Sustainable Energy Handbook

Module 2.3

Electricity tariff structures

Published in February 2016

1 General Introduction

In most developing countries, the need to increase access of the population to electricity requires the mobilisation of huge investments in additional generation, transmission and distribution infrastructures. The primary source of recovering this electricity sector extension is the tariff.

Electricity tariffs do more than just ensure the revenue required by the utility companies. The tariff design shapes incentives for the use and expansion of the system, which further influence costs. A tariff design that is clear to network users and well understood by them help them to make efficient decisions. A design that sets up inappropriate incentives could lead to economic distortions.

As inputs into virtually every sector of the economy, and as a good whose use rises faster than income in most developing countries, electricity prices have a unique impact on the well-being of households and competitiveness of electricity intensive industry providing export revenue.

A well-constructed electricity tariff should provide the owner of the assets, the customers, policymakers, regulators and potential investors with the following types of information about a power system:

- How much does it cost to supply load at a given time and what are the revenues for that same period?
- Where are the weak points of the system and what types of investments are needed to remedy these weaknesses?
- Does the pricing system implement the government's policies in the electricity sector effectively and balance competing goals and interests?
- Does the pricing system inform investors about where investments are needed?
- Can the system pay for itself, including current and future investment needs?

Ultimately, electricity pricing policies have to meet contradictory goals such as attracting investment and trade in electricity, allowing sustainable development of the power supply industry as well as of the demand side economic sectors, improving security of supply, expanding opportunities for isolated and poor citizens, improving service quality and sound financial status for the national utilities.

2 General principles

In light of all the choices available to an electricity system while designing the tariff structure, a number of economic or regulatory principles can be used as a guide, based on the goals of the system.

Table 1 List of economic and regulatory principles for Electricity Tariff Structure

Principle	Goal	Description
System sustainability	Universal access	Electricity is an essential service to which all consumers can have access
	Complete cost recovery	All eligible system costs must be recovered for the system to be financially viable
	Additivity of components	Various tariff components must add-up to give the total revenue requirement to be recovered
Economic Efficiency	Productive efficiency	Network services should be delivered to consumers at the lowest possible cost
	Allocative efficiency	Consumers should be charged taking into account their willingness to pay
	Equity	For all consumers that belong to a certain category and demand the same network services should be charged with the tariff without any consideration of the accessibility of their geographical position
	Competition	Consumer tariff should be structured in the perspective of allowing competition between electricity suppliers and establishing a competitive market. The utility(ies) should receive from their supply of electricity to any category of consumer, the exact cost of supply to that category
	Social equity	Social tariff applicable to certain categories of consumers is necessary to move toward universal access. But cross subsidization between categories of consumers is not advisable, as it builds an obstacle to the establishment of a competitive market.
Consumer Protection	Transparency	The methodology and results of tariff allocations should be published and available to network participants
	Simplicity	The methodology and results of the tariff allocations should be easy to understand
	Stability	The tariff structure should result in stable electricity prices in the short-term, with gradual changes in the long-term

Source: NERA

3 Tariff regulation approaches

An effective network pricing system must be accompanied by a regulatory system that gives all parties confidence that *the system is fair, non-discriminatory, predictable, transparent and representative of actual conditions*.

Regulators generally approach tariff adjustments with the aim of ensuring that the service is sustainable and there are sufficient incentives for system expansion through efficient technologies and enhanced trade opportunities.

The various tariff regulation approaches are described in table 2.

The various cost control methods – cost cap, revenue cap, price cap – are generally better suited for a relatively static electricity system. In a rapidly growing system, these caps limit the funds available to expand network capacity and quality in particular, and may exacerbate service quality issues.

The proper mix and pathway of regulation forms depends on the country's needs and objectives, institutional capabilities and arrangements, social and political systems, cost and/or difficulty of obtaining information, status of market (mature or ramping up) and potential for competition.

However, where there is too much limitation on prices there are two general impacts: (i) demand rises in response to lower real prices for electricity; and (ii) resources available to expand or even maintain the supply system may be limited by price controls.

