Open Access and Transmission Pricing

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WORLD BANK GROUP

CAIRO WORKSHOP
FEBRUARY 2023

Agenda

1. Open and non-discriminatory access
2. Open access considerations
3. The need for a regional transmission tariff
4. Transmission pricing methodologies
5. Transmission tariff design and implementation

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1. Open and non-discriminatory access
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3. The need for a regional transmission tariff
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Why are we discussing the topic?


جامعة الدول العربية
الأمانة العامة

مرفق

القطاع الاقتصادي
إدارة الطاقة
أمانة المجلس الوزاري العربي للكهرباء

مذكرة تفاهم
لإنشاء
سوق عربية مشتركة للكهرباء

نسخة مطابقة للأصل


جامعة الدول العربية
الأمانة العامة

المادة الثالثة عشر: قواعد تشغيل الشبكة العربية المشتركة للكهرباء:

هي وثيقة تحدد بصورة قانونية المتطلبات الفنية للربط بنظام النقل واستخدامه من قبل مستخدمي الشبكة على نحو يضمن موثوقية وفاعلية وسلامة التشغيل. وقواعد تشغيل الشبكات تصبح ضرورية في حالة التغيرات في الهيكل التنظيمي، أو إعادة هيكلة قطاع الكهربــاء، أو ملكية قطاع الكهرباء، والحاجة إلى "الوصول المفتوح" لنظام النقل. قواعد تشغيل الشبكة تمكن مشغلي نظم النقل من إدارة شبكة النقل ذات الجهد العالي بطريقة سليمة وآمنــة واقتــصادية فضلا عن تمهيد السبيل لفرص متساوية لاستخدام شبكة النقل بشفافية وبدون تمييز.

يجب أن تتضمن قواعد تشغيل الشبكة العربية المشتركة للكهرباء، وعلــى الأخــص الأقسام التالية:

1- تعريفات تضع معايير الصناعة.
2- تخطيط يحدد الأدوار في تطوير وتوسعة الشبكة.

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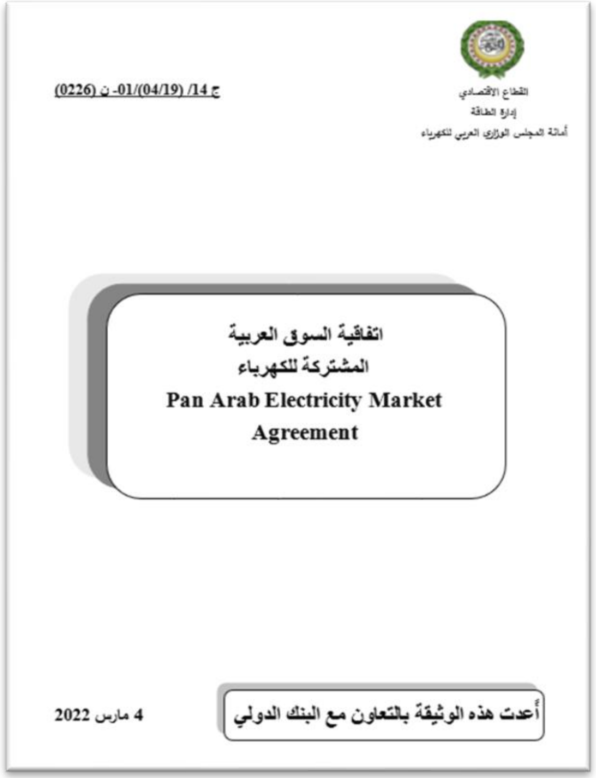
Energy & Extractives

Why are we discussing the topic?



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اتفاقية السوق العربية
المشتركة للكهرباء
Pan Arab Electricity Market
Agreement

4 مارس 2022

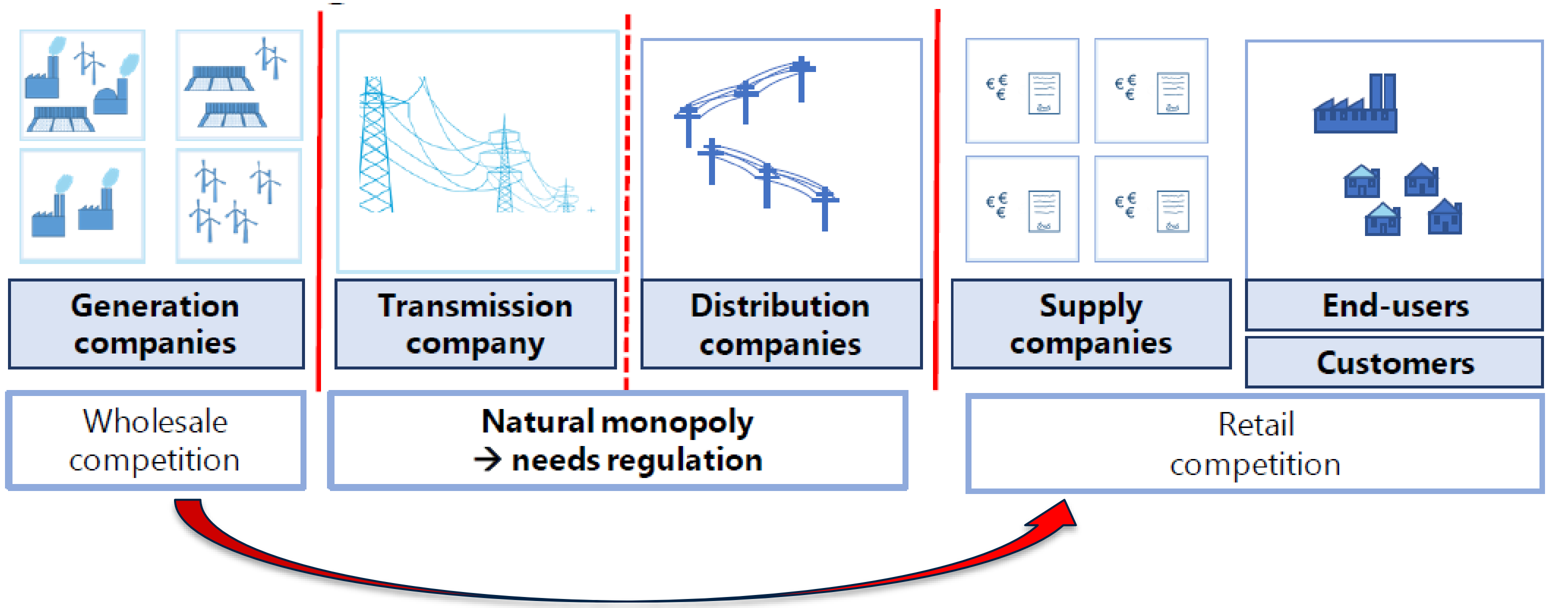
أعدت هذه الوثيقة بالتعاون مع البنك الدولي

3.3.1.6 The direct sale of Energy bilaterally is supported in the PAEM, but regional trading platforms (power exchanges) may also be available in the PAEM. The cost of transactions in the case of bilateral trading is negotiated outside the PAEM, but a bid-based system may be used to make transmission service available. Trading platforms (power exchanges) may provide an implicit auction capacity management system. The Regional Market Facilitator shall be responsible for scheduling bilateral transactions.	**3-3-1-6** تدعم السوق العربية المشتركة للكهرباء البيع المباشر الطاقة على الصعيد الثنائي، لكن يجوز كذلك توفير منصات التداول الإقليمية (بورصات الكهرباء) في السوق العربية المشتركة للكهرباء. ويجري التفاوض بشأن تكلفة التعاملات في حالة التجارة الثنائية خارج السوق العربية المشتركة للكهرباء، ولكن يجوز استخدام نظام قائم على تقديم عطاءات للحصول على خدمة نقل الطاقة. وقد تتيح منصات التداول (بورصات الكهرباء) نظام إدارة ضمنية لقدرة المزادات. ويتولى وسيط السوق الإقليمية مسؤولية جدولة التعاملات الثنائية.

3.7 Transmission Service	**3-7 خدمات النقل**
3.7.1 PAEM Participants shall have open, fair and non-discriminatory access to the domestic Transmission Systems of Member States to support their transactions in the PAEM. A Transmission System includes all domestic facilities that are deemed to be part of the transmission network, and all International Interconnections. The Arab TSOs Committee shall Publish guidelines for identifying the facilities which form part of the domestic transmission network for the purposes of determining a Member State's Transmission Service Charge.	**3-7-1** يجب أن يكون للمشاركين في السوق العربية المشتركة للكهرباء إمكانية الوصول المنصف والمفتوح والعادل وغير التمييزي إلى أنظمة النقل المحلية للدول الأعضاء لدعم تعاملاتهم في هذه السوق. ويتضمن نظام النقل كل المرافق المحلية التي تعتبر جزءا من شبكة النقل وكل خطوط الربط الدولية. وتنشر اللجنة العربية لمشغلي أنظمة نقل الكهرباء إرشادات لتحديد المرافق التي تشكل جزءا من شبكة النقل المحلية لغرض تحديد رسوم خدمات النقل للدولة العضو.

3.7.3 The Pan-Arab ARC shall be responsible for developing a methodology for determining Transmission Service Charges. Each National TSO and Sub-Regional TSO shall be responsible for developing and submitting its transmission services charge to the Pan-Arab ARC for review. Following its review, the Pan-Arab ARC shall forward the proposed Transmission Service Charges along with its recommendations to the Ministerial Council for approval. Once approved, the Regional Market Facilitator shall Publish the Transmission Service Charge for each Member State on its website, and shall invoice PAEM Participants for *international* transactions in the PAEM according to the Published Transmission Service Charges.	**3-7-3** تكون اللجنة العربية الاستشارية والتنظيمية مسؤولة عن وضع منهجية لتحديد رسوم خدمة النقل. ويكون كل مشغل لأنظمة النقل الوطنية ومشغل أنظمة النقل الإقليمية الفرعية مسؤولا عن وضع رسوم خدمة النقل الخاصة به وتقديمها إلى اللجنة لمراجعتها. وعقب هذه المراجعة، يجب على اللجنة العربية الاستشارية والتنظيمية إحالة رسوم خدمة النقل المقترحة إلى جانب توصيات اللجنة إلى المجلس الوزاري للموافقة عليها. وبعد الموافقة، يجب على وسيط السوق الإقليمية نشر رسوم خدمة النقل لكل دولة عضو على موقعه الإلكتروني، ويجب عليه إصدار الفواتير للمشاركين في السوق العربية المشتركة للكهرباء عن التعاملات الدولية في هذه السوق وفقا لرسوم خدمة النقل المنشورة.

For competition to exist, there must be open and non-discriminatory access to the transmission network.



- All services in the monopoly components must be accounted for and costs for their provision must be recovered.
- Charges to market participants should reflect the cost they impose on the system (economic efficiency principle).

- Customers are free to choose their suppliers
- New supply companies should be able to enter the market procuring electricity on wholesale market.
- New generation companies should be able to enter market selling electricity on wholesale market.
- Generation companies with different production technologies and costs competing.
- Competition creates better utilization of the transmission assets, hence create more revenues to TSOs.

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Open and Non-Discriminatory Access

"Open" means that all market participants have access to transmission system

"Non-discriminatory" means that market participants pay similar prices for similar levels of service

- Regulators provide oversight and enforcement to ensure access is fair and open
- The transmission access regime is generally administered by the TSOs/ISOs/RTOs via the dispatch, congestion management rules and transmission pricing regime
- To ensure fairness, market participants with similar transmission service requirements are subject to similar tariffs
- Rules and prices are transparent and readily available to everyone, generally via publication on the TSO website

Open and Non-discriminatory Access

- The documentation requirements to ensure open and non-discriminatory access are extensive and generally include market (commercial) rules, grid code (technical rules) and the transmission tariff (pricing)

- In most jurisdictions, there is a formal stakeholder engagement and consultation process with respective market participants; e.g., large and small consumers (via representative groups such as consumer advocate) and service providers such as generators, transmitters, distributors and system/market operators

- The documents must ultimately be submitted for regulatory approval. Implementation is generally the responsibility of the TSO

For competition to exist, there must be open and non-discriminatory access to the transmission network. Regulators and TSOs/ISOs/RTOs play important roles in this regard …

Regional Market Regulator

- ACER provides oversight of the national regulators and ensures regulatory consistency across the broader European region. The regulators **monitor and enforce** open and non-discriminatory access and fair trade in the market.

- FERC and state regulators play this role in the U.S.

Regional Market TSO

- ENTSO-E as the regional TSO provides oversight of the national TSOs and ensures operations and planning consistency across the broader European region. The TSOs **implement** open and non-discriminatory access and fair trade in the market.

- NERC and the regional RTOs play this role in the U.S.

