates requires a proper regulatory framework which is broader than the calculation of the rates. It involves rules/guidelines informed by clear principles to ensure the efficient operation of the process. The OUR has therefore deemed it a necessity to build a wheeling framework that will govern transactions related to the use of the national transmission and distribution grid by self-generators in the transportation of electricity from power production sites to consumption points where demand and supply are not co-located.

The Consultation Document outlines the various methodological options that may be employed in the development of wheeling charges and explores factors such as congestion and losses that should be taken into consideration in the design process. The document also recommends the MW-KW (load flow) approach based on the simplicity of the methodology, the efficiency it incorporates and its capacity for cost recovery. Stakeholders and other individuals with an interest, are being asked to contribute to the design of the framework by providing feedback on this document.

On receiving responses, the OUR will make a determination on the methodological approach and undertake the modelling of the wheeling charges as well as framing the other instruments required to make this feature of the electricity industry possible.

Comments from Interested Parties

Persons who wish to express opinions on this Consultation Document are invited to submit their comments in writing to the OUR. Responses to this document should be delivered or sent by post, fax or e-mail to:-

Cedric Wilson
36 Trafalgar Road
Kingston 10
Fax: (876) 929-3635
E-mail: cwilson@our.org.jm

Responses are requested by Friday, January 25, 2013.

Any confidential information should be submitted separately and clearly identified as such. In the interest of promoting transparent debate, respondents are requested to limit as far as possible the use of confidentiality markings. Respondents are encouraged to supply their responses in electronic form, so that they can be posted on the OUR's website (www.our.org.jm).

Comments on responses

The OUR's intention in issuing this Consultation Document is to stimulate public debate. The responses to this document are a vital part of that public debate, and so as far as possible, should also be publicly available. The OUR considers that respondents should have an opportunity both to examine the evidence and views put forward in other responses, with which they may disagree, and to comment on them. The comments may take the form of correcting a factual error, putting forward counterarguments and/or providing data relating to Transmission & Distribution grid, cost, revenues, etc.

Comments on responses are requested by Friday, February 1, 2013.

Arrangements for viewing responses

To allow all responses and comments to be publicly available, in addition to posting them on its website, the OUR will keep copies of the responses and comments in the OUR's Information Centre. These can be viewed and copied for visitors to the OUR's offices. Individuals who wish to view the responses and comments should make an appointment by contacting Kishana Munroe (Public Affairs/Information Officer) by one of the following means:-

Telephone: (876) 968 6053 (or 6057)
Fax: (876) 929 3635
E-mail: kmunroe@our.org.jm

At the pre-arranged time individuals should visit the OUR's offices at:

3rd Floor, PCJ Resource Centre
36 Trafalgar Road
Kingston 10

Individuals will be able to receive photocopies of selected responses and/or comments on responses at a price which reflects the cost to the OUR.

Timetable

The timetable for the consultation is summarized in the Table below:-

Summary of the timetable for public consultation

<i>Event</i>	<i>Date</i>
Deadline to Receive Responses to Consultation Document	By January 25, 2013
Deadline to Receive Comments on Responses to Consultation Document	By February 1, 2013
Publication of Determination Notice	By February 15, 2013

1.0 Introduction

- 1.1 An amendment to the Licence granted to Jamaica Public Service Company Limited (“JPS”) in August 2011 has paved the way for the introduction of electricity wheeling in Jamaica. The change which is codified in the *Amended and Restated All-Island Electric Licence, 2011* (the “Licence”) provides for movement of electricity across the national grid by self-generators “*on a basis that is cost reflective and consistent with tariffs and the Price Controls as approved by the Office.*” The aim of this amendment is to promote greater competition in the electricity sector and provide more options with regards to source of electricity to the consumers of electricity.
- 1.2 The Licence stipulates that JPS submit wheeling rates to the Office of Utilities Regulation (OUR) for approval one year after its amendment. This was done. However, the submission was deemed unacceptable by the OUR because JPS omitted to include a current cost of service study in their analysis of the rates as required by Licence.
- 1.3 The OUR recognizes that for electricity wheeling to be feasible it is necessary to address issues that are much broader than the evaluation of prices. These issues include among others, selecting an appropriate pricing methodology, assessing the risk of power congestion and formulating an approach for the treatment of losses. These issues can be complex and requires proper consideration to ensure satisfactory implementation of wheeling. Against this background, the OUR engaged the services of PPA Energy Consulting in October 2012 (the “Consultant”) to assist in the development of the Electricity Wheeling Framework (“Framework”). The Consultant’s Terms of Reference were also extended to include a cost of service study.
- 1.4 This document provides a detailed analysis of the full range of wheeling charge methodologies and their applicability in the context of the existing regulatory framework. The main objectives are:
 - 1) To explore wheeling charge methodologies and the computation of transmission and distribution network access fees in order to guide the development of an appropriate wheeling framework.
 - 2) To develop a fair and practical framework for the provision of wheeling services on Jamaica’s transmission and distribution network.
- 1.5 The OUR is also of the view that it is important to engage stakeholders in the industry to contribute to the development of the framework as they:
 - 1) bring to the discussion a wide range of perspectives informed by their experience and commercial environment; and
 - 2) through their participation provide technical depth to the evaluation of options that is essential to the development of robust policies.

1.6 This Consultation Document has been developed with these considerations in mind. The ensuing sections in this document are organized as follow:

- Section 2: delineates the legal and regulatory framework
- Section 3: considers the principles involved in wheeling pricing
- Section 4: examines the cost components of the transmission grid that should be recovered in the wheeling prices.
- Sections 5 - 7: outline the methodologies that may be used in the development of wheeling prices.
- Section 8: explores the issue of congestion management.
- Sections 9 – 10: outline a comparative analysis of wheeling pricing in a number of countries.
- Sections 11-12: delineate the factors that merit consideration in the development of the Framework.
- Section 13: sets out the OUR recommended methodological approach.

2.0 Legal and Regulatory Framework

2.1 The OUR is a multi-sector regulatory agency which was established in 1995 by the Office of Utilities Regulation Act (“the OUR Act”). Section 4(1) of the OUR Act specifies the functions of the Office. Pursuant to Section 4(1)(a) of the OUR Act, the OUR has regulatory authority over prescribed utility services. “Prescribed utility services” is defined in the First Schedule of the OUR Act as the telecommunications, electricity, water and sewage and the transportation (road, rail and ferry) sectors.

