Sustainable Energy Handbook

Module 2.2

Regulation of the electricity sector

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1 General Introduction

Regulation, in very broad terms, seeks to address "market failure" and is deemed necessary to protect consumers, society and the environment. The primary driver for regulation of the electricity sector is to ensure proper competition and good governance as well as to keep price affordable for all type of consumers.

Technical regulation is performed through the promulgation of service standards, guidelines, and codes of practice for electricity service. This is essential to ensure the quality of electricity services for the industrial and service sectors, and, therefore, for economic growth. This concerns in particular:

- grid codes
- quality of service codes
- codes for protection of consumers

The African Forum for Utilities Regulator (AFUR) has developed guidelines on quality of services which are presented in section 4.

Economic and tariff regulation of the power market is the formal arm of governance that balances the interests of market participants—power generators, suppliers, network and market service providers, and users. It also considers the interests of those who aspire to participate in the market—new entrants that are either power suppliers that want to sell their product or power users that want access to the public electricity network. It is used to control prices and ensure efficient provision of services. Tariff regulation is necessary and difficult because the price of electricity services is highly political since these services are important for the welfare of households.

Incentive regulation is designed to give owners and operators of natural monopolies in the electricity sector incentives to behave as if they were subject to competition. It promotes innovation, cost containment, and service tailored to the needs of end-users of electricity. It allows regulators to reward suppliers for good performance and penalize them for poor performance. Performance goals are typically to improve investment and operating efficiency or connect a target number of new consumers.

Arbitration

With the sole exception of Uganda, where an Electricity Disputes tribunal exists, there are no systems of judicial arbitration; in most cases the only way to complain for a decision of the Regulatory Agency is to bring the issue to the Courts of Justice.

International guarantees against regulatory risk can support these approaches for those countries where the domestic institutions do not provide a basis for credible commitments to any set of rules.

2 Developing Regional Regulatory Frameworks for the Power Sector

Worldwide experience in developing power pools has led to a consensus on three key building blocks for success:

- a common legal and regulatory framework,
- a durable framework for systems planning and operation at regional level, and
- an equitable commercial framework for cross-border trade (energy exchanges)

Regional power trading requires cross-border infrastructure, harmonized pricing of transmission services, third-party access regulations, effective cross border trading contracts, and reliable and creditworthy national utilities as well as private stakeholders. In much of Sub-Saharan Africa, bilateral arrangements between vertically integrated utilities guide cross-border electricity exchanges, although, increasingly, regional power pools are a way to develop and liberalize the international electricity markets.

3 Economic and tariff regulation approaches

The regulatory system gives all parties confidence that the pricing 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 different 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 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.
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.
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 yields larger gains to the most efficient suppliers. 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.

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.

4 Technical regulations: Quality of service for end-consumers

"Quality of services for the customers" is the term defining the quality level of all the services linked to the supply of electricity. The African Forum for Utility Regulators (AFUR) has defined comprehensive guidelines[1] on quality of electricity services.

An indicative list of indicators and criteria which are recommended by AFUR to measure the quality of service are presented below:

1°) Interruptions

A) The System Average Interruption Frequency Index (SAIFI)

SAIFI is defined as follows:

$$SAIFI = \frac{\text{total number of customer interruptions}}{\text{total number of customers served}}$$

SAIFI is measured in units of interruptions per customer.

SAIFI should be calculated on a monthly basis and reported semi-annually and annually. SAIFI can be calculated at different levels of voltage and for different sized territories.

B) The System Average Interruption Duration Index (SAIDI)

SAIDI is defined as follows:

$$SAIDI = \frac{\text{sum of all customer interruption durations}}{\text{total number of customers served}}$$

SAIDI is measured in units of time, often minutes or hours. It should be calculated on a monthly basis and reported annually. SAIDI can be calculated at different levels of voltage and for different sized territories.