PAEM

The Pan-Arab ARC will play a similar role to ACER and FERC, and the Arab TSOs Committee will play a similar role to ENTSO-E and NERC/RTOs

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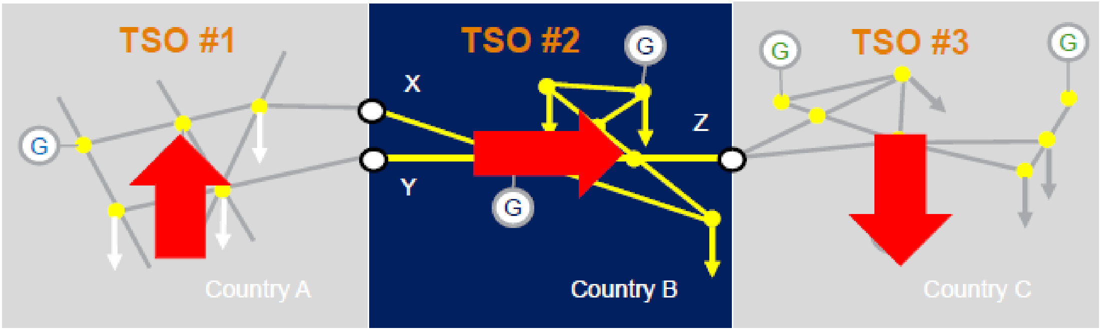
Open Access Considerations

- The following represent the key areas of focus when considering transmission open access:
    - Congestion management (and pricing)
    - Imbalance Settlement
    - Transmission Service Charges
    - Management of Ancillary Services
    - Physical network connection
    - Contractual framework

This week's Focus

Congestion Management

- Congestion reflect bottlenecks in transmission networks caused by lack of sufficient transmission capacity or by operational attempts to maintain voltage and system stability Congestion is addressed by re-dispatching generation; e.g., congestion results in uneconomic dispatch
- Congestion management is fundamental for regional market integration
- Cross-border capacities are often congested during certain periods of time and need, which requires efficient means of congestion management
- Conflicting objectives:
    - **Market**: Free trading of electricity to enable liquidity
    - **TSO**: Keep resulting physical flows within technical limits



Source: Ricardo Energy & Environment.

Need to find balance between restriction of competition and increasing operational costs

Congestion Management

- There are different methods to address transmission constraints.
- The methods differ in the responsibilities of dealing with constraints
  - through an integrated market for energy and transmission capacity
  - outside the energy market with interactions of the TSOs (e.g. first come first served)
- Preference for market-based methods (auctions)
  - Economically efficient -reflect willingness to pay
  - Non-discriminatory -equal access to all system users
  - Transparent –principles and results easily understood

Congestion Management

Some Methods for Congestion Management

Re-dispatch

- TSOs solve constraints in real time by re-dispatching
- The costs of constrained scheduling typically recovered as an uplift to the market prices.
- Payments for redispatch are typically integrated in the transmission pricing (sometimes using separate charges) and/or imbalance charges
- Ex: Most European markets (France, Germany, the Netherlands, Alberta)

Nodal Pricing (Locational)

- Simultaneous clearing of energy and capacity. Prices deviate by location / nodes
- The cost related to transmission constraints are reflected at the respective nodal prices and outside of the transmission pricing
- Ex: PJM, NYISO, NZ, Russia

Zonal pricing

- Simultaneous clearing of energy and capacity. Prices deviate by zone
- The cost related to transmission constraints are reflected at the respective zonal prices and outside of the transmission pricing.
- Ex: Australia, Ontario/ Australia, Market coupling / splitting in Europe (days ahead market)

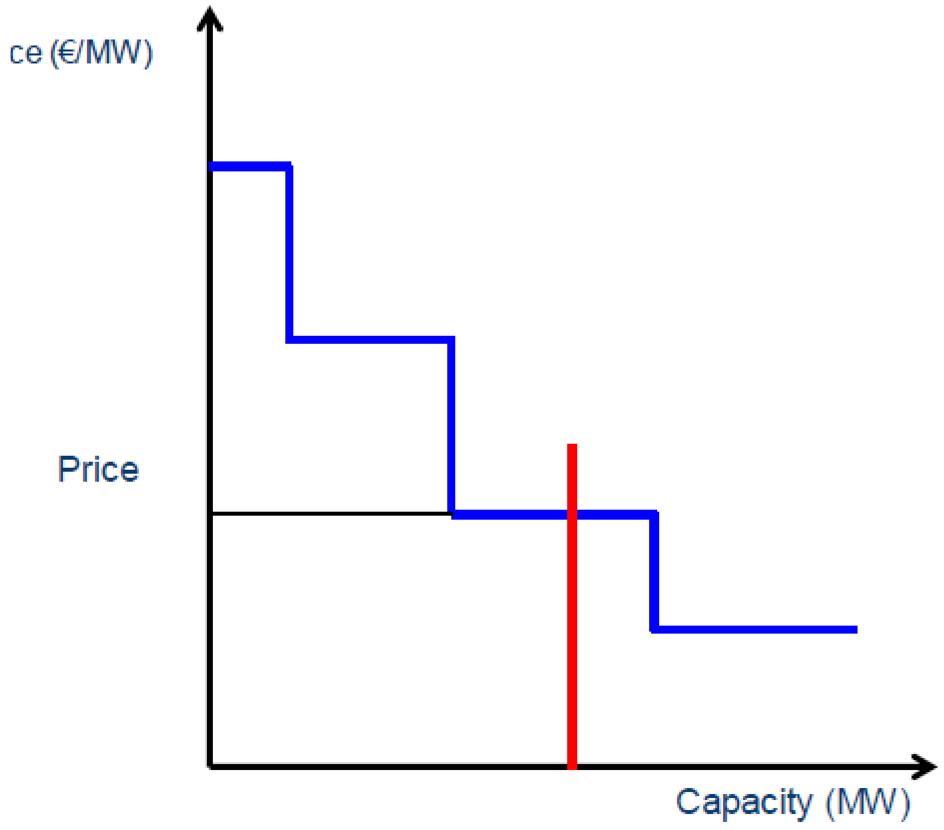
Explicit capacity rights (Capacity Allocation)

- Allocation of explicit capacity rights (e.g. by auctions)
- The rents resulting from selling capacity rights are often integrated in the transmission pricing.
- Ex: Financial Transmission Rights (FTR) at PJM, NYISO. Cross border transmission capacity (monthly / annual) in Europe

Congestion Management

Explicit Auctions

- Explicit auctions sell available transport capacities to the bidder offering the highest price(s)
- Variations in auction design are possible with regards to the bidding mechanisms or the time periods, which are auctioned (days, weeks, months, years)
- Explicit auctions separate energy flows from transmission capacity: Once interconnection capacity has been secured by a market participant, the participant will need another transaction for energy



Congestion Management

3.6 Transmission Congestion	**6-3 اختناق النقل**
3.6.1 Transmission Congestion may occur when PAEM Participant Bilateral Contract transactions result in transmission line flows that exceed Available Transmission Capacity.	**1-6-3** يُمكن أن يحدث اختناق النقل في الشبكة العربية المشتركة للكهرباء عندما ينتج عن تعاملات العقود الثنائية للمشاركين في السوق تدفقات على خطوط النقل تتجاوز قدرات النقل المتاحة.
3.6.2 The Regional Market Facilitator in conjunction with the National TSOs, and Sub-RegionalSub-Regional TSOs, is responsible for identifying Congestion as a result of transactions in the PAEM. When transmission congestion is identified, the Regional Market Facilitator shall notify the parties to the bilateral contract transaction that the transaction is not approved. PAEM Participants can voluntarily re-submit bilateral contract nominations to the Regional Market Facilitator with revised terms and conditions in an effort to "self-manage" Congestion caused by their Bilateral Contracts. If transmission Congestion occurs in real-time, for example, owing to unexpected system conditions, the National TSOs shall use Balancing Energy to manage the Congestion and maintain the domestic power systems in a reliable state.	**2-6-3** يكون وسيط السوق الإقليمية بالتعاون مع مشغلي أنظمة النقل الوطنية ومشغلي أنظمة النقل الإقليمية الفرعية، مسؤولا عن تحديد وإدارة الاختناق كنتيجة للتعاملات في السوق العربية المشتركة للكهرباء. وعندما يتم التعرف على وجود اختناق في الشبكة يجب على وسيط السوق الإقليمية إخطار أطراف تعاملات العقود الثنائية بأن هذه المعاملة غير مقبولة. يمكن للمشاركين في السوق العربية المشتركة للكهرباء طوعا أن يعيدوا تقديم كميات العقود الثنائية إلى وسيط السوق الإقليمي وذلك بشروط وأحكام منقحة كمحاولة أن "يديروا ذاتيا" الاختناق الناجم عن العقود الثنائية. وإذا استمر اختناق النقل عند التنفيذ، مثلا، نظرا لظروف غير متوقعة، يجب على مشغلي أنظمة النقل الوطنية استخدام طاقة التوازن لإدارة الاختناق والحفاظ على أنظمة الطاقة المحلية في حالة يعتمد عليها.

3.6.3 In cases where Congestion is forecast to arise on International Interconnections, the Regional Market Facilitator shall conduct an auction for International Interconnection capacity, with the right to use the International Interconnection going to the highest bidders. The auction process shall be developed by the Regional Market Facilitator for review and approval by the Pan-Arab ARC.	**3-6-3** في الحالات التي يتوقع أن ينشأ فيها الاختناق في خطوط الربط الدولية البينية، يتعين على وسيط السوق الإقليمية إقامة مزاد لقدرة الربط الدولي البيني، مع الحق في ترسية الربط الدولي البيني على أعلى المزايدين. ويجب على وسيط السوق الإقليمية إعداد عملية المزاد لتقديمها إلى اللجنة العربية الاستشارية والتنظيمية لمراجعتها والموافقة عليها.
3.6.4 A National TSO or Sub-Regional TSO may have to disconnect the international tie line if, and to the extent that it reasonably considers it necessary, to provide for the safe and secure operation of the Transmission System in circumstances which otherwise cause, or are likely to cause, a violation of one or more conditions specified in the Arab Grid Code.	**4-6-3** من الممكن أن يقوم مشغل أنظمة النقل الوطنية أو مشغل أنظمة النقل الإقليمية الفرعية بفصل خط ربط دولي، في الحال وبالقدر الذي يراه ضروريا من أجل توفير عملية آمنة وسليمة لنظام النقل في الظروف التي في خلاف ذلك تسبب، أو من المحتمل أن تسبب مخالفة لواحد أو أكثر من الشروط المنصوص عليها في قواعد الشبكة العربية للكهرباء.

Open Access Considerations

- The following represent the key areas of focus when considering transmission open access:
  - Congestion management (and pricing)
  - Imbalance Settlement
  - Transmission Service Charges
  - Management of Ancillary Services
  - Physical network connection
  - Contractual framework

This week's Focus

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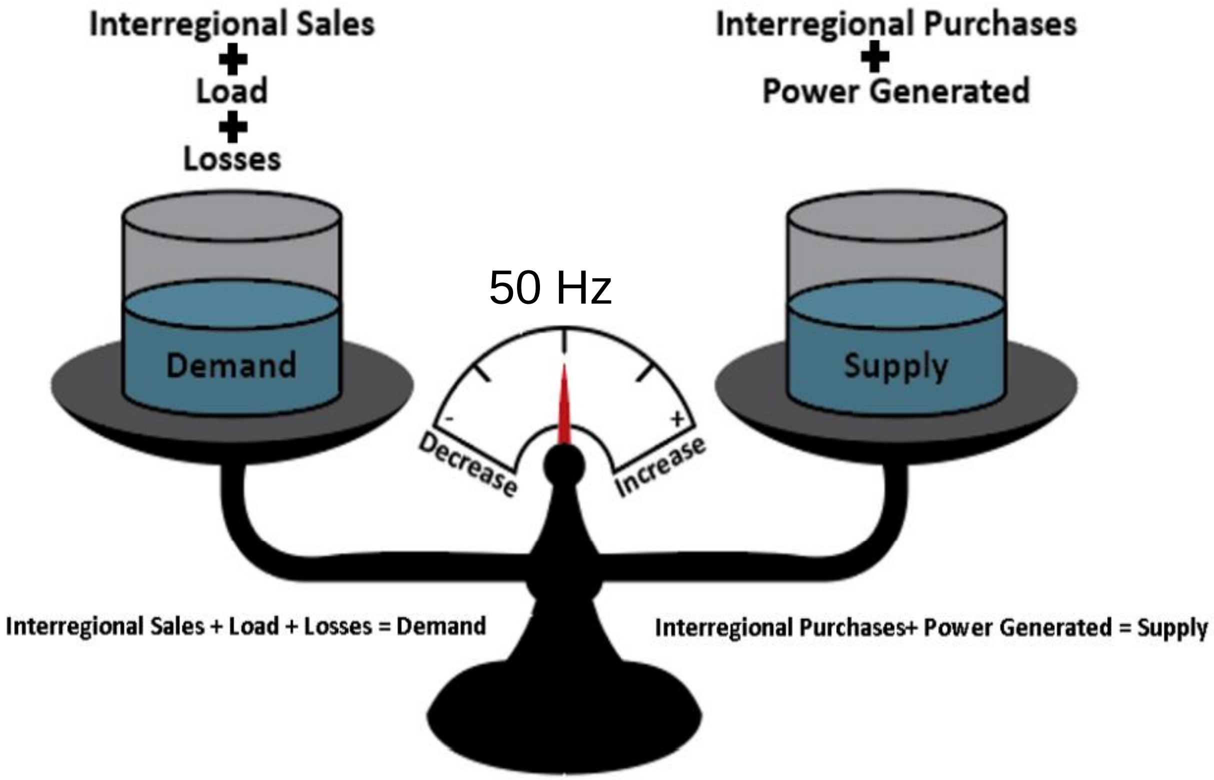
Imbalance Settlement