2.2 Section 4(3) of the OUR Act provides inter alia, that the Office in the performance of its functions under the OUR Act may “*undertake such measures as it considers necessary or desirable to:*

- a) encourage competition in the provision of prescribed utility services;*
- b) protect the interests of consumers in relation to the supply of a prescribed utility service;*
- c) encourage the development and use of indigenous resources; and*
- d) promote and encourage the development of modern and efficient utility services... ”*

2.3 Section 4(4) of the OUR Act provides:

“The Office shall have power to determine, in accordance with the provisions of this Act, the rates or fares which may be charged in respect of the provisions of a prescribed utility service.”

2.4 The Licence is the instrument that establishes the legal framework within which JPS operates. Under Condition 2(3) of the Licence, JPS “*shall provide an adequate, safe and efficient service based on modern standards, to all parts of the Island of Jamaica at reasonable rates so as to meet the demands of the Island and contribute to economic development.*”

2.5 Conditions 2(4) of the Licence provides that the generation of electricity may be carried out by several players in the industry. However JPS, the sole owner of the national grid, has exclusive right to transmit, distribute and supply electricity island-wide until 2027. Condition 2(4)(a), of the Licence provides as follows: “*...the Licensee shall have the right together with other outside person(s) to compete for the right to develop new generation capacity.*”

Also, Condition 2(4)(b) of the Licence stipulates as follows:

“The exclusive right specified herein shall be as follows: “...the Licensee shall have the exclusive right to transmit, distribute and supply electricity throughout Jamaica... until July 8, 2027.

Provided that no firm or corporation or the Government of Jamaica or other entity or Person shall be prevented from providing a service for its or his own exclusive use.”

2.6 Notwithstanding, Condition 12 of the Licence mandates JPS to provide open access to self-generators to its national grid on such terms and conditions as are approved by the OUR. Condition 12 provides:

“The Licensee shall permit Electric Power Wheeling Services in accordance with the terms and conditions approved by the Office.”

The Licensee shall prepare its charges for use of the System or top-up or standby supplies, including but not limited to Electric Power Wheeling service, on a basis which is cost reflective and consistent with tariffs and Price Controls as approved by the Office”. With regards to Electric Power Wheeling, the charges for this service shall additionally be guided by the results of a cost of service study conducted by the Licensee, which results shall be submitted to the Office for approval. The cost of service study shall be conducted within twelve (12) months of the date hereof.”

2.7 Within the context of the legal and governance regime outlined above, the OUR intends to establish a framework that will allow open access to the transmission and distribution network to allow self-generators to wheel power to locations remote to the point of generation through a process that is transparent, a methodology that is appropriate and mandate charges which are fair and cost reflective.

3.0 Wheeling Pricing Principles

- 3.1 To create a framework that is fair and promotes competition, certain core regulatory principles must inform the methodology employed in the development of wheeling charges. These principles are outlined below.
- 3.2 **Promoting efficiency:** This is achieved 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.
- 3.3 **Recovering costs:** Different methodologies can be applied to determine the costs to be recovered, for example historic costs vs. forward looking costs. While historic cost methodologies tend to ensure the full recovery of cost there is no guarantee that this will happen with forward looking methodologies. However cost recovery is important since it lowers the risk of investment, which impacts the cost of capital.
- 3.4 **Ensuring transparency, fairness and predictability:** This requires a governance regime that inspires confidence in regulatory framework and encourages new market participants. Ideally the methodology should be easy to explain and should be stable in the long-term, avoiding “price shocks”.
- 3.5 **Promoting non-discriminatory behaviour:** This means the equal treatment of network users who have the same impact. Consequently, this involves ensuring that the recovery of any residual costs (where price signals do not recover the full costs required) is allocated in a fair way.

4.0 Cost Recovery

- 4.1 A number of cost components may be legitimately recovered through wheeling prices. These include (i) capital costs of network plant and equipment; (ii) operation and maintenance (O&M) costs; (iii) network losses; and (iv) congestion.

Capital Cost

- 4.2 For capital cost recovery, historical cost approaches rely solely on obtaining an accurate calculation of the annuitized cost of network assets. Consequently, the cost recovered is based on an accurate assessment of the cost of the existing network, from an asset valuation. These approaches are generally good at recovering actual system costs, although there are tradeoffs in the extent to which historical costs are considered to be economically efficient.

- 4.3 Greater economic efficiency is gained by applying so-called “forward-looking” pricing methodologies to the recovery of capital cost. These methodologies assign part or all of the costs of providing new transmission facilities for a transaction directly to that transaction. As such, only the new transmission costs caused by a new transaction are considered in calculating the transmission charge. There are a number of methodologies using forward-looking concepts, which differ in their use of incremental and marginal costs, and of the short-run and long-run.
- 4.4 There is an important difference between incremental cost and marginal cost. The incremental cost of a transaction is found by comparing the total system costs with and without the transaction. The marginal cost of the transaction, on the other hand, is calculated by assessing the extra cost of providing an extra unit of transmission.
- 4.5 Long-run cost methodologies although efficient tend to lead to the under-recovery of capital cost. This is due to the likelihood that a transmission system is sub-optimally designed for current patterns of use for historic reasons, and the “lumpy” nature of transmission investment leads to the provision of over-capacity being cost-effective on occasion.
- 4.6 Short-run methodologies only take operating costs into consideration. As such, it is unlikely that system prices will be allowed to rise to the levels necessary to recover the full costs of required new investment. In a perfect market, short-run and long-run costs would be identical. In practice, the presence of large fixed costs and economies of scale in transmission systems mean that short-run costs (in which the network is considered to be invariant) are below long-run costs (which include the costs of system expansion/reinforcement). Consequently, short run methodologies invariably lead to the under-recovery of cost in the real world.
- 4.7 Whichever method is used for signalling capital costs to network users, there is likely to be a requirement to scale the final incomes received to meet the revenue requirements of the network company. A key issue in transmission pricing concerns the relative size of this scaling component compared with the level of revenue recovered through the application of the “pure” prices. If the scaling component becomes too significant, there is the risk that the method reverts towards a flat charge that is unrelated to the use of network assets, which risks losing a significant degree of economic efficiency.

Operating and Maintenance Costs

- 4.8 O&M costs are most readily recovered by allowing a predetermined margin on the capital costs of equipment to cover an appropriate amount on an annual basis to cover the O&M costs of each asset. Annual allowances vary from utility to utility, but typical figures in the range 2%-5% of the capital cost per annum are applied to cover O&M costs for the system as a whole. This needs to be sufficient to cover the costs of operating the centralised

control functions within the transmission operator business, as well as the maintenance requirements of the individual assets themselves.

