



AFRICAN
SCHOOL OF
REGULATION

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Course on

Power Sector Regulation in Africa

Program

Duration

10 weeks online plus one week (optional) in person.

Starting date: Monday April 8th, 2024.

Language

The official course language is English. All essential course materials will be translated into French.

Objective

The objective of this course on "Power Sector Regulation in Africa" is to provide a comprehensive overview and a sound understanding of the fundamentals of power sector regulation in the diverse contexts of African countries. The course goes far beyond "having an informed opinion" on regulatory issues. It is designed with the practical objective of "learning the trade" of regulatory practice, at a level that can be achieved over the duration of the course. The course will provide a solid platform on which to build later with specialised training on different topics.

The power sector in many African countries presents unique challenges that require distinctive solutions, not by copying and pasting international best practices, but by creatively adapting them or inventing new ones, always starting from the basic principles of economic regulation and an understanding of the engineering aspects of this complex industry. This is the mindset the course seeks to stimulate in the participants.

Target Audience

This course is designed for professionals working in the multiple entities related to the power sector, which includes regulatory authorities, ministries and governmental agencies, power utilities, academia, investors, development organisations, and others who wish to gain an in-depth and practical understanding of the regulation of the power sector in Africa.

Course structure and organisation

The course consists of two parts: the first is online and lasts ten weeks; the second is in person and lasts one week. In the online and main part of the course, participants will learn the regulatory principles that apply to the several activities involved in the delivery and utilisation of electricity and their implementation in the African power sector context. The course will end with an optional in-person week devoted to the analysis of practical cases of application of the material covered during the online part of the course.

E-learning

The course provides a flexible e-learning environment that features a combination of pre-selected resources – videos, podcasts and readings –, live lectures and discussions with the course instructors and other participants, and a project.

The training is structured around weekly lessons covering a specific thematic area. Each week begins with a brief podcast introducing the objectives for the week and the main topics to be covered. The weekly learning content is delivered through a combination of either visual and/or audio media such as short videos, podcasts or readings by specialists in the topic, complemented by carefully selected recommended readings. Additional readings are provided for further study by course participants who wish to learn more on a particular topic. Questions are provided by the instructors – course participants can also initiate other topics – for each weekly lesson to launch a forum discussion among the participants on the course platform.

At the end of the week, a live class with the course director and/or one of the lesson's instructors gives the participants an opportunity to ask questions and clarify doubts on the content that has been presented during the week. Additional live sessions with relevant guest experts will be scheduled along the course. A weekly quiz is provided to enable participants test their level of understanding of the week's learning material.

Course participants can also undertake an optional individual project to advance in their understanding of the material of the course and to get a higher level of recognition for having taken the course.

In-Person (optional)

At the end of the e-learning phase, course participants can opt for an additional week-long in person activity focused on discussing relevant case studies with the course instructors and other power sector experts from Africa and around the world.

A more detailed description of some aspects of course organisation can be found at the end of this document.

Course Content

Introduction to the Course (Week 0)

Live welcome class. A live class is dedicated to welcoming participants and presenting the structure of the course, how to use the e-learning platform, how to interact with other participants, coordinators and trainers, the logistical aspects, the grading system and the course coordinators.

Introduction to the course. The course director introduces the course content and instructors, presents the course objectives, and provides an overview of the main challenges facing the energy sector in Africa and how policy and regulation can help to address them.

Power Systems Engineering and Economics. An optional introductory session is provided for participants not familiar with the energy sector, given the expected diversity of backgrounds among course participants.

Preparatory Readings. Optional readings of introductory material relevant to the course, as well as recent news items that may provide context for some of the topics to be covered, are made available one week prior to the start of the sessions.

Lesson 1: The power sector in Africa

The aim of this lesson is to understand how the context – the physical, economic, social and political characteristics of a country – largely determines the structure and regulatory solutions adopted by countries around the world and African countries in particular.

Content: Overview of the electricity sector in African countries, the history of its development and the regulatory reforms that have taken place, highlighting the differences and similarities with other countries in the world. In addition, the lesson highlights the major challenges currently facing the power sector in African countries.

The lesson consists of the following modules:

Module 1.1. Development of the power sector in Africa

Module 1.2. Power systems in developing countries

Module 1.3. The power sector within the broader energy sector

Module 1.4. Current state and challenges (incorporating some country case studies).

Each lesson includes media resources (pre-recorded videos and podcasts), required and optional readings, self-assessment tests, and topics for discussion in open forums among course participants. As mentioned above, a live class at the end of each lesson gives students the opportunity to ask questions of the instructors, receive feedback on the discussions in the forums or listen to expert guests on the topic of the week.

Lesson 2. Regulation: principles, institutions and regulation of monopolies

This lesson provides participants with an understanding of the need for regulation and the existence of regulatory authorities for the power sector, as well as the diversity of implementation approaches that have been adopted, with a special focus on the regulation of natural monopolies.