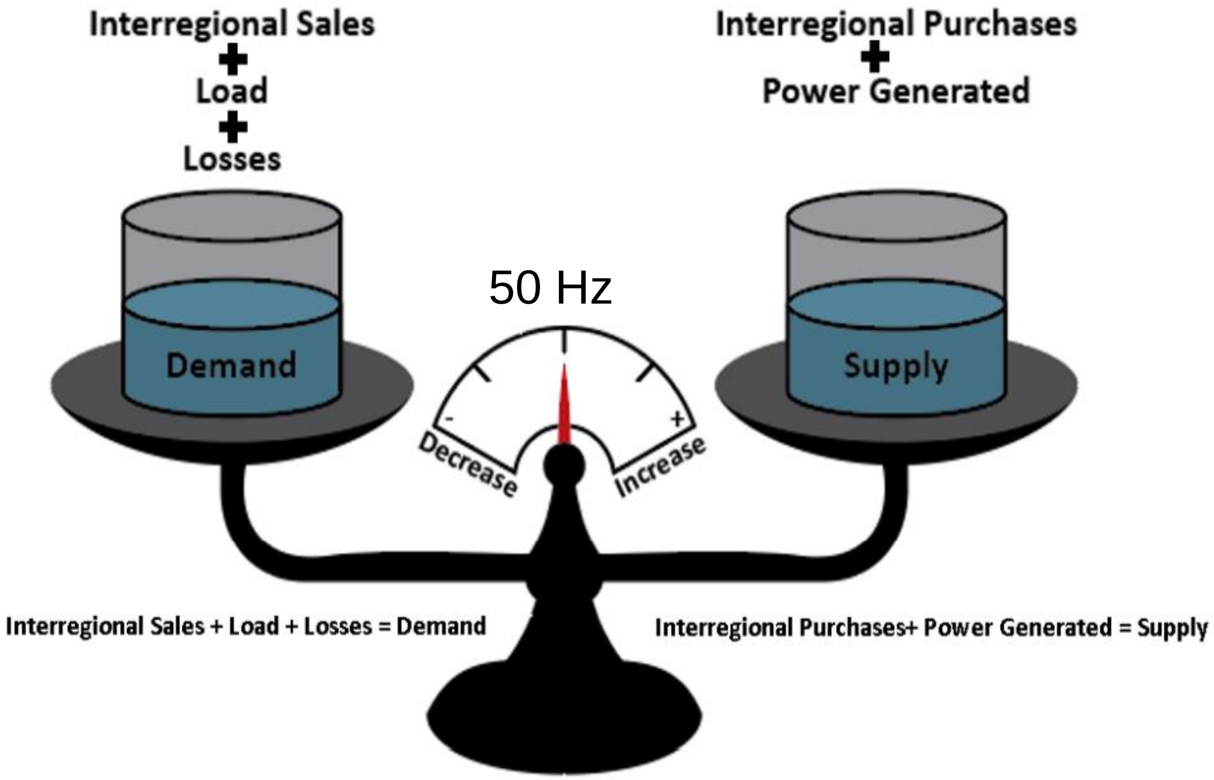
- Actual power flows may differ from those agreed and scheduled between parties.
- Any failure of parties to meet their obligations to produce or consume energy when engaging in international trade can result in imbalances on the power system.
- Reconciling the differences that arise between scheduled energy transfers and actual exchanges is necessary to compensate utilities if they provide energy to maintain the equilibrium of the power system.



Source: Balancing and Frequency Control, NERC Resources Subcommittee, May 11, 2021

Imbalance Settlement

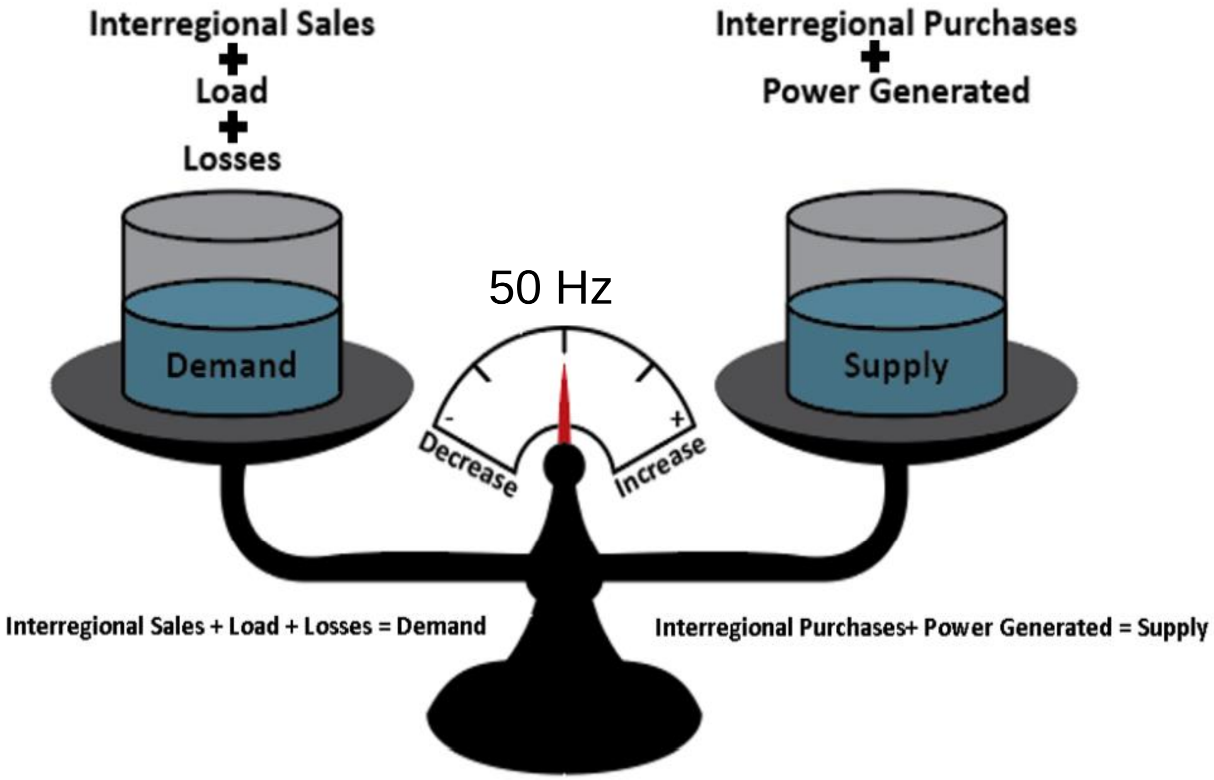
- Many regional authorities recognize that it is difficult to control the power exactly on schedule and have thus created a term called "inadvertent energy."
- This energy is typically paid back in kind on a same time-same day principle, otherwise the inadvertent energy is not compensated or reconciled.



Source: Balancing and Frequency Control, NERC Resources Subcommittee, May 11, 2021

Imbalance Settlement

- A harmonized balancing methodology across the region would have significant benefits, such as:
  - Knowing imbalance calculation and settlement arrangements ahead of entering a contract impose transparency to existing and potential market participants and facilitate regional power trading.
  - Acknowledging when the imbalances occurred (e.g., time of day, season) and how it will be settlement (in kind, cash) will improve the fairness and non- discriminatory nature of regional trading.



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Imbalance Settlement – Continental Europe

- *In Continental Europe*, inadvertent energy is calculated every 15 minutes between control areas. Inadvertent energy is calculated as the difference between actual and scheduled power flows.
- The imbalance pricing for each TSO is calculated based on the opportunity price (avoided cost) that each TSO has gained from importing or exporting balancing energy instead of activating more expensive local reserve. Prices are to be determined every 15 minutes.

Imbalance Settlement – Nordic Region

- *The Nordic region's interconnection* calculates imbalance energy as the difference between actual power flows and day-ahead scheduled energy flows. This is calculated by the hour, but the goal is to reduce the period to 15 minutes as per EU rules and guidelines.
- The Nordic region's interconnection calculates imbalance prices based on the weighted average of activated manual Frequency Response Reserve (mFRR) in the region when there is no congestion.
- If there is congestion toward a zone, then there is a separate price calculated for the congested zone. This is based on the zonal activated mFRR weighted average price. The price in the congested zone is higher than that of the rest of the uncongested system. Imbalance energy between two zones with different prices is calculated at the average price between the two zones.

Imbalance Settlement – NERC

- *In the US, NERC* calculates *the* inadvertent energy as the difference between actual and scheduled power flows for each balancing authority.
- Since NERC allows dynamic schedules between Balancing Authorities; these schedules can change as fast as every two seconds, so the imbalance energy can be the net position after the dynamic schedule.
- New England ISO, PJM ISO, and New York ISO price the inadvertent energy at the post-dispatch locational marginal price (LMP).

Imbalance Settlement – NERC

Area Control Error (ACE) Review

The CPSs are based on measures that limit the magnitude and direction of the BAs Reporting ACE. The equation for Reporting ACE is as follows:

- Reporting ACE = $(NI_A - NI_S) - 10B\,(F_A - F_S) - I_{ME}$
- Reporting ACE (WI) = $(NI_A - NI_S) - 10B\,(F_A - F_S) - I_{ME} + I_{ATEC}$

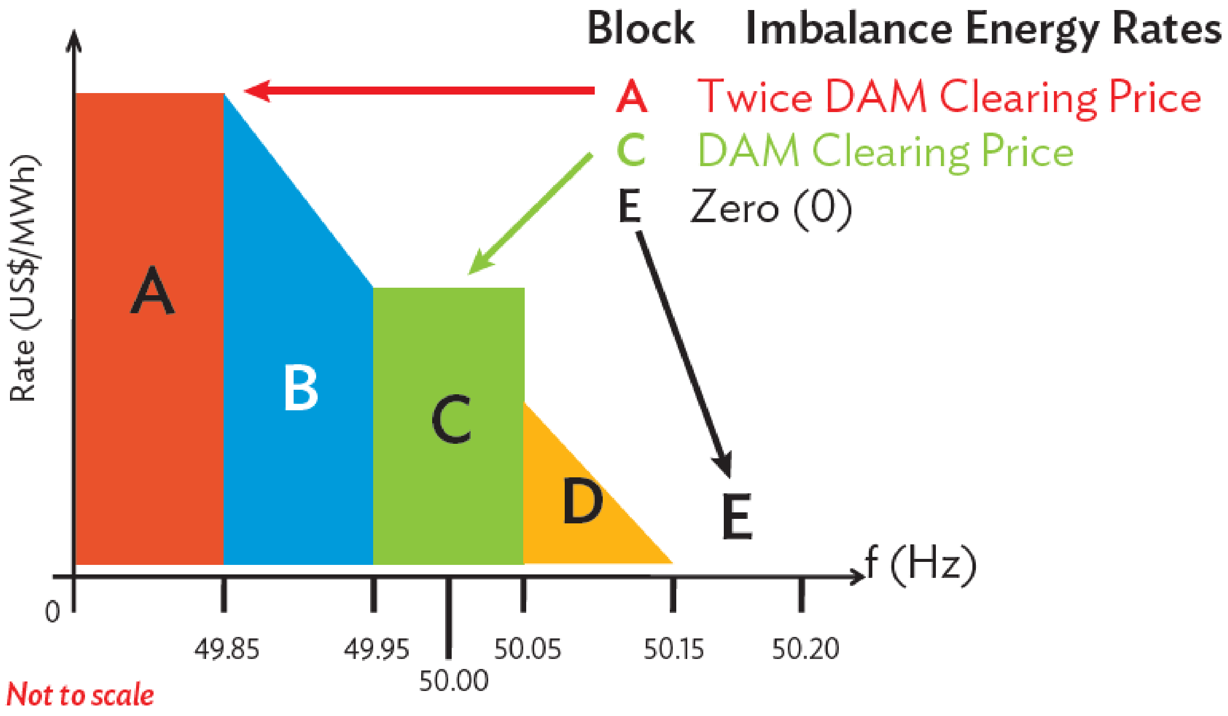
where:

- NI_A is Actual Net Interchange,
- NI_S is Scheduled Net Interchange,
- B is BA Bias Setting
- F_A is Actual Frequency,
- F_S is Scheduled Frequency,
- I_{ME} is Interchange (tie line) Metering Error
- I_{ATEC} is ATEC (WI only)

Source: NERC

Imbalance Settlement – SAPP

- *The SAPP interconnection* calculates imbalance energy as the difference between actual power flows and day-ahead plus bilateral scheduled energy flows. The day ahead schedules can be adjusted by intra-day trading.
- If imbalance energy is less than 25 MWh between control areas, then this is treated as inadvertent energy.
- SAPP uses frequency-based imbalance energy rates calculation based on day-ahead market (DAM) clearing prices.