Network Losses

- 4.9 In principle, the cost of transmission losses can similarly be included in the costs recovered by the wheeling pricing methodology, although this is dependent on understanding the costs that are actually involved in covering these. Many international market models leave the allocation of losses for the electricity market to resolve, through the adjustment of metered quantities in the settlement process. A key consideration here is the route by which the costs of losses are recovered, and how the transmission operator is incentivised to reduce losses.
- 4.10 Particular attention to losses is required in the design of wheeling charge methods, to ensure that only those incremental losses associated with the impact of specific wheeling trades on the network are taken into consideration.

5.0 Historic Cost Methodologies

Postage Stamp

- 5.1 The postage stamp approach is generally regarded as the simplest to implement. The methodology allocates system costs between users on the basis of their share of total peak load on the system. It therefore results in a flat transmission charge per unit of demand equal to the total transmission costs divided by peak load. The postage stamp method is often supported with reference to the fact that, in power transactions, electrons do not actually travel from the seller to the buyer and the system is operated on an integrated basis.
- 5.2 There are a number of clear advantages of such a transmission charge methodology:
- a) Full historic cost recovery is ensured. As this allows investors to recover their investment costs, it solves the problem of under investment apparent in nodal pricing approaches.
 - b) The system results in a clear, simple and stable transmission charge as each consumer pays the same charge, regardless of location. Also as the peak load is likely to increase at a relatively moderate pace in most cases, the charge is largely invariant with time.
 - c) Postage stamp pricing is most justified in systems in which there are few constraints and load and generators are fairly equally spaced. In such systems, bulk power

transmission costs do not significantly increase with the distance between buyers and sellers.

5.3 The postage stamp method does suffer from a number of significant problems:

- a) As the methodology does not consider the actual utilisation of the system, it does not create the correct incentives for system users. This can result in serious efficiency concerns as users are not liable for the full costs of their actions. For instance, a transaction whose costs in terms of system upgrades and investments exceed its benefits may still occur as the parties to the transaction face only a small part of the extra transmission cost.
- b) As all users face the same transmission tariff, the postage stamp methodology discriminates against low-cost transmission users in favour of higher-cost users. In effect those parties engaging in high-cost transmission deals are subsidised by those who, for instance because they utilise only a small part of the network, create a smaller fraction of the transmission costs. This provides incentives for low-cost users to bypass the existing transmission network.

Contract Paths

5.4 Under the contract path methodology, a specific path is agreed for an individual wheeling transaction between two points. This ‘contract path’ does not take account of the actual path of the power flow that would occur. A share of the asset costs, including the costs of new investment, along the contract path is allocated to the wheeling customer in proportion to their use.

5.5 The contract path methodology does create a number of benefits. The most notable of these are similar to the postage stamp method:

- a) Full cost recovery is possible as all asset costs along the contract path are considered, including the costs of new assets if they are required. This will allow investors to benefit fully from their actions, and so encourage an efficient level of investment.
- b) The system creates a simple and stable pricing regime, and is easy to implement.
- c) Relative to the postage stamp methodology, the contract path approach provides an improved ability to signal the costs of decisions by individual users.

5.6 As with the postage stamp method, this methodology ignores the actual system operation and any congestion issues. An energy transaction will affect all assets on the transmission system, not just those along the contract path. This may lead to investments being necessary in areas of the system which are not on the contract path at all. Therefore, the

use of a contract path approach is low in economic efficiency, as well as potentially discriminating between users.

MW-km (Distance-based)

- 5.7 This methodology is an extension of the concept behind the postage stamp and contract path approaches. The distance travelled by the energy transmitted under a specific transaction is either determined on a 'straight-line' basis between the points of entry and exit to the network, or on a contract path approach. The MW-km of the transaction is then determined and the ratio of this to the total system MW-km determined. This ratio is then used to determine the cost of the transaction.
- 5.8 As an enhancement of the postage stamp method, this methodology enjoys the majority of the former's advantages. The total cost of all transmission activities includes fixed and variable costs, allowing investors to fully recover their costs and so providing efficient investment incentives. Also, the relatively simple and clear nature of the methodology makes it easy both for the users to understand the system of transmission prices and for the method to be implemented.
- 5.9 As with the previous methodologies, the actual operation and costs incurred in the system are not fully considered. Although the distance between delivery and receipt does provide some indication of actual use of the system, it still fails to take account of the impact of Kirchoff's Law; which states that electricity will follow the path of least resistance. Thus the distance-based approach does not provide the correct economic signals to users, leading to reduced allocative and dynamic efficiency and discrimination between users.

MW-km (Load Flow-based)

- 5.10 The load flow-based MW-km methodology reflects, to some extent, the actual usage of the power system. Transmission prices are determined in relation to the proportion of the transmission system used by individual transactions, as determined by load-flow studies.
- 5.11 A power flow model is used to calculate the flow caused by the transaction on each circuit of the transmission system. The ratio of the power flow due to the transaction and the circuit capacity is then determined. This ratio is multiplied by the circuit cost to obtain a cost for the transaction on each circuit. The share of the total system costs for the transaction is the sum of the costs for each circuit.
- 5.12 The relatively simple and clear calculation of transmission charges using this method increases the degree of transparency of charges. In addition, the problem of prices not being cost-reflective which is common to distance-based methodology is reduced by making users face prices that more closely relate to their use of the network. Consequently, this results in decreased discrimination between users and increased allocative efficiency.

5.13 Notwithstanding, the load flow-based MW-km approach still fails to signal the costs of future investment caused by individual users' decisions, based as it is on the recovery of historic costs. Additionally it is expected that the total power flows are less than the circuit capacity, hence not all the transmission system capital cost may be recovered. If congestion occurs due to the transactions this will be observed from the results of the load flow and a methodology to address congestion can be considered.

5.14 The shortcomings in load flow-based MW-km might be mitigated through a refinement process. The refinements include:

- a) the replacement of the circuit capacities with the total power flow caused by all transactions to fully recover the costs of network assets; and
- b) taking account of the direction of the flow, if the flow due to the transaction is in the opposite direction to the net flow then the transaction is not charged as a net flow reduction is beneficial to the system.