Table 2 Choice of tariff regulation approaches

Type of tariff regulation	Description
Rate of return regulation or cost of service	This regulatory instrument establishes an overall price level that allows the operator to cover all eligible cost and receive accounting profits that are just equal to the operator's cost of capital at the time the price level is set. Actual profits may deviate from the cost of capital until the next time the regulator reviews the operator's profits. By controlling gains from efficiency improvement, rate of return regulation creates weak incentives for minimizing costs, except when specific clauses on improvement of cost efficiency are built-in the price regulation.
Cost indexation	With indexation of tariffs to specific input costs (for example, fuel) – Normally used in conjunction with other types of pricing regulation, thus leading to 'hybrid' price regulation. It does not include incentives to pass productivity gains to consumers, as all gains are captured by the utility.
Price cap or RPI-X	This method establishes the operator's overall price level by indexing the price level according to inflation minus an offset, called X-factor. The X-factor should reflect the difference between this operator and the average firm in the economy with respect to their abilities to improve efficiency and to changes in input prices. By inducing cost minimizing behaviour by power suppliers, price cap regulation (like cost indexation) yields larger gains to the most efficient suppliers but passes some productivity gains to consumers. Regular price reviews are held – typically every five or so years – at which time the base prices and X factors for the period up to the next price review are set. The prices set at the time of the price reviews tend to be based on rate of return (RoR) considerations.
Revenue cap	This method is similar to price cap except that the inflation-minus-X formula applies to revenue rather than prices. Revenue capping is adapted for markets that could become competitive in time.
Benchmarking or yardstick	This form of regulation is forcing the operator to compete against reference benchmark performance reflecting the performance of comparable operators in other markets. In practice benchmarking regulation is an input used in price cap or revenue cap regulation, and sometimes in rate of return regulation. Benchmarking regulation is adapted in activities with monopolistic functions such as distribution. Benchmarking is also particularly useful for regulating small off-grid power systems.

Source: National Audit Office (see reference)

Incentive based price controls require the use of a **multi-year control period**. It is the only way that ensures that the incentives included in such a regime are effective, as it strikes a balance between providing incentives for improving efficiency, reducing regulatory uncertainty and allowing sufficient time for a service provider to improve its performance. On the other hand, the longer the regulatory period, the longer customers must wait to share in the benefits of out-performance. Additionally, the longer the price control period the greater the likelihood that cost differentials would arise, especially in a highly uncertain environment which may allow a firm to make profits or losses well over those anticipated by the regulator. By choosing a shorter regulatory period there is the risk that a service provider will focus its efforts on short term gains, rather than on innovative actions that will lower costs in the long term. A regulator must therefore weigh the advantages of a longer term price control over a shorter period. Most of the regulators opt for a 3 to 5 year control period with re-opener option at the request of the utility company.

Under a **pass-through** mechanism, exogenous events that can lead to a pass-through of costs are defined in advance, usually with a high degree of precision (e.g. variation of fossil fuel price, exchange rate, etc.). This means that pass-through events can be considered in isolation, and the regulator need not re-assess elements of the revenue allowance that have not been affected directly by the exogenous event. Pass through costs may be adjusted on an annual basis or shorter period (e.g. monthly basis).

4 Tariff architecture

Within the class of network tariffs, a number of typical architectural elements for different services are prevalent such as (i) connection services, (ii) use of the network system, (iii) commercial services, etc. For each of these elements, the question of what methodology or formula to use must be addressed. The typical design choices for each element are summarized in Table 3.

4.1. Incidence of connections charges

Connection charges are levied on connecting parties by way of either a deep or shallow connection charging policy. Under a ***shallow*** *connection* policy the connecting customer is charged directly for its respective portion of new assets required to connect it to the Network system. Under a ***deep*** *connection* policy the connecting customer is charged for both the assets required for connection to the system and all wider system development costs incurred as a result of its connection.

Shallow and deep connection charges are often in the form of an upfront, one-off charge. A deep connection charging policy results in higher upfront charges for the customer and as a result reduces the network revenue to be recovered through the Use of System tariff.