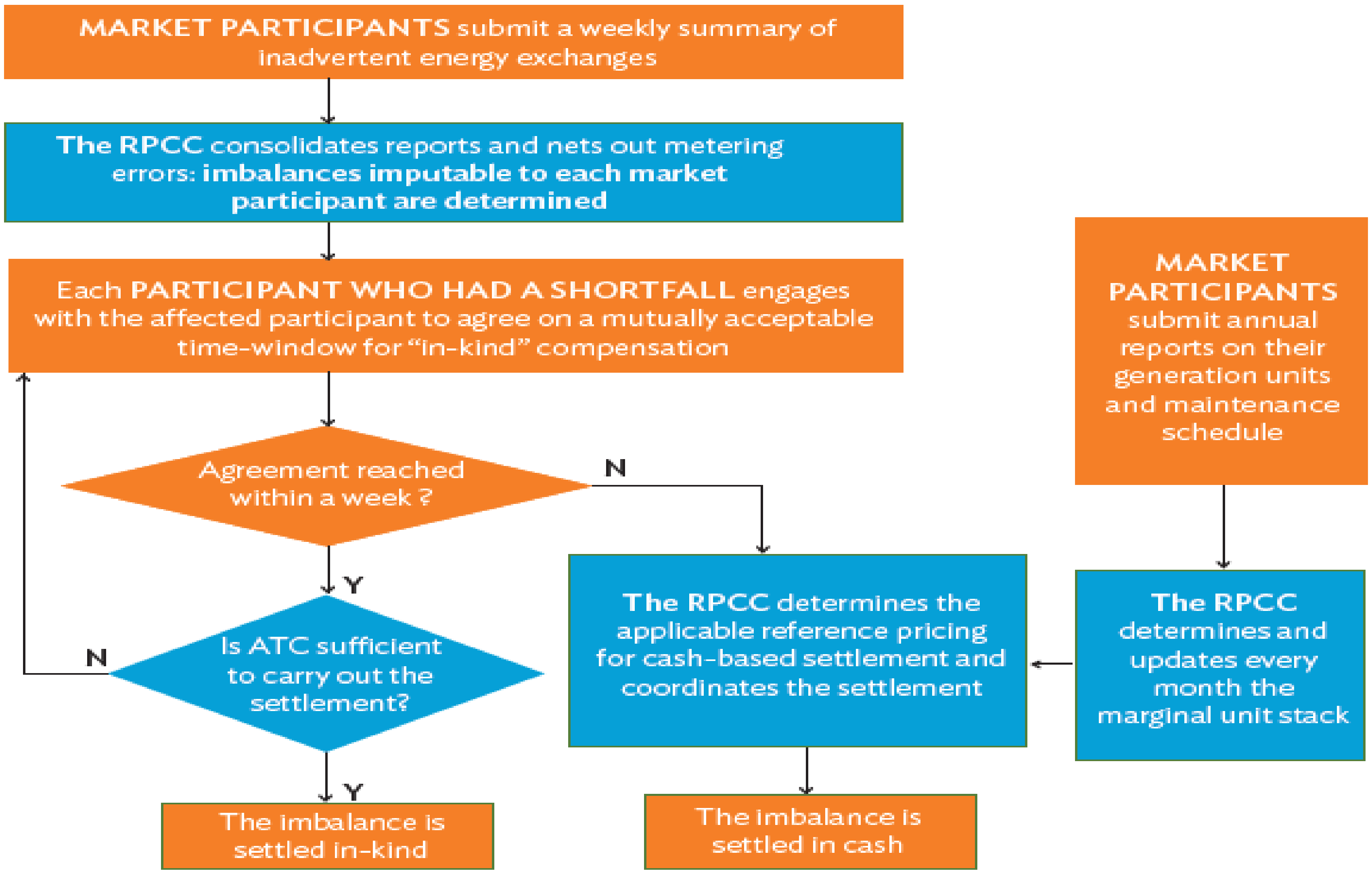


Source: SAPP

Imbalance Settlement - GCCIA

- *GCCIA* calculates imbalance energy as the difference between actual power flows and scheduled bilateral energy flows.
- GCCIA price the imbalance energy as follows:
  - if imbalance energy is less than 50 MWh between control areas, then the bilateral schedule for the same time on the next similar day is adjusted.
  - If the imbalance energy is above 50 MWh, then the imbalance energy is priced at open-cycle gas turbine prices.

Imbalance Settlement - Implementation



ATC = available transfer capacity, RPCC = Regional Power Coordination Centre.

Source: Ricardo Energy & Environment.

How do you do it in your Country?

Agenda

1. Open and non-discriminatory access
2. Open access considerations
3. The need for a regional transmission tariff
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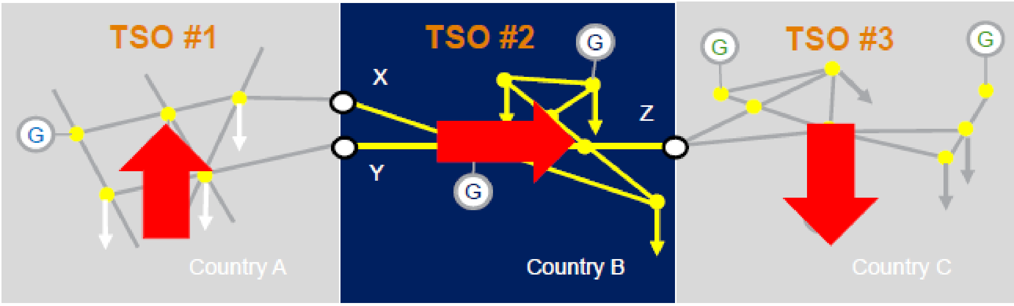
5. Transmission design and implementation

Need for Regional Transmission Tariff

- Transmission tariff is a fundamental requirement for the successful integration and operation of regional transmission networks.
- Transmission Tariff is the price that the trading partners pay to the TSO so that the former can use the latter's assets.
- Implementing a Transmission Tariff that is economically efficient and recovers the actual costs borne by the TSO to facilitate open access, while offering the best deal to energy users, is critical to ensuring that the regional power network is fit for its purpose and encouraging new investment in the system.

- In the beginning, the transmission tariff could primarily focus on wheeling transactions through a third-party country, but the same concept could also apply to trades within the national electricity markets of the Member States, once needed.



Source: Ricardo Energy & Environment.

Agenda

1. Open and non-discriminatory access
2. Challenges and experience with Open Access
3. The need for a regional transmission tariff
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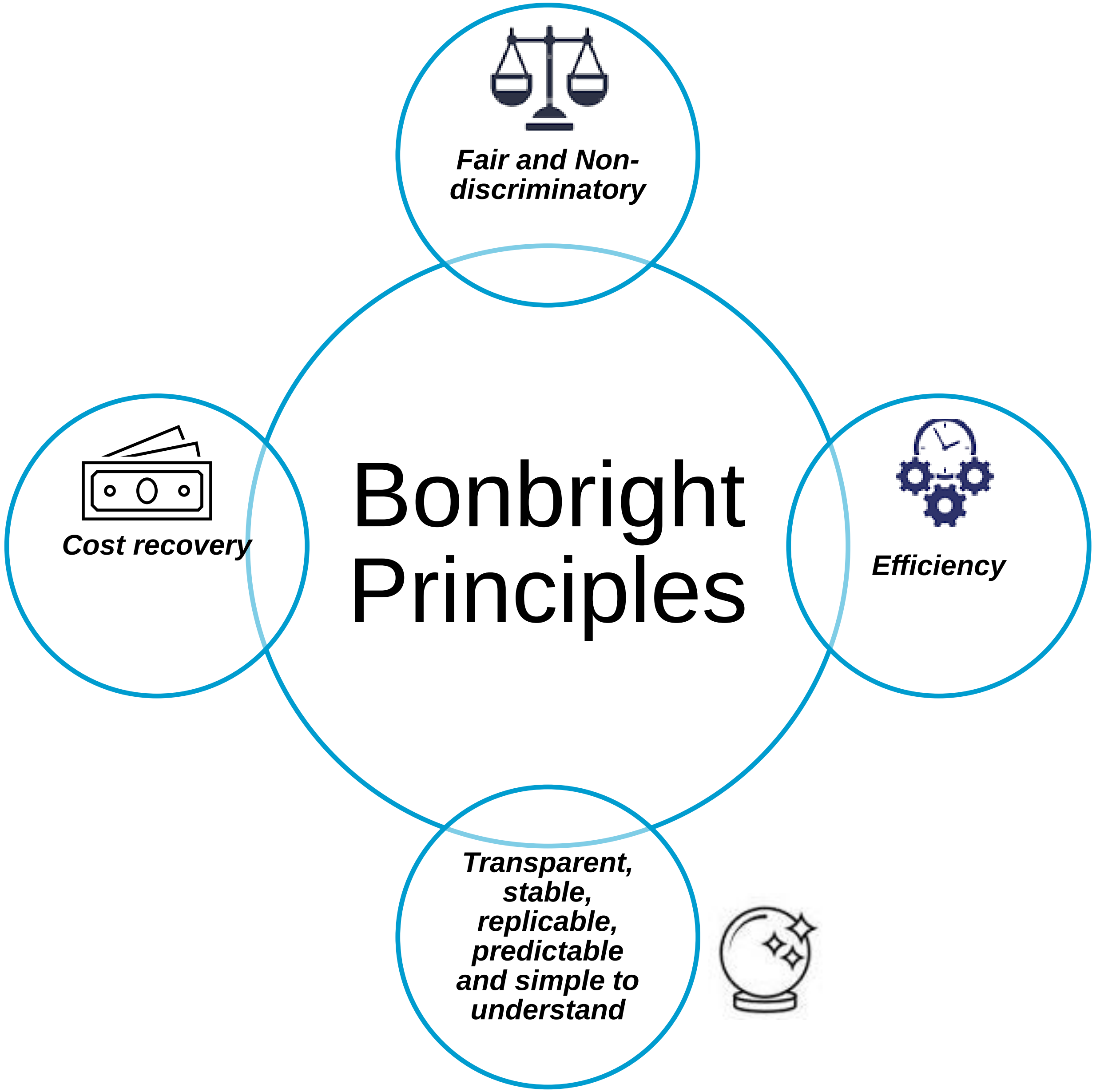
Tariff Setting Principles/Objectives

- The transmission tariff methodology should:
  - Be based on equal treatment of domestic and international traders (i.e., *excludes any national subsidies*).
  - Evolve over time as the need arises via the rules change process included in the Market Rules, once developed



Tariff Setting Principles/Objectives

Objective	Explanation
① Revenue Recovery	Ensure that the network operator can recover the revenue required for the network service.
② Economic Efficiency	Pricing design should provide adequate short and long-term signal to the network operator to operate, maintain and expand the network.
③ Efficient Regulation	The pricing methodology should encourage efficient operation, while keeping a manageable regulatory burden.
④ Complexity & Transparency	Highly sophisticated approaches might promote efficiency at first sight but may appear as a "black box" to network users.
⑤ Non-Discrimination	Level playing field should be created for all users. Users are treated equally irrespective of size, ownership or other factors.
⑥ Stability & Stakeholder Acceptance	Price changes may result when changing the pricing model. This will have an impact on all stakeholders. Mitigation measures may be required.
⑦ Macroeconomic Constraints	Policy objectives like inflation control and regional development policy may present additional challenges for the tariff design.

Tariff Setting Principles/Objectives

- The objectives can be contradictory. For example, promoting efficient consumption decisions often comes with greater complexity contrary to the transparency, predictability and simplicity objective
- It is necessary to balance the interests of service providers and customers when developing a tariff
- When assessing transmission tariff alternatives, it is important to understand that transmission accounts for a relatively small proportion of the cost of electricity. According to the United States Energy Association (USEA), on average:
  - Generation accounts for 59% of the total cost of electricity,
  - Distribution accounts for 28% of the total cost of electricity, and
  - Transmission accounts for the remaining 13% of the total cost of electricity.