[1] AFUR Common guideline on qualityofelectricityservices, December 2013

C) *Customer Average Interruption Duration Index (CAIDI)*

CAIDI is the average time each customer is without power per interruption per year. CAIDI is defined as the sum of all the customer interruption durations divided by the total number of customer interruptions.

$$CAIDI = \frac{\text{sum of all customer interruption durations}}{\text{total number of customer interruptions}} = \frac{SAIDI}{SAIFI}$$

CAIDI should be calculated on a monthly basis and reported annually. CAIDI can be calculated at different levels of voltage and for different sized territories.

2°) Voltage quality

Different criteria are used to measure the voltage quality of the electricity supply to end -consumers. These are:

- **Frequency withstand:** Indicates the frequency quality and is measured by the number and duration of excursions outside a permitted range (F +/- ΔF).
- **Slow voltage changes:** the voltage of all networks operating at less than 132 kV should be maintained within ±10% of nominal. A voltage excursion event is defined as one in which the voltage at any bus-bar or delivery point on the distribution system falls outside the permitted limits.
- **Voltage fluctuations:** Flicker is a visible change in brightness of a lamp due to rapid fluctuations in the voltage of the power supply. The voltage drop is generated over the source impedance of the grid by the changing load current of an equipment or facility. These fluctuations in time generate flicker. Flicker, to be acceptable, should be perceivable by 50% of the population when reading with a 60W incandescent lamp.
- **Voltage harmonics:** Harmonics are sinusoidal voltages or currents having frequencies that are whole multiples of the frequency at which the supply system is designed to operate.
- **Voltage unbalance**: Voltage unbalance in a three-phase system is marked by a difference in the phase voltages, or when the phase separation is not 120 degrees.
- **Voltage dips and swells**: A voltage dip (British English) is a short duration reduction in Root-Mean-Square (rms) voltage (can be caused by a short circuit, overload or starting of electric motors). Voltage swells or surges are brief increases in voltage over the same time range. Longer periods of low or high voltage are referred to as "undervoltage" or "overvoltage".
- **Transient overvoltages:** A transient overvoltage can be defined as the response of an electrical network to a sudden change in network conditions, either intended or accidental, (e.g. a switching operation or a fault) or network stimuli (e.g. a lightning strike).

In most of the above cases, following a customer complaint, measurements should be taken at a delivery point until both the system operator and the customer are satisfied for the normal range of operating conditions. In the event of repeated non-compliance at a delivery point, the supply company and customer should work together to consider system re-configuration or reinforcement to bring the factor at hand back within the compatibility levels given.

3°) Commercial quality to end-consumers

The following factors are considered to significantly affect commercial quality for end-consumers:

a) *Information on interruptions*

In the event of interruption of supply (whether incidental or planned), the electricity company must establish an organisational structure to provide customers with information on the nature and the expected duration of the interruption. Various solution techniques are possible: FM Radio for major incidents, programmable answering machines, answering phone calls and outgoing calls to customers and authorities, sending of SMS.

b) *Frequency of meter readings*

Meters should be read and physically inspected at regular intervals to avoid theft and to allow charging based on actual energy consumption. If the meter is not read on monthly basis, and if some bills are estimated, a procedure for reconciling estimated and physical measurements at least in every 3 or 4 months must be defined.

c) *Disconnection for non-payment*

Customers cannot be disconnected for non-payment until 14 days after the payment deadline. A minimum of 7 days' notice should be given to customers before they are disconnected. Direct contact with the customer can be requested before disconnection. Disconnection should not occur on weekends or public holidays. A customer who has been disconnected due to non-payment should be reconnected on the first working day after their account is satisfactorily settled.

d) *Provision of vending stations for prepayment meters*

Vending stations for prepaying customers should be located within a reasonable distance of each customer and there should be a vending station for an acceptable number of customers. Vending stations should be open (at least) during normal weekday working hours and could be open all day and partially or totally at weekends and on public holidays.

e) *Treatment of customer queries*

A customer who makes a query regarding an account or meter accuracy issue should receive a response within a reasonable time frame if the query is made in writing.

f) *Responses to requests for new connections*

The following standards[2] are suggested:

	Time to respond to a quotation request (Working days)		Time to provide the connection after customer acceptance of the quotation (Working days)	
	Level 1	Level 2	Level 1	Level 2
No extension required	20	10	50	30
Extension required	50	30	100	60

g) *Individual failure*

The electricity company must act as quickly as possible when a customer reports an individual failure. Whether or not the failure is individual is determined by checking whether calls have been received from other customers in the same area.