6.0 Forward Looking Methodologies

Short Run Pricing

6.1 Short-run forward pricing methodologies include short-run incremental cost (SRIC) pricing and short-run marginal cost (SRMC) pricing. Within the SRIC methodology, all operating costs associated with a new transmission transaction are allocated to that transaction. As described in Sections 4.3 -4.5 above, this differs from the marginal cost methodology, in that the SRMC method includes the operating cost of extra use of the transmission system caused by a new transaction (the increase in losses and congestion costs).

6.2 Under the SRIC approach, costs are calculated using a model of optimal power flows, whilst to estimate the SRMC, the marginal operating cost of an extra MW of power is calculated at all points of delivery and receipt. This is then multiplied by the size of the transaction to provide SRMCs.

6.3 Despite the different methods of calculation, analysis of the advantages and disadvantages of the two methods is very similar. In using the pricing methods, a number of common concerns must be addressed:

- a) It is difficult to accurately evaluate the operating costs of a single transaction when multiple transactions occur simultaneously and an assessment has to be made about which investment cost relates to which individual transaction.

- b) The use of SRIC methodology requires the forecasting of future operating costs. Such forecasts clearly become decreasingly accurate as the time horizon increases.
- c) The short-term nature of the pricing methodology leads to two issues: it is likely that transmission prices based on the methods will be volatile, and the use of SRMC/SRIC approaches may lead to underinvestment.

6.4 In addition there are some additional disadvantages in using the SRMC process.

- a) If the individual transaction is very large in relation to the transmission system load, then the SRMC price may not be an accurate estimate of the actual extra costs imposed by the transaction, as they fail to capture additional system reinforcement costs imposed.
- b) Once any investment is made, the future SRMC prices will fall, reducing the potential for the network owner to fully recover these costs.

6.5 Notwithstanding, the transmission price for a transaction, under the short run pricing methodologies, is approximately equal to the actual cost placed upon the network due to the transaction, thus promoting efficiency in the recovery of the transmission system cost.

Long Run Pricing

6.6 Long-run forward pricing methodologies include long-run incremental cost (LRIC) pricing and long-run marginal cost (LRMC) pricing. The LRIC methodology is similar to that of the SRIC. However both operating and investment costs are considered. The investment costs are estimated from the change caused in long-term investment plans due to the individual transaction.

6.7 The LRMC method only differs from the SRMC methodology in the use of marginal investment costs as well as marginal operating costs to determine transmission costs. To calculate the extra investment costs, future transmission expansion projects are costed. This cost is then divided by the size of new planned transmission transactions to calculate the marginal investment cost.

6.8 The advantages and disadvantages of LRIC and LRMC pricing are almost identical. Estimating the investment costs and evaluating the costs caused by the individual transactions can be difficult. Multiple transactions occurring simultaneously create problems in assessing which investment cost relates to which individual transaction, and therefore the extent to which users should contribute to new investments. This is particularly so where new beneficiaries connect to the system at a later date. The sensitivity of future investment programmes to assumptions on future system use means that transmission prices can be rather unstable. There may also be concerns over double-

counting of investment requirements, in that these are driven by congestion costs that are also captured in LRMC pricing through the inclusion of operating costs.

- 6.9 Despite these problems, there are advantages apparent under the long-run methodologies that are not apparent with short-run methods. These include the fact that;
- a) Users face the full long-term costs of their actions, including the costs of new investments.
 - b) Prices are more stable in the long-run than under short-run pricing, allowing users to more easily engage in long-term contracts.

7.0 Nodal Pricing

- 7.1 The nodal pricing methodology, where a node can be any point in the network, can be seen as the economically ‘ideal’ transmission pricing system as prices are calculated to accurately reflect the costs imposed on the system by the transaction. The difference in charges at each node on the system (which is equal to the transmission charge between these nodes) is set on the basis of the marginal cost of losses and congestion at that node i.e. the cost of injecting one additional unit of energy at that node. Nodal prices obviate the issue of which assets are used for wheeling purposes by not defining the path followed by flows between nodes. Instead, prices are set on the basis of the marginal impact on the system as a whole.
- 7.2 The nodal methodology provides for any busbar, or node, on the network, a pricing signal relative to any other node. For nodes located in areas with surplus generation there will be a comparatively high cost for adding additional generation, and conversely for nodes located in areas with a deficit of generation the price for adding additional load will be high. Parties considering electricity trading can obtain an indication of the price of power transfers between nodes on the network. Similarly, potential investors in transmission lines can obtain an indication of the returns they might make on investments in different parts of the network.
- 7.3 In its simplest form nodal pricing system solves the dispatch problem in a decentralised market by ensuring the marginal cost at all supplying nodes is equal to the marginal benefit at all consuming nodes. This results in users consuming electricity up to the point where their marginal value of power is equal to the marginal cost of supply, the nodal price, ensuring that both allocative and dynamic efficiency are maximised.
- 7.4 Nodal pricing can continue to lead to optimal dispatch in a more complex model incorporating transmission losses and congestion costs. Each nodal price is equal to the cost of providing an extra unit of electricity to the node, including costs of losses and

congestion. Thus efficiency is still maximised within the more complex model. The methodology results in transmission charges being variable by time and location. Individual nodal prices can change instantaneously to allow for changes in supply and demand, as well as being dependent on distance from generation.

7.5 Although nodal pricing methodology leads to maximum efficiency benefits, there are a number of issues that have resulted in the system being rarely adopted in practice:

- a) It is probable that nodal pricing will result in under-recovery of fixed costs, as pricing is a function of marginal costs. This does not allow for the recovery of the significant existing fixed costs that characterise transmission networks, which lead to average total costs exceeding short-run marginal costs. For these costs to be more fully recovered, it is necessary to move to a system of ‘second-best’ pricing in which economic efficiency is sacrificed for prices that allow the network operator to recover all their costs, including variable and fixed costs.
- b) To set the prices, the transmission system operator would require constant real-time information about all loads, generators, bids and the condition of all equipment. Prices would not only vary over different nodes, but also over time as elements such as supply, demand and transmission constraints change. This creates significant instability and complexity in implementation, requiring advanced information technology and communications, often resulting in countries adopting different pricing systems or simplifications of full nodal pricing.