Tariff Setting Principles/Objectives

- Tariff Setting Process:

ARR

- Calculate Annual Required Revenue (ARR)

Classification

- Classify the cost driver (energy, demand, customer)

Allocation and Tariff Design

- Type of Customers
- Locational differences
- Time Dependency
- Type of Charges (capacity charge, energy charge)

Cost Components for Transmission

Transmission infrastructure	Transaction-related services	TSO dispatch service (including ancillary services)
• Capital and O&M • Network Facilities and Connection Facilities	• system losses • Congestion management • Network and connection Studies	• System operation (Control Center, SCADA, etc.) • Balancing/inadvertent flows • Regulation and frequency response service • Operating reserve service – spinning, primary, secondary, tertiary, etc. • Voltage and reactive power • Black start

Types of Transmission Tariffs

- ***Historical***
  - Postage stamp
  - Contract path
  - MW-km Distance-based
  - MW-km Load-flow based
- ***Forward-looking***
  - Short-run pricing
  - Long-run pricing
  - Nodal pricing

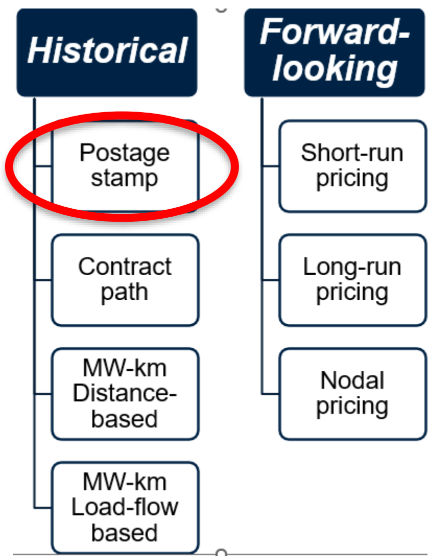
Transmission Tariff Design – Historical Approaches

Historical approaches:

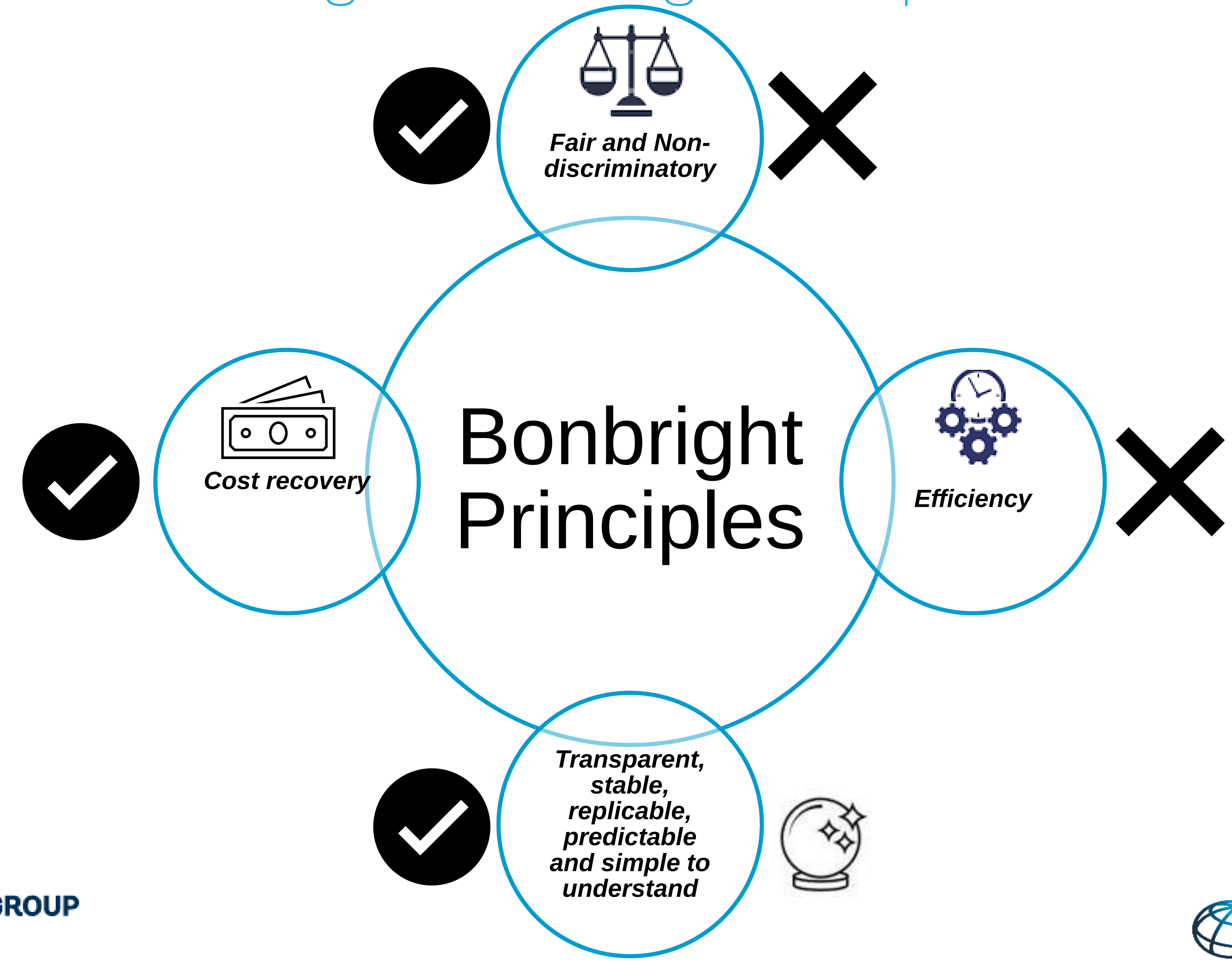
- Based on the costs incurred to construct the existing transmission network
- Costs are translated into an annual cost using depreciation techniques based on the expected life of the assets
- If historical cost information is not readily available, an asset valuation can be undertaken that estimates the replacement cost of the asset
- The asset owner is allowed a return on its assets; e.g., 10%
- The biggest criticism of historical cost methodologies is that they do not send a price signal that promotes efficient consumption decisions (since everyone is paying an average cost of the asset over a year regardless of when the transaction happened)

Historical Methodologies – Postage Stamp

- The postage stamp approach is generally regarded as the simplest to implement.
- The methodology allocates system costs between users based on their share of total peak load on the system, i.e., flat transmission charge per unit of demand equal to the total transmission costs divided by peak load.
- The postage stamp method inherently acknowledges that electrons do not actually travel from the seller to the buyer, and the system is operated on an integrated basis.
- Not Economically Efficient as it doesn't always send right price signals: transmission customers can in fact benefit from components of the transmission network even if not used specifically to support the trade; e.g., loss reduction, etc.
- The postage stamp methodology works well when there are few network constraints, or when there are only a limited number of trades.



Historical Methodologies – Postage Stamp



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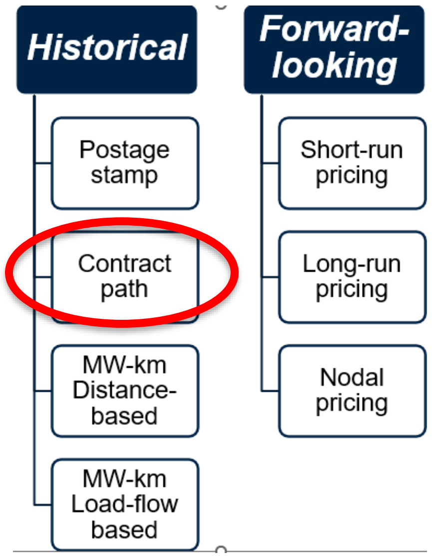
Historical Methodologies – Contract Path

- 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, but rather is based on calculations related to an assumed set of assets used by the transaction.
- A share of the cost of the assets, including any new investment, is allocated to the parties to the transaction in proportion to use



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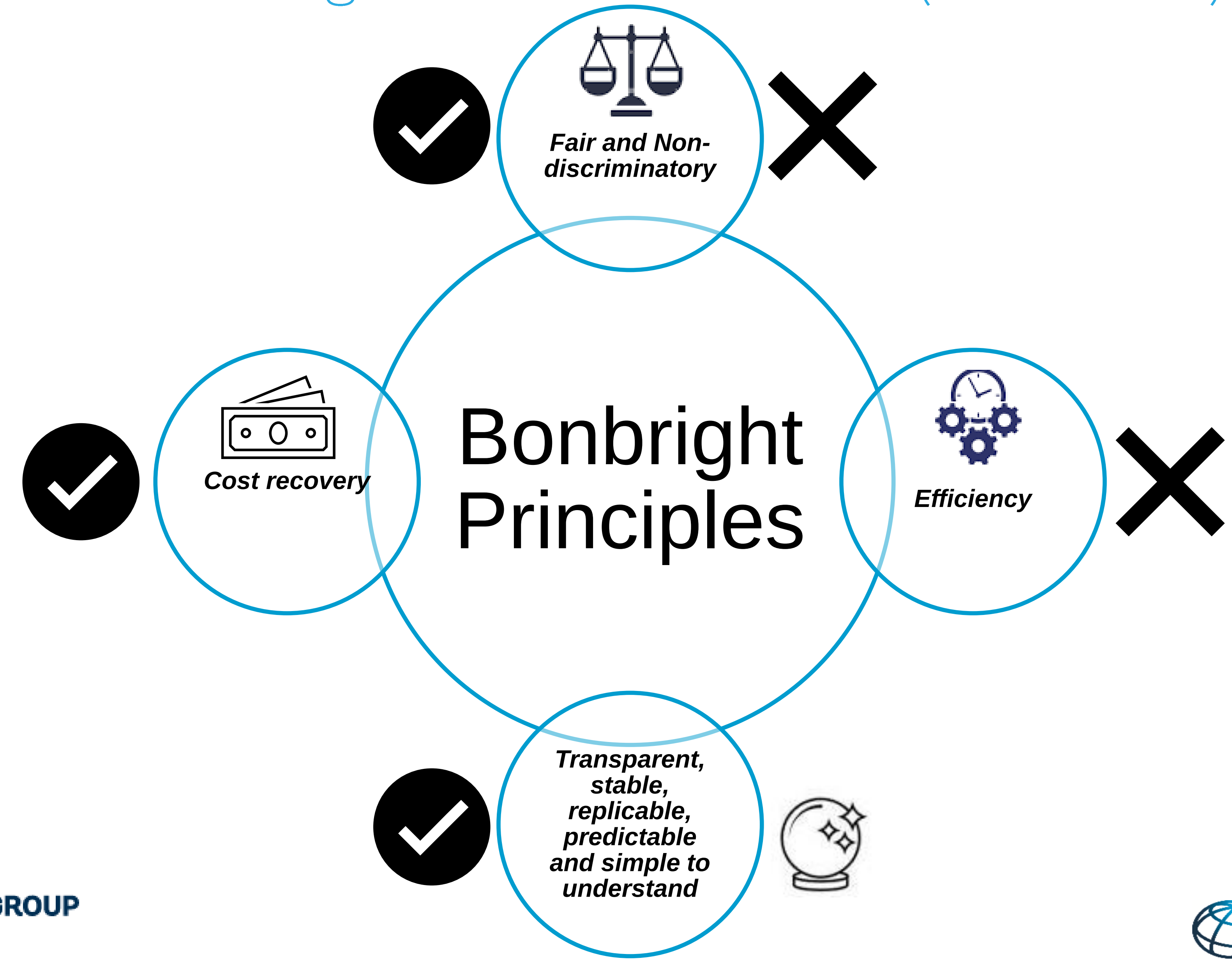
Historical Methodologies – Contract Path (continued)



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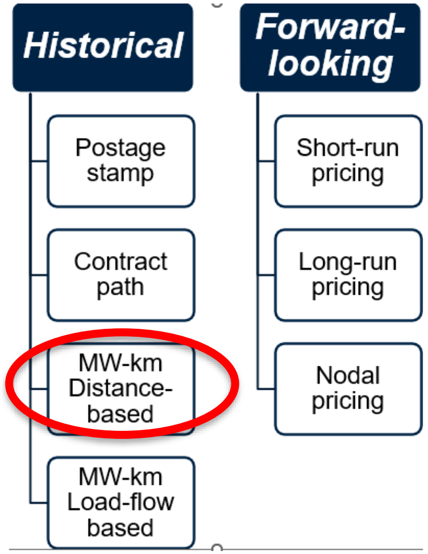
Historical Methodologies – MW-km – Distance-Based

- The price is based on the distance travelled by the energy associated with the transaction on a straight-line basis between the entry and exit points.
- The tariff is based on the product of the MW of the transaction and the km travelled divided by the total MW-km for the system
- This is referred to as MW-km because the cost is proportional to the length of transmission lines used in the transaction and the power flow on the network