In general terms policy applied in regard to connection charging is characterised by a variety of variables and customer attributes. These are as follows:

- Generator / Demand Customer Differentiation
- Favourable treatment of renewable generation connections
- Deep vs (Semi-) Shallow Charging
- Full vs. Partial Payment for Connection
- Refunds for Existing Line Users
- Ongoing Operations & Maintenance Charges

The **connection charges** for customers in Sub-Saharan Africa are highly variable and can be amongst the highest in the world (Rwanda $350, Burkina Faso $264, Benin $150, Cote d'Ivoire $127, Mauritania $106, Ghana $32, Cape Verde $2). This has resulted in low rates of electrification in many countries.

Electricity companies can lower their connection-related costs, and thus consumer charges, by using a variety of low-cost technologies and materials in distribution networks and household connections; making bulk purchases of materials; and adjusting technical standards to reflect the lower loads of households that use a minimum amount of electricity.

Strategies for lowering connection charges may also include spreading charges over a reasonable period, rolling them into monthly service payments, subsidizing connections, or amortizing them through loans. A consideration when designing connection charges lowering approaches is to ensure that it does not distort competition between power suppliers. The implementation of connection financing schemes is difficult to implement in a fair manner, as it requires that the tariff is different for consumers already connected and new consumers and requires a complex "claw back" if a new consumer decides to disconnect or switch to competition. Lowering connection charges is not the only step, but it is an essential part of any strategy for addressing the electricity access gap between rich and poor households in Sub-Saharan Africa.

4.2. Incidence of Use of system charges

The Use of System (UoS) charging regime is designed to recover the total allowed costs of the network business (net of connection charges revenue) from all users of the network. The allowed revenues comprise the network and non-network costs of constructing, operating and maintaining the network. These are charged to customers according to a number of parameters namely:

- UoS Customer Categories (e.g. residential, commercial, industrial, agricultural and street lighting)
- UoS Structure/Components (Fixed customer charges - per customer per month; generation charges - per kWh; capacity charges - per kVA of maximum import capacity; network energy charges – kWh; demand charges - per KW of metered peak demand during the billing period; low power factor penalties)
- Blocks (energy blocks, demand blocks, load factor blocks)
- Time of Use (Diurnal) & Time of Year (Seasonal)

At the transmission level, a number of cost allocation methods such as postage stamping, megawatt-km, contract path have been proposed for UoS charges:

In a method like **postage stamping**, the UoS charges are uniform across the entire transmission system, irrespective of the location of a network user, as long as the usage remains within the local system. The charge may vary with capacity ratings of generators or peak demand ratings of consumers (MW).

In transmission cost allocation methods like **contract path** or **megawatt km**, assumptions are made about the power flow between a generator and a consumer and the users are responsible for costs related to only those network facilities that are in the path of power flow.

At the distribution level, the marginal costs for particular users could be approximated using an instrument such as a **reference network model**, which simulates the conditions of the real network under a variety of scenarios. This method allows for sophisticated charging schemes that generally reflect the costs incurred to provide network services to particular users.

Methods such as **gross-metering** or **net-metering** are relevant when generation is located at the customer site as with distributed generation.

Decoupling is a method in which the revenues and profits of the network company are separated from the volume of energy sold.

4.3. Incidence of commercial service charges

Network companies incur administrative costs for providing services to consumers such as billing, meter reading, and customer support that are independent of network operations. A network company can charge for commercial services in the form of a charge that is **averaged** over all customers irrespective of the number of transactions or services provided to particular customers. Alternatively, it can charge fixed **transaction fees** that are unique to the type of transaction.

4.4. Incidence of Energy Policy Costs

The recovery of energy policy costs such as stranded costs of restructuring in network tariffs may be essential for overall electricity system sustainability. However, an electricity system is not faced with the issue of cost allocation with regard to these costs because they are not incurred while providing network services to particular users. In some systems, the high costs of energy from renewable sources is subsidized due to the policy goal of reducing greenhouse gas emissions and reducing reliance on fossil fuel sources. The benefits of reduced emissions and fuel diversity are accrued by the entire population. Calculating the marginal benefit accrued and the marginal costs to certain users is unfeasible as in the case of some network related issues. But a system could decide to recover such policy related costs from the population as a whole instead of captive electricity network users only.