8.0 Congestion Management

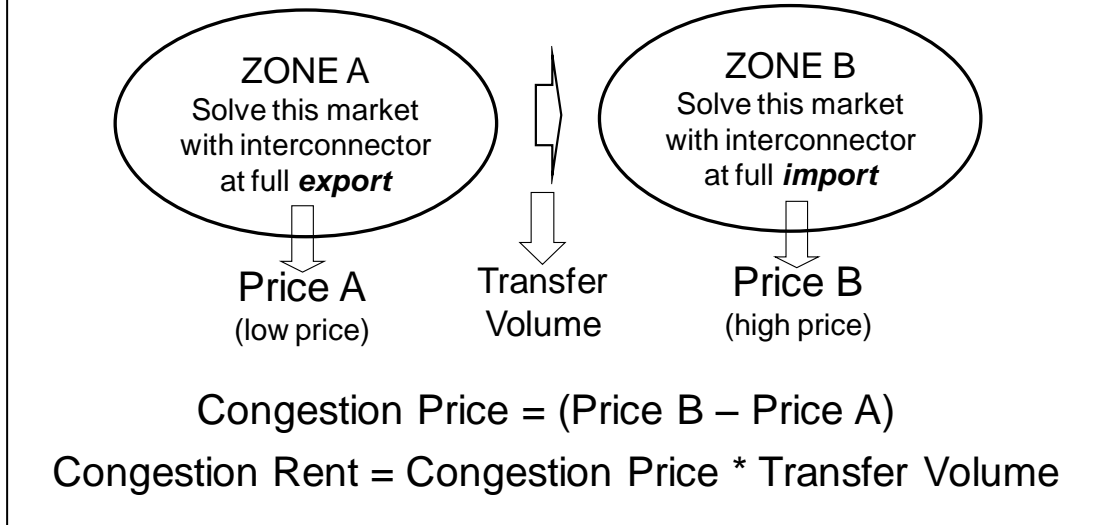
8.1 The issue of congestion on transmission interconnectors is one that straddles wheeling pricing and market operation, and as such needs to be considered carefully in terms of its treatment in relation to wheeling.

8.2 Transmission congestion has several principal impacts on system and market operation:

- a) it can affect the dispatch of generation, resulting in “out of merit” generation being required to counteract bottlenecks on the transmission network and to avoid system overloads;
- b) it can require procedures to be developed for giving access to transmission circuits for specific transactions, including the management of “Available Transmission Capacity”; and

- c) it can lead to the separation of an electricity market into different physical zones for the purposes of defining market prices (so-called “market splitting”).
- 8.3 The presence of congestion can be signalled relatively simply in transmission pricing by allowing charges for the use of specific lines to vary depending on whether the flow created by a given transaction increases or decreases the prevailing flow on the line. If a proposed wheeling trade, for example, runs counter to the main power flow, it could be argued that this should not face as high a charge as one that *adds* to the existing flow. The way that transmission prices are determined under any of the methods outlined above is essentially an ex ante process requiring prices to be published ahead of electricity trading taking place, and therefore calculations would need to be based on a predicted base case of power flows. The resulting signals relating to congestion can only therefore be approximate.
- 8.4 Under a more dynamic approach, the possible existence of congestion is predicted and managed through the splitting of a market into zones, or even nodes, at which separate prices are calculated. The ability to do this depends on the sophistication of the electricity market and the existence of some form of short-term market in which the costs of electricity are time varying. As demand changes and the flows on the network change, so the loading on different transmission lines varies to the point where operational ratings are at risk of being exceeded. In this situation, shown graphically in Figure 1 below, the price at which energy is traded in two zones of the electricity market changes once the capacity of the interconnector between them is reached. This generates a difference between the price at which the transferred volume of energy is sold to a consumer in Zone B and purchased from a generator in Zone A. The resulting “congestion price”, and the “congestion rent” that it generates, can be used in a variety of ways, but is typically either returned to market participants or used to create a fund for investment in interconnector capacity.

Figure 1: Demonstration of Market Splitting and Congestion Management



- 8.5 The interconnector capacity in the above example could be allocated via a process such as an auction, in which it is made available to specific combinations of buyers and sellers on either side of the interconnector in advance. This approach is straightforward to administer; the challenge comes in maximising the utilisation of the interconnector as trading evolves towards real time. This so-called “explicit auction” approach is sometimes criticised as being less economically efficient than the alternative “implicit auction”, in which energy and capacity are traded together, such that the interconnector capacity is fully utilised by the trades that are entered into.
- 8.6 The complexity of the congestion management approach outlined in Figure 1 above is unlikely to be justified for the situation of wheeling energy between self-generators and their associated demand, and would be dependent on the evolution of the electricity market towards shorter term contracting arrangements such as a day-ahead or spot market. Nevertheless, it will be important to signal to self-generators the impact of their exports on the network, in order to encourage optimum utilisation of the network assets.

9.0 Pricing Methodologies in Different Countries

- 9.1 In practice transmission pricing methodologies adopted by countries rarely fit exactly to the ‘standard’ methodologies described above. As electricity markets develop and increase in sophistication the complexity of the transmission pricing increases. The methodologies adopted by different countries are described below.

Nord Pool

- 9.2 Nord Pool covers six (6) countries in Europe: Denmark, Finland, Sweden, Norway, Estonia and Lithuania. Each country has its own Transmission System Operator (TSO) and many have different levels of transmission grid, for example Norway has a central grid, which spans from the very North to the very South of Norway and connects Norway to the surrounding countries, below the central grid are regional grids. Norway has five defined market areas, Denmark has two and Sweden has four defined market areas while Finland, Estonia, Lithuania operates one market area each. The Nord Pool spot market (Elspot) operates fourteen (14) market areas in six(6) countries.
- 9.3 The Nord Pool transmission pricing methodology is based on a point or stamp tariff system, where the producers and consumers pay a fee for the kWh injected or drawn from the system. The distance or transmission path between the seller and buyer is of no significance to the transmission price.
- 9.4 The actual transmission price depends on where (what point in the grid) the power is injected or consumed and how much power is injected or consumed. The charges are determined by the individual TSOs and paid to the TSO to which the connection is made. However the payment allows trading of electricity across the whole Nord Pool market area.
- 9.5 Within each member country there is a transmission tariff payable within the country. In Norway the transmission tariff comprises several components, a fixed component, a load component and an energy component.
- 9.6 The allocation of charges between generation and demand differs across the countries: Sweden 25:75; Norway 35:65; Finland 12:88; Denmark 2-5:95-98; Estonia 0:100; Lithuania 0:100.
- 9.7 In addition to the transmission tariff cost congestion costs are recovered through congestion rents which are the income or cost that arise due to the price differences between the areas. The congestion rent from the interconnectors is shared among the four TSOs in accordance with a separate agreement.
- 9.8 The Nord Pool spot market carries out the day-ahead congestion management on external and internal transmission lines. The available transmission capacity and the price differences in the surplus and deficit area manage the congestion day ahead implicitly within the energy market auctions.
- 9.9 Transmission losses are recovered by a standard Elspot trading fee in EUR/MWh which is paid by both buyers and sellers.