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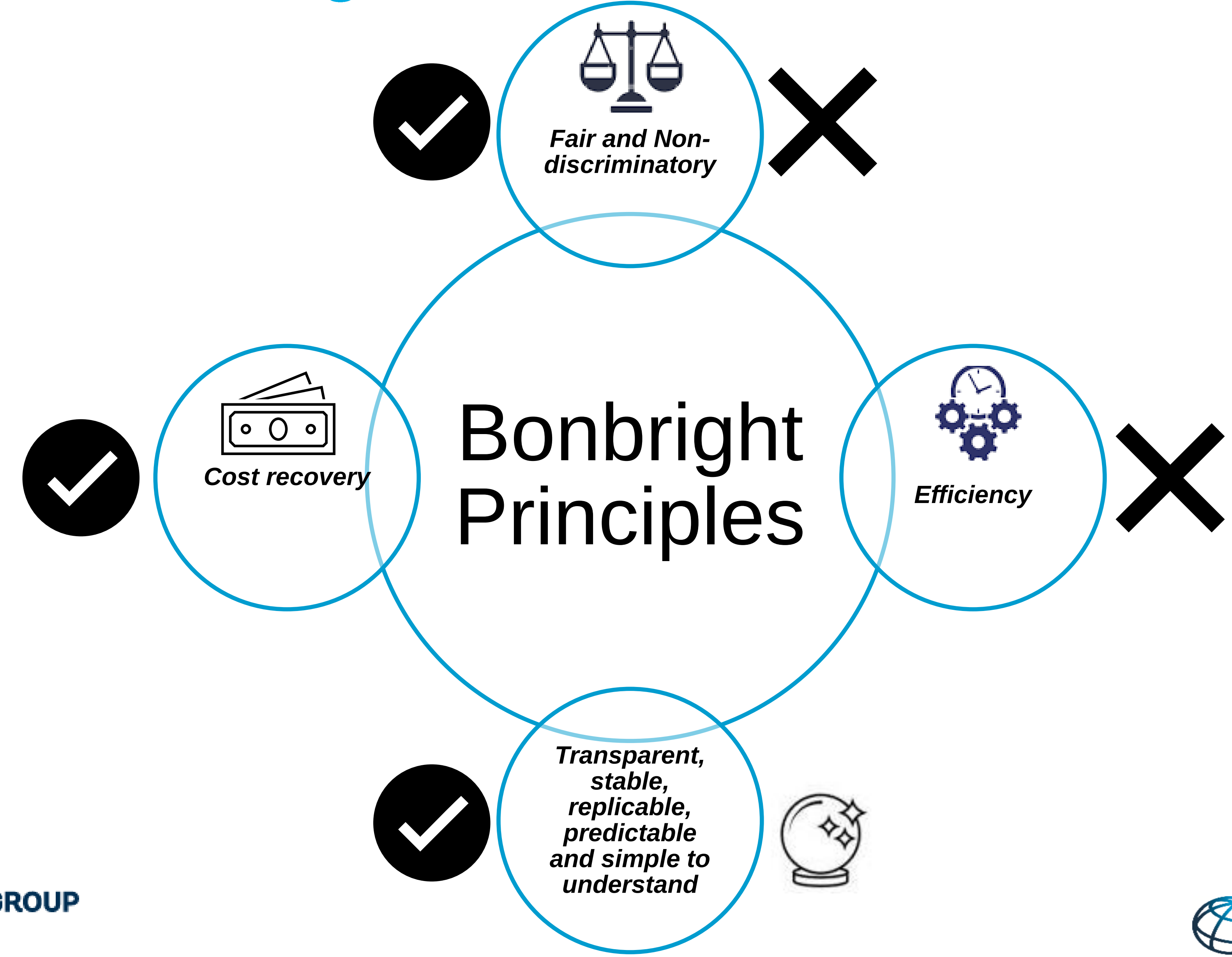
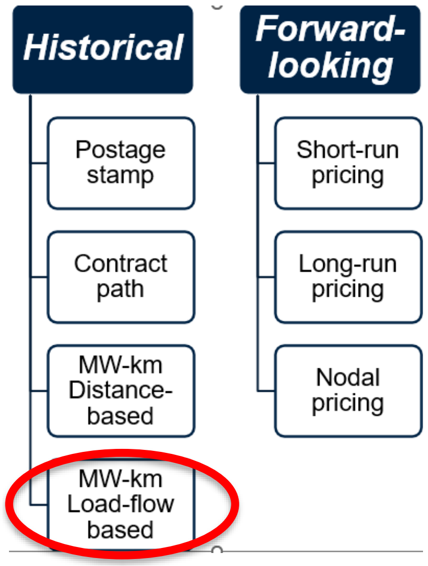
Historical Methodologies – MW-km – Distance-Based

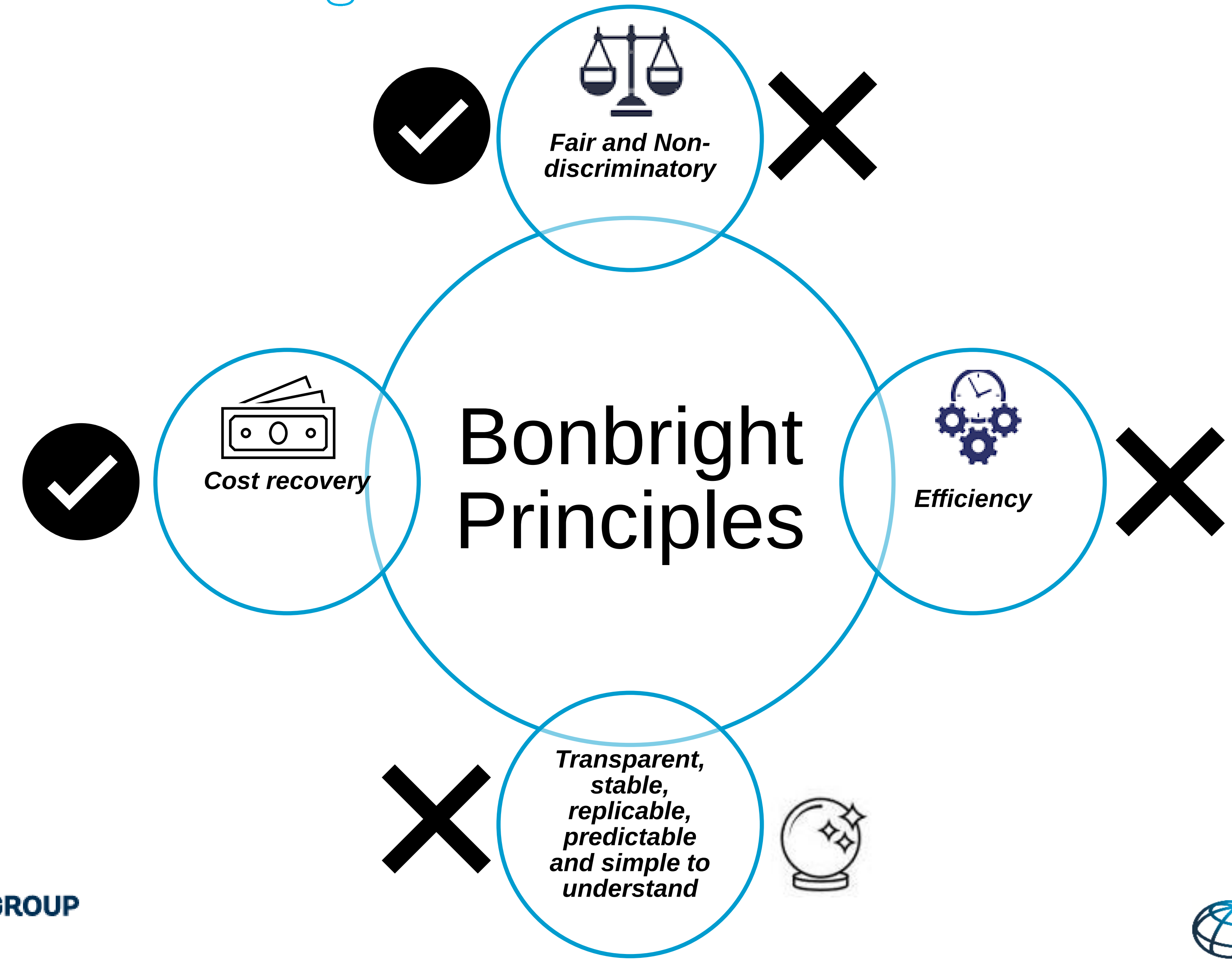


Historical Methodologies – MW-km – Load Flow-Based

- Based on the proportion of the transmission system used by individual transactions as determined by load-flow studies
- Modeling must reflect all transactions on the system, and it is necessary to develop an appropriate allocation of the results if they are to be meaningful
- Load-flow based transmission pricing methods do a better job of reflecting actual usage of the transmission network than the previous methods discussed
- A load-flow model calculates the flow owing to the transaction on each transmission asset
- The ratio of the flow caused by a transaction to the total flow on the transmission system is multiplied by the total cost of the transmission system to determine the cost of the transaction. The total flow on the transmission system is the sum of power flows caused by all transactions is used

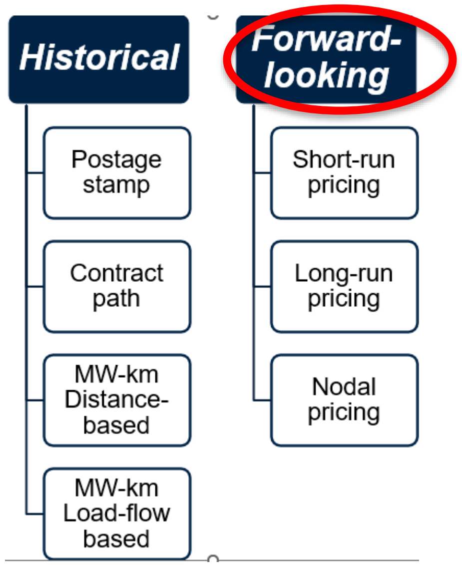


Historical Methodologies – MW-km – Load Flow-Based



Transmission Tariff Design – Forward Looking Approaches

- Economic theory suggests that efficient consumption decisions are promoted by using forward-looking prices which reflect costs of transmission expansion.
- Transmission systems are capital intense. Forward-looking costs tend to under-collect the revenue requirement of the transmission service providers
- This necessitates scaling up of forward-looking costs, or some other means, to ensure cost recovery. Otherwise, the transmission service providers would not invest in infrastructure and reliability may be impacted.



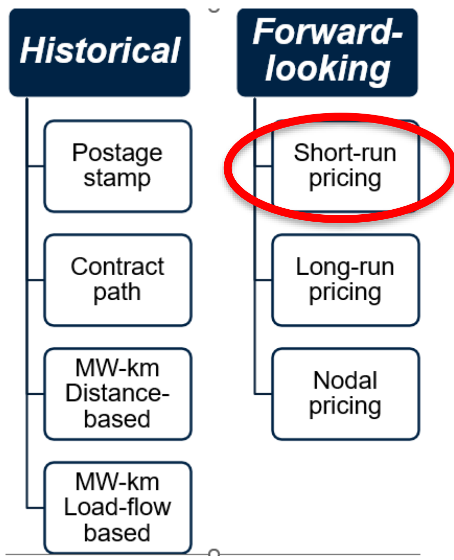
Transmission Tariff Design – Forward Looking Approaches

The following two definitions are made:

- **Marginal cost** reflects the cost of providing an additional unit of transmission (while this can work for fuel cost, it is inconsistent with the lumpy nature of transmission investments).
- **Incremental costs** reflect the cost associated with providing the next increment of transmission to meet a complete transaction (rather than a unit of transmission). It is determined by comparing the cost of transmission with and without a transaction (or increase in demand). Incremental is more reflective of the lumpy nature of transmission investment and the fact that the transmission network is often overbuilt for security and reliability

Forward-Looking Methodologies – Short-Run Pricing

- Under the short-run cost methodology all operating costs associated with the transaction are allocated to the transaction.
- Costs are calculated by modeling optimal power flows with and without the transaction