Table 3 Choice of Architectural Elements for Electricity Tariff

Element	Purpose	Design Choices	Variations
Connection charge	To recover the initial, non-recurring connection costs for enabling the user to receive network services	- Shallow - Deep - Average	May be levied - Up-front - In limited instalments - Periodically
Use of System Charge	To recover the recurring operating and capital cost for network maintenance and expansion	- Postage stamp - Megawatt km or Contract path - Reference network model - Gross or net metering Decoupling	May be differentiated by - Capacity demand (MW) - Consumption (MWh) - Time of day - Season - Average per connection
Commercial services charge	To recover the cost of services such as billing, customer support, etc	- Average - Transaction fees	- Minimum fee - Maximum fee
Energy Policy charge	To recover the cost of policy outcome such as cross subsidisation of low incomes or rural communities, stranded costs of electricity market restructuring, feed-in tariff for renewables, etc.	- Average fee - Lump sums	- Increasing over time - Decreasing over time

Source: MIT

5 Key questions

System sustainability

1. Can the system pay for itself, including current and future investment needs?
2. How much is the sector subsidised (per kWh consumed, per % of GDP,% of total cost)

Cost Allocation, Non-Discrimination, Social policy and Competition

1. Are costs being allocated appropriately according to "causer pays" principle[1]?
2. Are revenues collected by the utility from each category of consumer reflecting marginal cost?
3. Is the tariff affordable for categories of consumers targeted by the Government for accelerated access and who pays the difference between affordable tariff and cost of supply?
4. Does the tariff structure allows and encourages competition in the market?

Existing & Alternative Tariffs and Connection Charges

1. What alternative tariffs and connection charges might better achieve the objectives of tariff setting?
2. What tariff structures are well suited to move toward a competitive distribution market?
3. How will embedded generation, in particular renewable energy generators and auto-producers, be facilitated?

Tariff Constraints: Metering & Billing Capabilities

1. How would metering and billing technology and investment affect the choice and implementation of alternative tariffs?

Alternative Screening & Customer Impact

1. How would the introduction of alternative tariff structures impact customers?

[1] The causer pays principle is a generic principle that allows for the efficient andequitable allocation of costs to parties that cause the cost to be incurred in the first instance

6 Useful references and links

Electricity Tariff Structure Review: Alternative Tariff Structures, NERA – CER http://www.seai.ie/uploadedfiles/Energyandbusiness/CERElecTariffReview04.pdf

Connection Charges and Electricity Access in Sub-Saharan Africa - Raluca Golumbeanu, Douglas Barnes - The World Bank, Africa Region, Sustainable Development Network, June 2013http://elibrary.worldbank.org/doi/pdf/10.1596/1813-9450-6511

Engineering, Economics & Regulation of the Electric Power Sector, ESD.934, 6.974 Session 17, Module F, Electricity tariffs Prof. Ignacio J. Pérez-Arriagahttp://ocw.mit.edu/courses/engineering-systems-division/esd-934-engineering-economics-and-regulation-of-the-electric-power-sector-spring-2010/lecture-notes/MITESD_934S10_lec_17.pdf

Study on tariff design for distribution systems - DIRECTORATE-GENERAL FOR ENERGY DIRECTORATE B – Internal Energy Market - 28 January 2015 - Refe-Mercados-Indra https://ec.europa.eu/energy/sites/ener/files/documents/20150313%20Tariff%20report%20fina_revREF-E.PDF

Economic Concepts for Pricing Electricity Network Services - A Report for the Australian Energy Market Commission - 21 July 2014 – NERA http://www.aemc.gov.au/getattachment/f2475394-d9f6-497d-b5f0-8d59dabf5e1c/NERA-Economic-Consulting-%E2%80%93-Network-pricing-report.aspx

Pipes and wire – National Audit Office - REPORT BY THE COMPTROLLER AND AUDITOR GENERALHC 723 Session 2001-2002: 10 April 2002http://www.nao.org.uk/wp-content/uploads/2002/04/0102723.pdf

Making Competition Work in electricity - Sally Hunt - John Wiley & Sons, Inc. - 2002 - http://regulationbodyofknowledge.org/wp-content/uploads/2013/03/Hunt_Making_Competition_Work.pdf

Electricity Network Tariff Architectures - A Comparison of Four OECD Countries – Vivek Sakhrani and John E. Parsons July 2010 – MIT Centre for Energy and Environmental Policy Research http://web.mit.edu/ceepr/www/publications/workingpapers/2010-008.pdf