Ireland

- 9.10 EirGrid is the independent system operator for the Republic of Ireland (RoI) and SONI (System Operator Northern Ireland) is the system operator for Northern Ireland (NI). A system operator agreement exists between the two TSOs and ensures the required coordination between them. The electricity market in NI and RoI together is referred to as the All Island market.
- 9.11 The SEMO (Single Electricity Market Operator) is responsible for the operation of the centralised gross pool/wholesale market. Electricity is marketed through market clearing mechanisms. Generators are paid the System Marginal Price (SMP) plus the capacity component for that half an hour and constraint payments for the differences between market schedule and system dispatch. Suppliers who buy energy will pay the SMP for each half an hour along with capacity costs and system charges.
- 9.12 According to the All Island transmission methodology, the transmission costs are allocated at 25:75 split with generators paying 25% and demand paying 75% of the transmission related costs.
- 9.13 The All Island transmission tariffs have been designed to recover a maximum of 30% of allowed revenue from a locational element which apportions the share of the cost that a generator uses of new assets. (New assets are those to be built in the next 5 years or those that have been built in the previous 7 years). The remaining amount is collected through a postage stamp methodology. Any revenue not recovered by the locational tariff component is shared across all units by a flat €/MW charge to obtain a postage stamp charge.
- 9.14 Transmission losses are allocated to generators/interconnectors, by means of Transmission Loss Adjustment Factors. This includes generators connected to the distribution network. Transmission losses are recovered through transmission prices in NI and through energy market in the RoI.

Southern African Power Pool (SAPP)

- 9.15 The SAPP members are the utilities and ministries involved in energy usage in Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, Swaziland, Tanzania, Zaire, Zimbabwe and South Africa. The transmission systems in the majority of these countries are interconnected. A fundamental SAPP objective is to allow wheeling of energy through the transmission systems, where wheeling is the transfer of power through a country who is neither the buyer or the seller of the power.
- 9.16 The original wheeling charge was based on the postage stamp principle. This applied a scaling factor of 7.5% to the value of the energy wheeled through one country, or 15% if the energy was wheeled through two countries, split between the two countries. The

increase (or decrease) in loss was supplied by the seller of the energy and paid for by the buyer.

9.17 This method was replaced in 2003 by a MW-km methodology where the charges are determined according to the proportion of assets used for wheeling. The use of assets for wheeling purposes is determined using load flow studies to calculate the proportion of total available capacity on each contract path accounted for by a wheeling transaction. Wheeling charges are then levied in accordance with this proportion as a share of the total asset values affected by the wheeling transaction.

9.18 Work was undertaken in 2005/6 to develop a nodal transmission pricing model, however due to various regional factors which resulted in a significant reduction in the amount of wheeling being undertaken with SAPP this has not yet been implemented. This was designed to coincide with the introduction of a Day-Ahead Market (DAM), which permits trading across constrained interconnectors in real time. A relatively sophisticated market model has been introduced that permits the splitting of the SAPP region into market zones that are able to split as constraints become binding on the interconnectors, with differentiated prices in each zone.

Great Britain

9.19 National Grid is the System Operator for the Great British (GB) system covering England, Scotland and Wales. The GB transmission system is divided into 14 geographical demand zones and 20 generation zones.

9.20 Transmission Network Use of System (TNUoS) charges reflect the cost of installing, operating and maintaining the GB transmission system. TNUoS charges are allocated at 27:73 split with 27% of the charges being levied on generators and 73% on demand.

9.21 The GB transmission pricing methodology is based on a nodal pricing methodology. The TNUoS charges reflect not only the incremental cost of transmission but also take into account a locational factor. A DCLF (Direct Current Load Flow) ICRP (Investment Cost Related Pricing) model is used to determine marginal cost of investment which would be required as a consequence of an increase in demand or generation at each node on the transmission system. From this the TNUoS are developed. In some zones there are negative charges providing an incentive for generators.

9.22 Transmission losses are recovered as part of the energy market, through the application of loss factors that relate the impact of generation and demand at specific nodes on the network to marginal changes in losses in the whole transmission system.

9.23 Transmission congestion management is dealt with by the use of constraint management balancing services.

United States: PJM

- 9.24 PJM is a regional transmission organisation which is responsible for the movement of wholesale electricity in all or parts of 13 states and the District of Columbia. PJM manages the continuous buying, selling and delivering energy. PJM undertakes interconnection management and is the market operator.
- 9.25 Demand users (load) pay for the cost of transmission infrastructure i.e. 100% transmission costs are allocated to the demand customers in accordance with their energy usage. PJM uses locational marginal pricing (LMP) that reflects the value of the energy at the specific location and time it is delivered. Prices are calculated for individual buses, aggregates, and transmission zones hence this is a form of nodal pricing.
- 9.26 If the lowest-priced electricity can reach all locations, prices are the same across the entire grid. However when there is transmission congestion, the locational marginal price is higher in the affected locations. Financial Transmission Rights (FTR) are used to provide a hedging mechanism that can be traded separately from the transmission service. The congestion rents are used to pay the holders of FTRs.
- 9.27 The PJM Day-Ahead Market is a forward market where hourly LMPs are calculated for the next operating day based on generation offers, demand bids and scheduled bilateral transactions. The Real-Time Market is a spot market in which current LMPs are calculated at five-minute intervals based on actual grid operating conditions.

New Zealand

- 9.28 The New Zealand transmission network comprises the North and South Islands. TransPower is the transmission system operator and the owner of grid in New Zealand. The New Zealand transmission pricing methodology reflects locational marginal pricing and is based on full nodal pricing.
- 9.29 Transmission use of system charges comprise an interconnection charge for all the load customers. This interconnection charge is calculated as the weighted-average RCPD (Regional Coincident Peak Demand). The costs of the HVDC link between the north and south island are charged for the generators only on the south island. 100% of the other transmission costs are allocated to loads.
- 9.30 NZEM, the New Zealand wholesale Electricity Market, calculates prices that reflect the cost of electricity at a node. The energy market is driven by long term bilateral contracts alongside a spot market. Contract and spot markets together are collectively referred to as the wholesale market.