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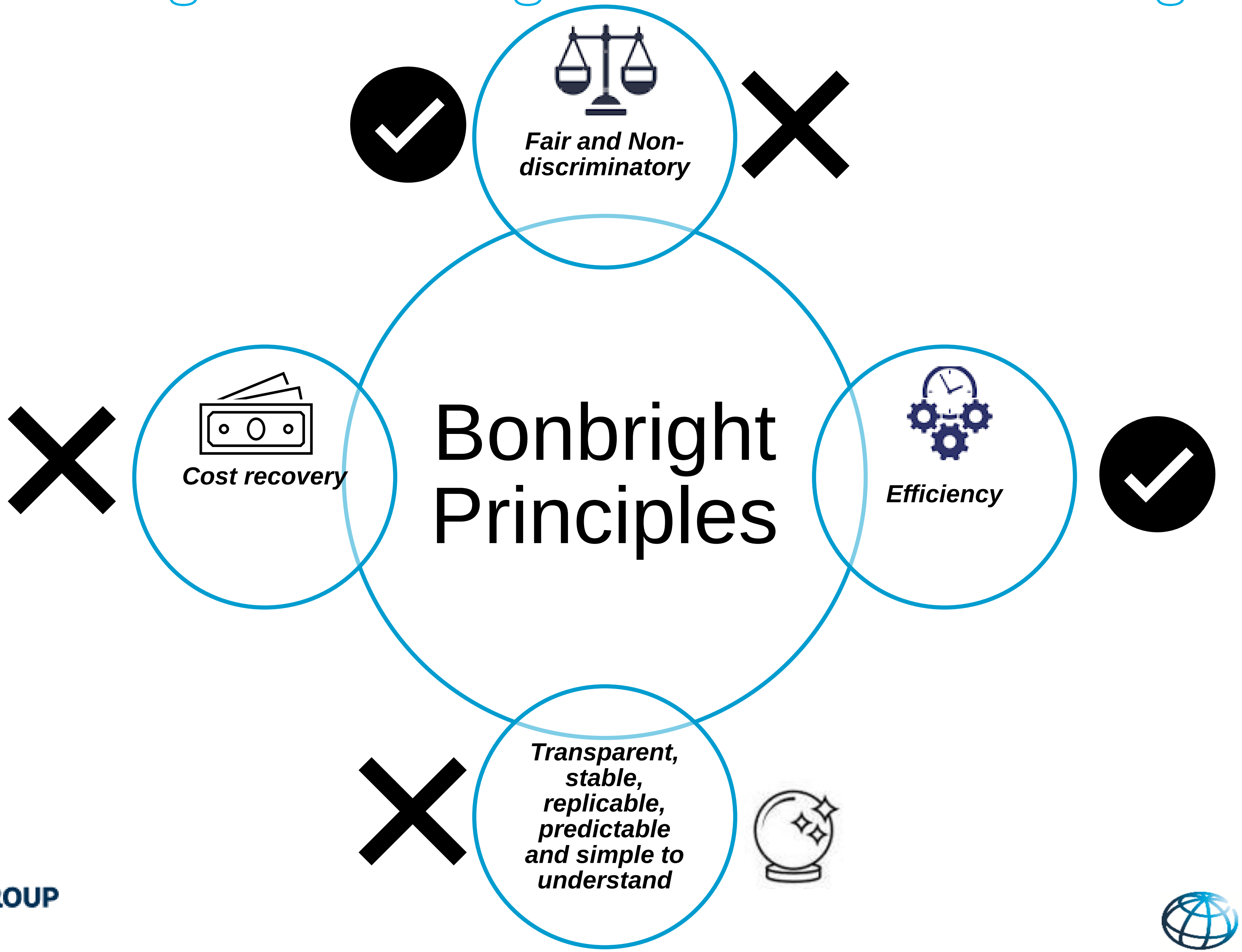
Forward-Looking Methodologies – Short-Run Pricing



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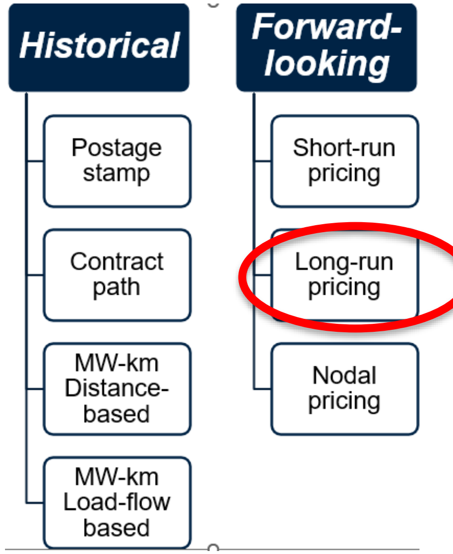
Forward-Looking Methodologies – Long-Run Pricing

- Both operating costs and investment costs are included.
- Investment costs reflect the change in costs caused by the transaction on transmission expansion plans
- In order to calculate long-run prices, an expansion plan and its costs are needed.
- The change in the cost of the transmission expansion plan owing to the transaction is divided by the size of the transaction to determine the incremental investment cost.



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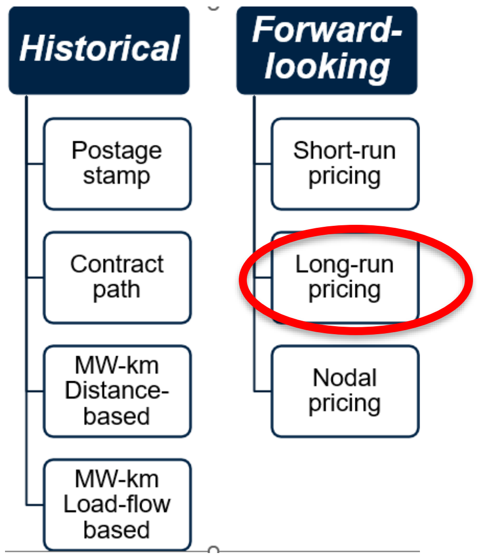
Forward-Looking Methodologies – Long-Run Pricing (continued)

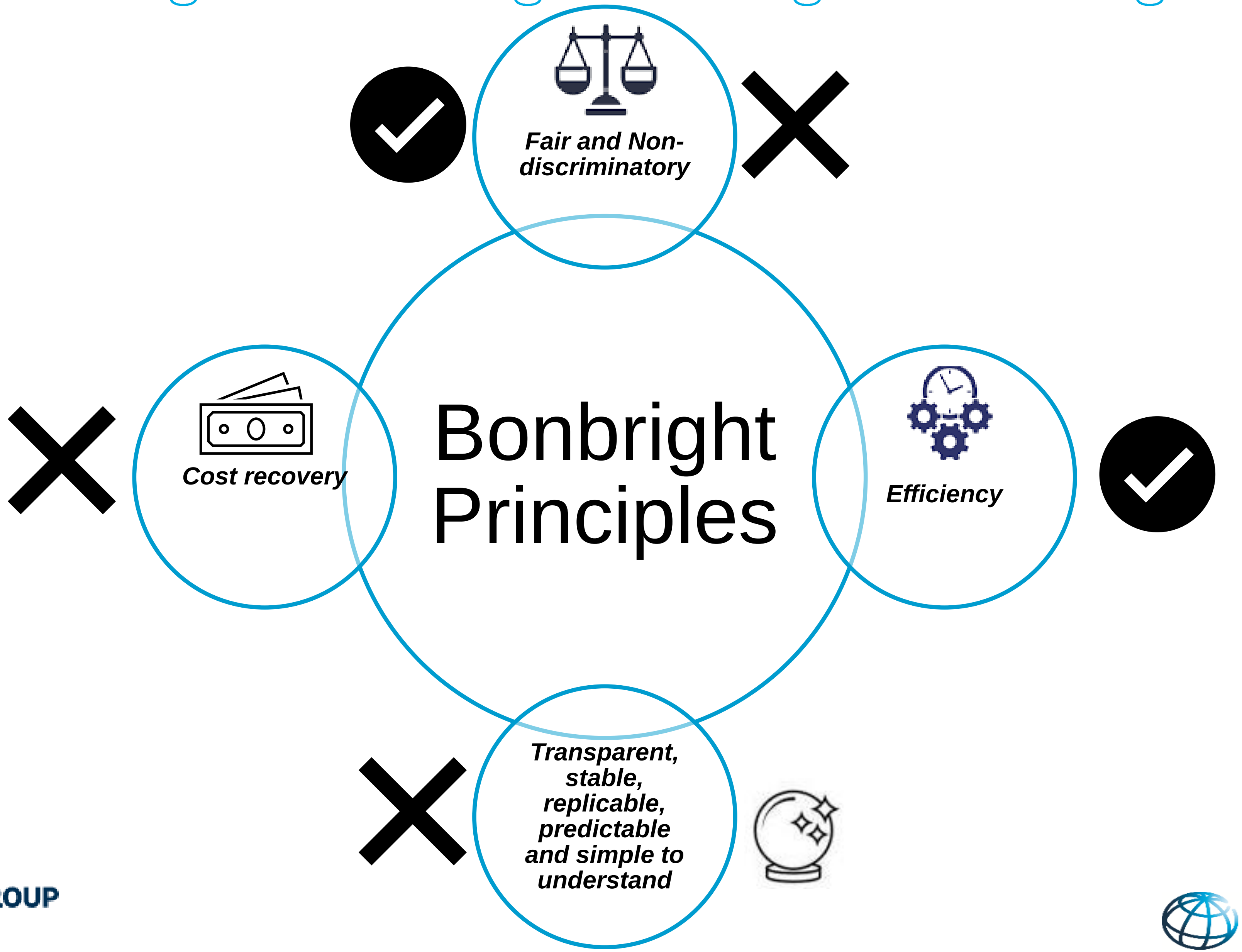
Disadvantages of Long-Run methods:

- Compiling a long-term transmission expansion plan is difficult, and subject to change, particularly the farther one goes out in time. This can lead to price volatility, although price volatility is likely to be less than that for short-run costing methodologies
- Evaluating the cost of an individual transaction is likewise difficult as there are multiple simultaneous transactions going on, so it is difficult to assign specific costs to specific transactions
- Double counting of investment costs must be avoided by ensuring congestion costs are not also captured in the transaction cost component of the transmission tariff



These disadvantages are offset somewhat by the improvement in the efficiency of the price signal as customers are charged prices that reflect the long-term cost of their transactions. This of course assumes that an accurate forecast of transmission expansion is used in the calculation

Forward-Looking Methodologies – Long-Run Pricing



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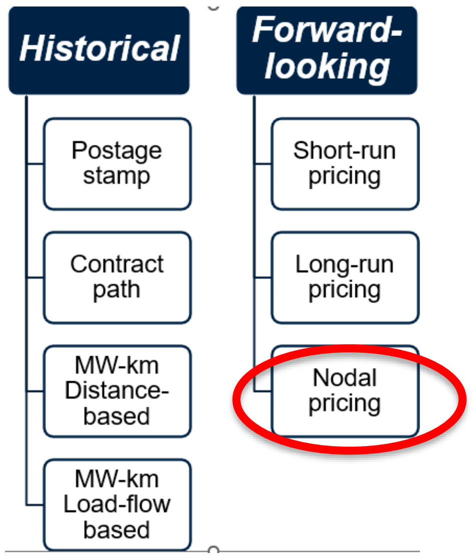
Forward-Looking Methodologies – Nodal Pricing

- Prices can be different at each node on the power system
- Nodes include both injection points and off-take points on a power system
- Nodal pricing is generally viewed as the ultimate pricing methodology because it reflects the costs of a transaction at each node on the system, so incorporates both losses and congestion costs of each and every transaction
- It is also by far the most complicated transmission pricing methodology



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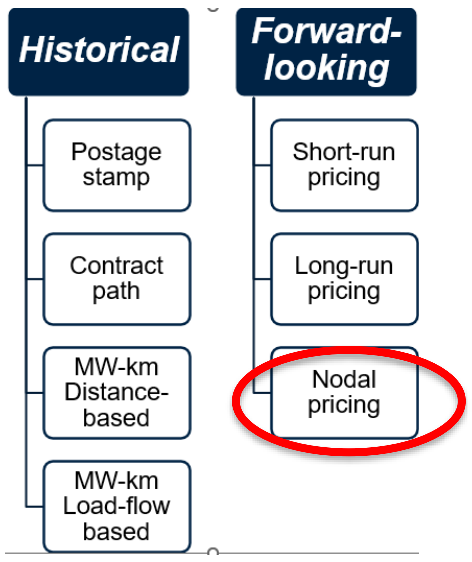
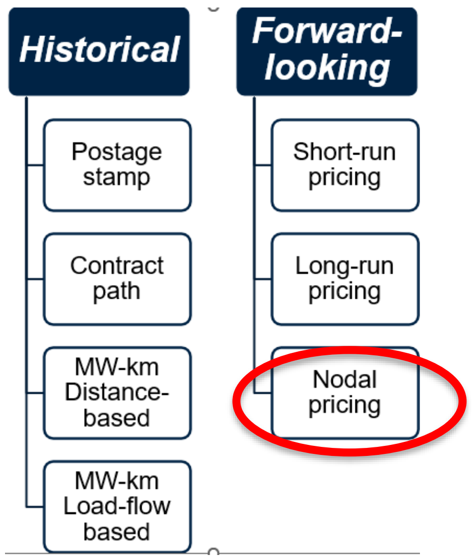
Forward-Looking Methodologies – Nodal Pricing

- The difference in prices between two nodes is equal to the transmission charge between the nodes
- It is not necessary to define the path followed by the transaction because prices are set to reflect the marginal impact of transactions at each node for the system
- Nodal pricing sets the price of power relative to all other nodes on the system, so for areas with surplus generation there will be a relatively high cost for additional generation (and the price for adding load will be low), and areas where there is a deficit of generation there will be a relatively low cost for additional generation (and the price for adding load will be high)
- Nodal prices should be published and tracked to improve predictability
- Similarly, investors can obtain an indication of the returns they might receive if they invest in transmission reinforcements at different nodes on the system