[2] Whenthreelevelsaregiven, theyshouldbeinterpretedasfollows:
- Level 1 correspondsto a low-performance reference; a lowerlevelthanlevel 1 isdeemedunacceptable.
- Level 3 correspondstogoodqualitystandardsfound in theworldtoday, whichcouldbetheultimatetarget.
- Level 2 is an intermediate target.

h) Notice of planned interruption

Planned interruptions cause limited inconvenience for the customer, provided they have prior notification and that the duration and repetition of this kind of interruption are limited. The following standards are suggested:

	Level 1	Level 2	Level 3
Notification	In newspapers or by FM radio	FM Radio + Individual letters 48 hours before the interruption	FM Radio + Individual letters 72 hours before or by SMS
Maximum duration	8 hours	8 hours	4 hours

i) Response to general complaints

The electricity supplier should respond to written complaints from customers within a specified timeframe after receiving the complaint. The following standards are suggested:

	Level 1	Level 2	Level 3
95% of customers receive an answer within	20 days	15 days	10 days

j) Quality of telephone response

Quality of telephone response is the quality of the response which customers receive when they contact the utility company about power loss, an emergency or any information request concerning their contract management. There is no actual definition of a standard, but the electricity company must provide customers with a telephone call service for use in emergencies (failure, or to report a technical incident) and to resolve issues related to contract management.

k) Making and keeping appointments

When the electricity supplier makes an appointment (e.g. for meter reading), they must offer a date and time within a specified period. If, for any reason, they are unable to keep the appointment, the customer must be informed.

l) Response to voltage complaints

The response to a voltage complaint made by a customer to the electricity supplier should be either a written explanation of the probable cause, or a visit to the customers' premises to install measuring apparatus.

To verify customer satisfaction, it is recommended to regularly proceed with customer satisfaction surveys. As customer responses are sensitive to the way the questions are asked, it is important to ensure the quality of the wording of the questions (to avoid any ambiguity) and the stability of the questionnaire over time in order to facilitate inter-annual or periodic comparisons. Having the surveys conducted by external agencies can offer a guarantee of neutrality with respect to the customer and therefore better quality results

5 The 4 main organisational models for the electricity market

5.1. Monopolistic vertically integrated industry structure (one national electrical utility)

The initial stage of the electricity industry in all sub-Sahara African countries in post-colonial area has been government owned and controlled utilities in a vertically integrated business model and closely regulated tariffs.

Electricity is considered an essential social and commercial commodity with restrictions on ownership and transaction of assets. This model may suffer from inefficiency and lack of commercial incentives.

5.2. 'Single Buyer' with several Independent Power Producers (IPPs) and "Power Purchase Agreement"

This option includes some aspects of competition through bilateral contracting between Independent Power Producers and the incumbent electric utility. The contract which is normally used between the parties is called a "power purchase agreement", or PPA. Opening generation to competitive forces can be worthwhile even in small power systems, though the form of the PPA is typically "take or pay" whereby the utility is forced to pay for capacity availability whether or not it is utilised. PPA contracts are normally of long-term nature (e.g. duration of ten years or more)

Under a single buyer model, a single entity (e.g. the National Utility or the Ministry) is responsible for deciding on the necessary generating capacity to be built. In the short-term, the System Operator (or the incumbent electric utility) conducts all energy purchases and sales, normally including imports and exports. The unit commitment and dispatch instructions are given by the single buyer, and there is no need for any additional market structures as prices are usually set by the responsible Ministry, based on (but not necessarily covering to the full extent) the actual costs of the whole value chain. Prices can be set for any period required.

Most of the private sector finance recorded relates to independent power producers (IPPs). In recent years, 34 IPP contracts in Africa have involved investments of $2.4 billion for the construction of 3,000 MW of new power generation capacity. Those projects have provided much-needed generation capacity. An independent assessment concluded that they have also been relatively costly because of technology choices, procurement problems, and currency devaluations (calling for adjustments in dollar- or euro-denominated off-take agreements).