- 9.31 Transmission losses and congestion costs are reflected in the half hourly prices that are generated for each of the pricing nodes in the market.

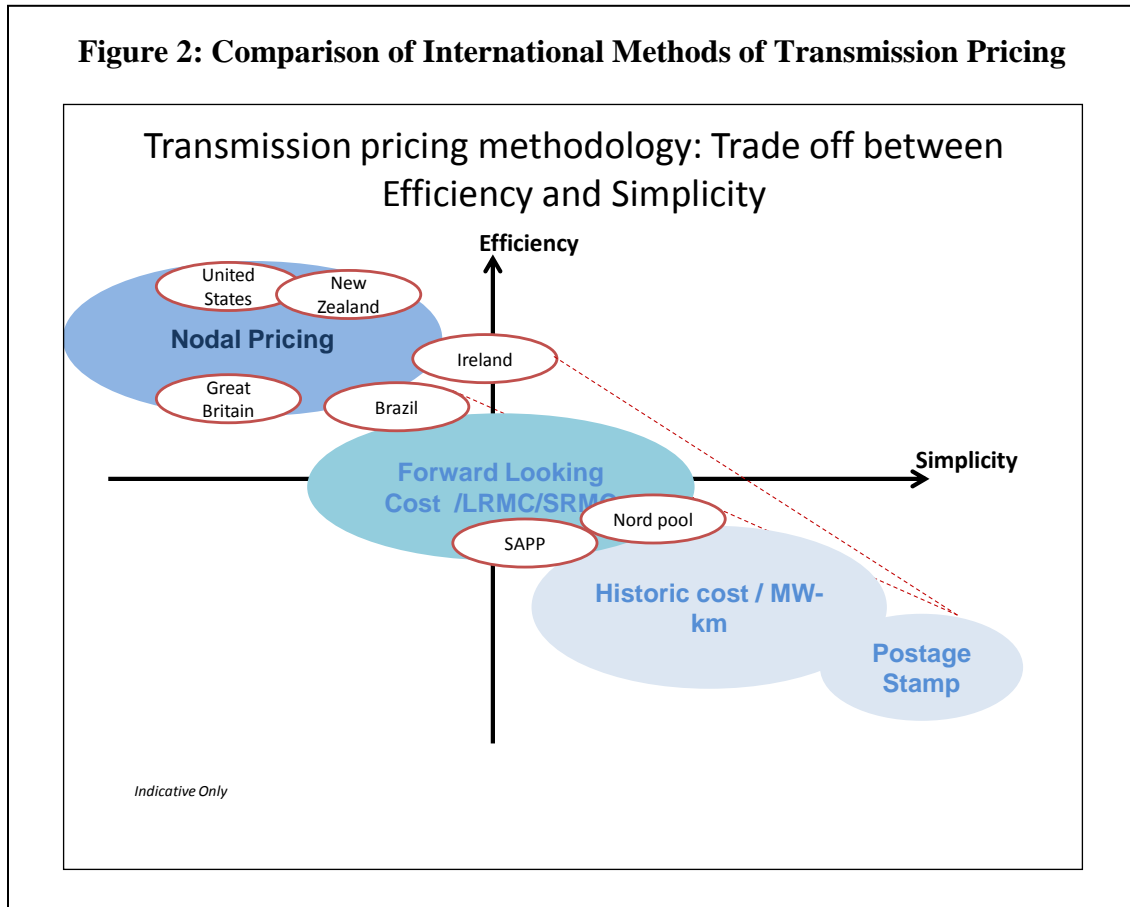
Brazil

- 9.32 In Brazil, the National Electric System Operator (ONS) is responsible for managing the dispatch of electric power from the generating stations in optimal conditions. The transmission related costs are split as 50% to generation and 50% to demand and a nodal pricing system is used to calculate the transmission related charges.
- 9.33 Up to 20% of transmission costs are recovered by a flow-based cost allocation. The flow based method is very similar to LRMC and is more suitable to lines with large power flows, as it enables a higher percentage cost recovery if utilisation is measured in relation to the capacity of the lines. The remaining 80% of the cost is recovered from charges based on peak usage for load or maximum capacity for generators.
- 9.34 The self-producers with a consumption unit connected directly to the basic grid are subject to a different charging mechanism. These charges are calculated on nodal basis and are associated with the connection point of the generation, with the addition of an element of socialised sectoral charges.

10.0 Comparison of International Methods

- 10.1 Figure 2 below shows a graphical comparison of the international methods of transmission pricing reviewed above, giving an estimate of where they are located on axes indicating relative economic efficiency vs. the simplicity of the method in its application.
- 10.2 The chart demonstrates in relative terms the strengths and weaknesses of the different approaches. In summary, it can be observed that whilst nodal pricing approaches in overall terms offer relatively high levels of economic efficiency, this comes at the price of significant complexity in the development and application of the methods. It should be noted that the choice of method for any international market is highly dependent on the nature of the market itself; in addition, the observations about efficiency and complexity that emerge relate only to the process of recovering the costs of transmission network assets. They do not consider wider issues such as the effectiveness of the market trading arrangements.
- 10.3 The trade-offs between simplicity and efficiency is an important factor. It therefore should be taken into consideration in the development of wheeling charge methodology and the framework to be implemented.

Figure 2: Comparison of International Methods of Transmission Pricing



11.0 Factors and Principles Influencing the Choice of the Methodology

11.1 The following factors require consideration in the choice of wheeling methodology:

- 1) The framework to be established requires the implementation of a wheeling service for which charges must be:
 - (a) cost reflective;
 - (b) consistent with tariffs set through the process of price controls; and
 - (c) guided by a Cost of Service Study.
- 2) Wheeling charges are to be “consistent with tariffs and Price Controls”, and over-recovery of costs of equipment and services that are already incorporated into tariffs

for industrial, commercial and domestic consumers must therefore be avoided in developing the wheeling charging framework.