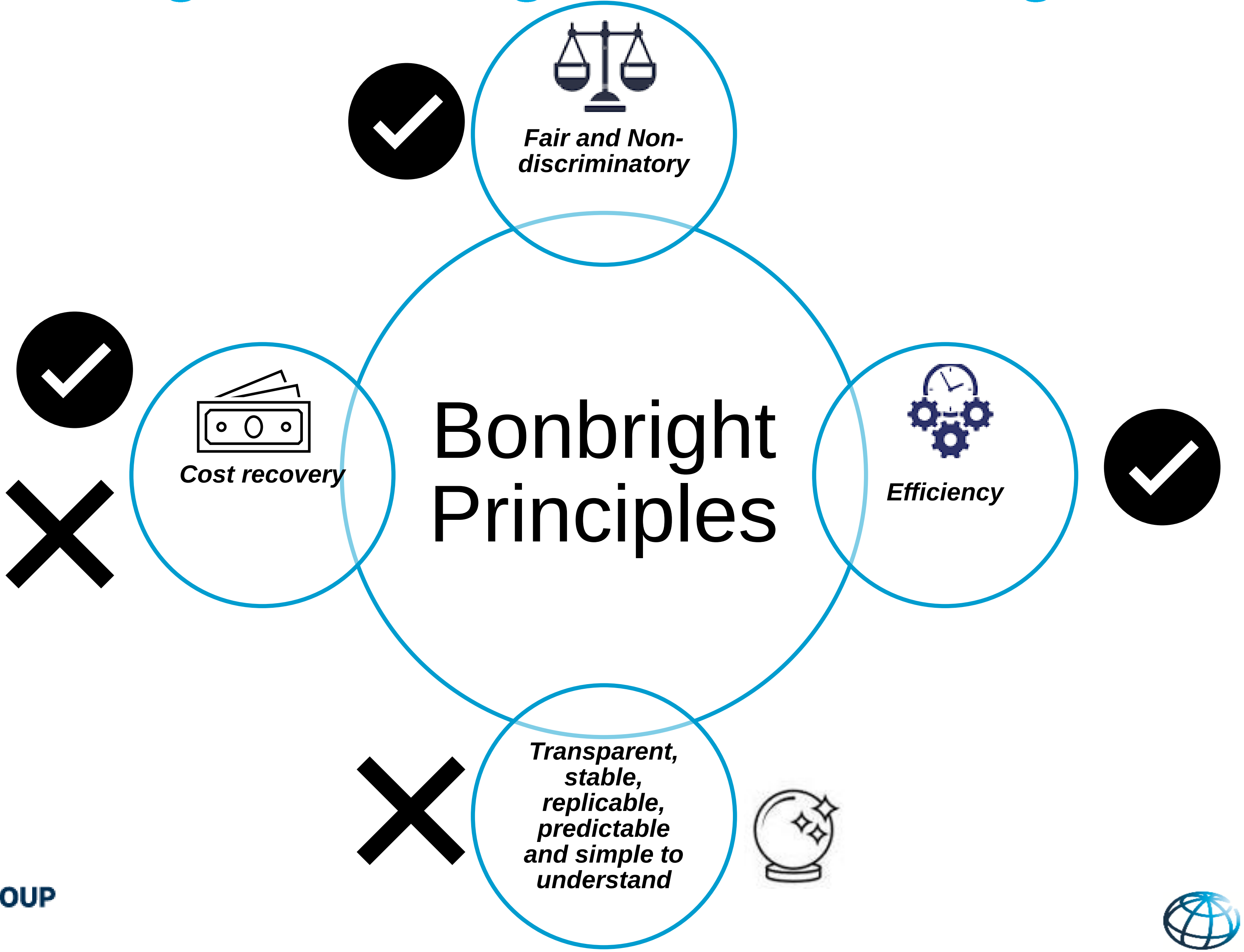


Forward-Looking Methodologies – Nodal Pricing (continued)

- This gain in economic efficiency comes at a cost:
  - Prices are volatile, and the methodology is complex and expensive to administer, particularly in a system with a limited number of transactions such as the PAEM
  - The TSOs require real-time information on load, generation, bids, and offers and equipment outages. A complex and costly settlement system is necessary
  - The additional benefits brought on by the methodology must be assessed versus the additional costs of implementation



Forward-Looking Methodologies – Nodal Pricing



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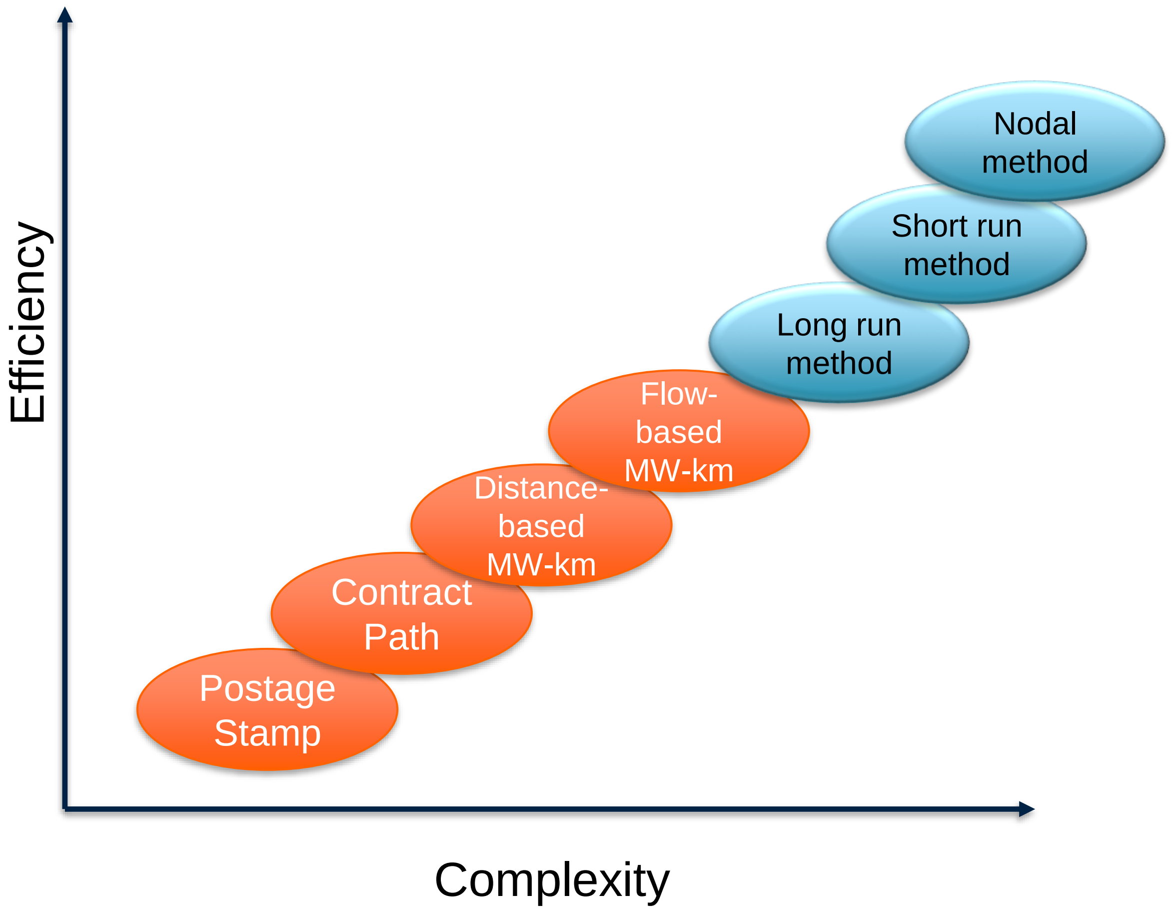
Assessment of Alternative Transmission Tariff Methodologies



Source: Ricardo Energy and Environment

What do Other Jurisdictions Do?

Jurisdiction	Postage Stamp	Contract path	Distance Based (MW-km)	Flow-based (MW-km)	Long Run Pricing	Short Run Pricing
UK (A)					✓	
Ireland	✓				✓	
Australia	✓			✓		
Brazil					✓	
New Zealand	✓					
ENTSO-E (B)	✓					
SAPP				✓		
WAPP				✓		

A- National Grid in United Kingdom calculates charges using a flow-based transport model but with unit costs of transmission built up using expansion costs based on LRMC principles. Charges are applied on a zonal basis.

B- In continental Europe, cross-border transmission charges are calculated from an assessment of the proportion of the energy supplied by each national network that arises from transits through the network arising from neighboring country transfers. A compensation sum is then agreed by the ENTSO-E members, which is allocated to the countries contributing to cross-border flows in proportion to their energy imports and exports.

Agenda

1. Open and non-discriminatory access
2. Challenges and experience with Open Access
3. The need for a regional transmission tariff
4. Transmission pricing methodologies
5. Transmission tariff design and implementation

Transmission tariff design and implementation

- Once a methodology has been chosen, it is necessary to develop the transmission tariff design
- Designs around the world have considerable variation. Even across Europe, designs vary widely (ENTSO-E's *Overview of Transmission Tariffs in Europe: Synthesis 2020*, dated May 2022)
- When designing the Transmission Tariff, several variables/parameters should be considered

Transmission tariff design and implementation

Design considerations include:

1) Transmission cost components to be recovered in the tariff
2) Single postage stamp or multiple license-plate tariffs for each country?
3) Different charges for different voltage levels; e.g., different tariffs for high and very high voltage?
4) Responsibility for payment; e.g., generation and/or load and in what proportions?
5) Geographic differentiation (locational pricing)
6) Time differentiation?
7) Billing determinants; e.g., fixed (fixed charge per month), capacity (charge per kW-month) and energy (charge per kWh)

Transmission tariff design and implementation

1- Asset Classification

- Voltage levels of transmission networks vary across the globe, particularly with respect to the lowest voltage levels classified as transmission network facilities
- As a general guide, only those facilities rated above 50 kV where there is loop flow and that benefit most transmission customers should be classified as transmission network facilities
- This excludes connection facilities that benefit only one or a few customers, and lower voltage facilities that are radial in nature that should be classified as distribution facilities
- While some of the PAEM countries have gone through the process of classifying each individual component of the transmission system, most have not. If Member States have not gone through such an asset classification process, they should do so to enable proper auditing and improve the fairness of the transmission tariff
- In countries where there is no separate transmission company, the costs of transmission should be separated from other components of the electricity services sector to form the transmission services tariff; e.g., transmission should be treated as a separate business unit.

Transmission tariff design and implementation

2- Standard System of Accounts/Asset Valuation

- An important consideration in tariff calculations is the accounting methodology used to value assets
- Tracking transmission costs according to a standard system of accounts enables auditing and cost comparison between countries. For example, a decision must be made on asset valuation - should assets be valued on the basis of actual historical costs (book value), or should they be valued on the basis of replacement costs?
- Comillas reviewed practice in Europe. Of the 14 countries included in the sample, eight use book value and two use replacement cost (*Benchmark of Electricity Transmission Tariffs* prepared by Comillas Madrid for DG TREN / European Commission, October 2002)
- Use of replacement cost generally leads to higher asset values and higher tariffs, but is often regarded as a fairer method to value assets
- In some cases, both historical and replacement costs are used to value assets
- Germany uses replacement cost to value the equity-financed share of old assets and historical cost to value the debt-financed share of old assets. New assets are valued at historical costs

Transmission tariff design and implementation

4- Approve Grid Code and Secondary Regulations

- A grid code has been developed for the PAEM, but has not yet been approved by the AMCE
- The grid code is relevant to certain aspects of transmission tariffs; in particular, connections and system/ancillary services
- It is recommended that customers be responsible for the costs of their connections. Therefore, there would be no specific tariff in the PAEM relating to connections
- The policy on connections ultimately adopted in the PAEM should be clearly delineated in the grid code

Transmission tariff design and implementation

5- Develop Price Control and Performance Indicators

- Most PAEM Member States regulate tariffs based on cost of service, or cost-plus, regulation
- In many PAEM countries retail electricity tariffs are subsidized
- Under cost-of-service regulation, market service providers are allowed full cost recovery, including a profit
- An incentive-based regulatory mechanism with a price or revenue cap on market service providers warrants consideration
- Price or revenue cap regulation provides incentives to transmission service providers to become more efficient in order to reduce costs and improve profit margins. Incentive regulatory mechanisms also provide a more favorable allocation of risks between service suppliers and customers

Transmission tariff design and implementation

5- Develop Price Control and Performance Indicators

- In order to guard against deterioration of performance and service owing to the overly aggressive pursuit of cost-cutting measures, performance indicators relating to areas that are of greatest importance to consumers are established; e.g., reliability
- Performance indicators that ensure appropriate levels of supply quality while bringing the PAEM up to best industry practice is desirable over time
- It would be worthwhile to start the data collection process so that the PAEM will be ready to implement a price control mechanism once cost and performance data and information are available
- Regardless of the regulatory mechanism chosen, it is necessary to first establish baseline costs. This generally means developing a full cost of service study on the basis of documented accounting principles; e.g., standard system of accounts

Thank You