In all countries, the incumbent utility remains the dominant generator.

5.3. Unbundled and Centralised Power Market or 'gross-pool' model

Under a gross pool arrangement the decision for building new generation capacity is usually left to the market (under a licensing process). In the short-term (e.g. Day-Ahead), all of the energy is again traded through a single entity – this time a pool – but there is usually a facility for generators and retailers to hedge their costs. The generators place bids for the price which they require per MWh generated, and these bids are ranked and plants are dispatched in merit order. In addition, Suppliers to end-users (or Retailers or Load Serving entities – LSEs) place offers to buy electricity. Bids and offers are submitted for every hour (or other period considered reasonable) and the market 'clears' (determining a uniform price and quantities to be produced / consumed by every participant) every hour based on balance of supply and demand.

5.4. Unbundled and Decentralised Power Market or the "net pool" market

Decentralized power market option covers net power pool or bilateral trading market arrangements.

Bilateral trading is the ultimate successor to a single buyer and gross pool models, once the basic requirements for competition in the market are met.

As in the gross pool, under net pool arrangements the decision for building new generation capacity is left to the market. Short-term (Day-Ahead) trading—most typically over 90 percent—of the trade is conducted under bilateral arrangements, under which generators sell power to power retailers (including distribution companies) that sell power to end users, power marketers (traders that deal with other traders and retailers), and large end-users of electricity.

Under this scheme, a mechanism to cover imbalances between contracted and actual trading positions is needed. This is usually achieved by establishing a Balancing Market, administered by the Transmission System Operator (TSO). In a simpler form, the system operator appoints a generator to increase or reduce its power production, as necessary, to keep supply in balance with demand on the system.

6 Key questions

General questions on the regulation scheme

- What is the legal basis for the sector (National energy law, electricity law, renewable energy law, energy efficiency law) and for the management of biomass?
- Is there a true and fair competition between the various operators?
- What is the regulation concerning IPP (Independent Power Producers)?
- Is the limit of scope of the national regulator? Who is in charge of off grid rural electrification schemes as well as biomass?
- The power of regulator to penalize operators for underperforming with regard to their obligation well transparent?

Technical regulations

- Which technical standards are used in the country for the electrical national grid, mini-grids, solar home systems, solar lanterns (lighting Africa standards) energy efficiency? Do they comply with the regional ones?
- How really are these standards applied?
- How efficient is the control?
- What is the quality of the electricity supply?

Tariff regulation

- Do the prices of energy reflect the actual cost of production/transport/distribution?
- Are there subsidies for energy? Is there a system of cross subsidies to facilitate access to energy for poorest population?
- What is the impact of the subsidies policy on public finances?
- Are there inefficient subsidies? Is there a plan to phase out those?
- What is the balance between incentives/subsidies and taxation
- What are the financial instruments for promoting renewable energy development (Feed in tariff, favourable loan conditions, etc.), and energy efficiency?
- Do they allow significant change in customers behaviour, in boosting investment in sustainable energy

Market organisation

- Is the electricity market liberalized?
- How is electricity trading performed?
- Which of the 4 main organizational models for the electricity market better fits the country's situation?
- How is cross border trading of electricity managed?
- UNBUNDLING: Is there a clear separation of competitive (generation, supply) activities from monopoly (transmission, distribution) ones in the country?
- How is the real-time balance of the power system achieved in the country?

7 Useful references and links

- African Forum for Utilities Regulators (AFUR): Common guideline on quality of electricity services, December 2013
- PEAC: Regional electricity code for Central Africa countries
- KEMA, Electricity Markets and Principle Market Design Models. available at: http://www.leonardo-energy.org/sites/leonardo-energy/files/root/pdf/2010/Electricity%20Markets%20Paper.pdf
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- Power Exchange Auction Platform Design, L. Meeus, 2006 available at: POWER EXCHANGE AUCTION TRADING PLATFORMDESIGN https://lirias.kuleuven.be/bitstream/1979/338/1/L
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