- 3) The correct distinction between connection assets and those network assets that are included in the calculation of wheeling charges must be made. Attention must be paid to the principles defined in the connection codes required by the Licence.
- 4) The principle of locational variation in wheeling charges if applied must be of such that that it is consistent with the Licence.
- 5) Although wheeling services will only be accessible to self-generators, the principle of whether generators and consumers, or only consumers, pay transmission wheeling charges will need to be considered as a signalling device.
- 6) There is already some treatment of the issue of transmission constraints incorporated in the tariff determination process; however this will need to be explored further in developing the wheeling framework.
- 7) The recovery of adequate wheeling revenues to support investment on the networks to ensure that appropriate Quality of Service standards are maintained will be important.
- 8) It is noted that the costs of maintaining spinning reserve are recovered through the Q-factor and heat rate calculations and it is not anticipated that reserves will therefore require consideration in the wheeling charge methodology.
- 9) One of the starting points for the wheeling framework is recognition that simple open access arrangements be developed. These should include limited metering and top-up and spill pricing to facilitate differences in the demand and supply of self-generators.
- 10) The JPS system consists of 138 kV and 69 kV Transmission system and a 24 kV, 13.8 kV and 12 kV Distribution system. Self generators for whom wheeling may therefore be connected at either the transmission level or the distribution level. Consequently, consideration should be given to the practicalities of introducing wheeling at the distribution level. In addition, the capacity threshold that qualifies a self-generator for wheeling services should be included in the design of the framework.

11.2 In order to develop an appropriate wheeling methodology, it is necessary to consider the full range of key factors outlined above and to check the compliance of the methodology with the principles discussed in Section 3 of this Consultation Document:

- a) the promotion of efficiency by giving appropriate price signals;

- b) the recovery the costs of transmission and distribution that are specifically associated with wheeling;
 - c) the maximization of transparency and fairness;
 - d) the promotion of a stable and predictable electricity sector to encourage new investments in the power sector; and
 - e) the promotion of non-discriminatory pricing.
- 11.3 The methodology needs to be reasonably flexible and straightforward to apply, and to have the potential for application to forms of electricity trading that move beyond the existing status quo. The initial trading development that is proposed, the move towards wheeling initiated by self-generators, can be achieved with a relatively uncomplicated initial methodology, since the location of the buyers and the sellers of energy are clearly defined.

12.0 Comparison of Possible Methodologies

- 12.1 In Table 1 below the various methodologies that have been discussed are shown in comparison with key criteria for their evaluation. In each case they are given a tick if they are broadly compliant with the criterion, a cross if they are not readily compliant, and a dash if they are broadly neutral against the criterion.
- 12.2 Based on this assessment, and awarding a points score of 1 for a tick, 0 for a dash and -1 for a cross, the evaluation emerges as shown in the Table .
- 12.3 The applicability of any of the above methods in a given electricity market is highly dependent on key factors such as:
- 12.3.1 Electricity trading rules: in a complex market where electricity can be traded with counterparties independent of their location, then methods involving the definition of specific locations as the starting and ending points of transactions can prove problematic. In the Jamaican context where the initial requirement is for wheeling charges related to specific self-generators' trades, this is less of an issue.
 - 12.3.2 Congestion management: as outlined earlier, congestion management is most fully achieved through the operation of market rules which give a clear and time varying signal of the impact of new transactions on finite transmission capacity. If appropriate signals are to be sent through transmission prices, it is clearly necessary for charges to be proposed that include a significant locational component. This way, medium to long term signals of the availability of

transmission capacity on particular routes can be provided for investors in new power facilities and the optimum utilisation of network assets can be encouraged. (This is particularly the case if network users can be credited through transmission charges if their wheeling transactions oppose the normal network power flows at peak time, for example.)

Table 1: Indicative Comparison of Wheeling Methodologies with Key Principles

Method	Efficiency	Cost recovery	Transparency	Stability	Non-discrimination	Ease of application	Score
Postage Stamp	x	✓	✓	✓	x	✓	2
Contract Path	x	✓	x	✓	x	✓	0
MW-km (distance)	-	✓	x	✓	x	✓	1
MW-km (flow-based)	✓	✓	✓	-	✓	-	4
Nodal Pricing	✓	-	x	x	✓	x	-1
SRIC	✓	-	-	x	✓	-	1
LRIC	✓	-	✓	✓	✓	-	4

12.3.3 Losses: the recovery of the cost of system losses is, under all of the methods other than the nodal pricing approach, treated separately from the application of network charges themselves. Recovery of the costs of transmission assets is the principal goal of the methods outlined above. Losses can, however be recovered in two key ways, either:

- a) via a “postage-stamp” approach, allocating the overall cost of losses across all system users; or
- b) by identifying the costs arising from the incremental effect of losses arising from generation and demand associated with specific wheeling transactions.

12.3.4 *Ancillary Services Costs:* a major issue concerns the impact of wheeling on the national grid as whole. This becomes important since in maintaining stability the grid operator from time to time will require additional generation to balance the network, maintain supply quality and security standards, and provide top-up/standby electricity supplies in the event that self-generators are unable to supply all of their own consumption requirements. These are, in other market models, often referred to as “Ancillary Services”, and comprise those system services that are focused on preserving the integrity of the network through the control of voltage and frequency and the avoidance of demand/generation imbalances. In the absence of a comprehensive balancing market, in which these services can be procured and dispatched centrally in response to the network requirements, there are essentially two options available:

- a) to “socialise” the costs, recovering them from all electricity consumers; or
- b) to take account of a requirement to contract for top-up and standby supplies in the wheeling agreements that are struck with self-generators, and to base the associated payments on the reconciliation of meter readings between the generation and consumption sites associated with self-generators.

13.0 Recommended Methodology

13.1 From the indicative assessment in Table 1 above, it can be seen that the MW-km and LRIC methods both score relatively highly in terms of offering reasonable economic efficiency, the ability to recover costs adequately and the benefits of stability and relative ease of implementation.

13.2 The MW-km method, as a historic-cost based method, is particularly compatible with the objectives of recovering the existing value of the network, and it can be argued that this renders it particularly suitable for application against the backdrop of the present regulatory arrangements in Jamaica.

13.3 The LRIC-based approach offers advantages in relation to giving signals to future developers of generation and load in the network as to where it is likely to be most expensive to locate, i.e. where costly transmission reinforcement would be required under a future operating scenario.

13.4 Based on the nature of the Jamaican electricity market, it is essential that in the implementation of the wheeling framework, a balance be struck between economic efficiency, methodological simplicity and transparency in the rate structure while ensuring full cost recovery for JPS. The OUR therefore proposes that the MW-km flow-based method should be the methodology employed in the wheeling framework that is being developed.