Content: Justification of the existence of a regulatory authority for the power sector, necessary both for the monopolistic activities – distribution and transmission networks and system operation – and for those that can be performed under traditional regulation or market conditions – electricity production and commercialisation, either wholesale or retail. Description of the main approaches adopted in African countries and throughout the world.

The second part of the lesson addresses a fundamental aspect of economic regulation: the existing methods to regulate monopolistic activities. The lesson focuses on those activities requiring network infrastructures – like the distribution and transmission of electricity. Distribution is a case of particular interest and difficulty, because of the very large number of assets involved, resulting in a manifest information asymmetry between the regulator and the firm.

This lesson consists of the following modules:

Module 2.1. Principles and approaches of economic regulation.

Module 2.2. Regulatory institutions.

Module 2.3. Economic regulation of monopolistic activities. A review of relevant approaches.

Module 2.4. Cost of service regulation and the implementation of incentives.

Lesson 3. Large scale generation of electricity: From centralized planning to wholesale markets

Most electricity consumed in the world is produced in large generation plants with diverse technologies. The objective of the lesson is to understand the decision making processes underlying the construction and operation of these plants, and why and how they must be regulated.

Content: Existing approaches to meet the aggregated electricity demand of a power system reliably – with an adequate mix of generation technologies that are operated at minimum production cost – under centralized planning and operation or in a competitive wholesale market. Remuneration of the generation activity under cost-of-service regulation and under market conditions. Regulatory approaches for the remuneration and the implementation of performance incentives in the provision of other generation services: security of supply, operating reserves and voltage control.

Adapting the regulation to cope with the growing presence of variable renewable resources: hydro, wind and solar. Regulatory trade-offs when trying to achieve an adequate generation mix in the transition towards a decarbonized and increasingly industrialised economy in African countries.

This lesson consists of the following modules:

Module 3.1. Technologies for large-scale electricity generation.

Module 3.2. Generation expansion planning and entry.

Module 3.3. Business models for large-scale electricity generation.

Module 3.4. Integration of different technologies in a common generation dispatch. The case of wind and solar.

Lesson 4. Electricity transmission and regional markets

There is a critical lack of transmission infrastructure in the African continent, especially in the interconnections among countries. Transmission regulation is essential to reduce the financial risk of potential investors and to enable efficient power trade at national and regional levels. However, it is the least understood of all aspects of electricity regulation. The aim of this lesson is to provide the solid basis that African decisionmakers need to design and implement sound regulatory solutions.

Content: The regulatory characterization of transmission networks; their physical impact in the operation of the bulk power sector, with technical losses and congestions. Regulatory differences between transmission and distribution and their interplay. Capacity expansion planning: criteria, allocation of responsibility and enforcement, remuneration and business models. Transmission cost allocation and pricing. Accounting for transmission in power system operation at national and regional market levels. Regional power trade and the design of power pools.

This lesson consists of the following modules:

Module 4.1. The technology of electricity transmission

Module 4.2. Transmission expansion planning

Module 4.3. Transmission cost allocation

Module 4.4. Transmission congestion management and system operation.

Module 4.5. Regional power trade and the design of power pools.

Lesson 5. On-grid distribution

Virtually none of the electricity utilities in sub-Saharan Africa are financially viable. This failure is at the heart of the slow progress in access to electricity and the reluctance of potential developers of generation and transmission projects to invest in the absence of creditworthy off-takers for the power to be generated or transported. This lesson provides the criteria for assessing which regulatory and business models are best suited to the specific conditions of each country and/or utility under consideration.

Content: The regulatory characterisation of distribution of electricity using the main grid that is connected to the transmission network and the large generation power plants. The need to regulate this natural monopolistic activity attracting investment, while promoting efficiency and good performance in delivering the service.

The major regulatory topic is designing and implementing the best method to determine a remuneration that reflects the efficient cost of distributing electricity in a particular territory, with an appropriate return on the invested capital, in a situation of manifest asymmetry of information between the regulator and the distribution company. The remuneration approach must be complemented with incentives to maintain prescribed levels of reliability and quality of power supply and customer service, and of technical and commercial losses.

Power distribution with off-grid technologies – minigrids and standalone systems – and the regulatory implications of distributed energy resources – such as rooftop solar, wind and solar farms, fossil fired microturbines, batteries or electric vehicles – will be dealt with in other lessons.

This lesson consists of the following modules:

Module 5.1. The technology of electricity distribution.

Module 5.2. Performance of distribution companies in Africa.

Module 5.3. Distribution remuneration.

Module 5.4. Incentive-based regulation: losses, reliability, quality of service, cost reduction and revenue collection.

Module 5.5. Regulatory and business models for distribution. Distribution concessions.

Lesson 6. Tariff design

Tariff design brings all the regulation topics together and has critical practical importance. Remuneration of the agents that make power supply possible determines their financial viability, and end customer tariffs have important social and political implications. This is perhaps the most characteristic activity of regulatory authorities and this lesson aims to provide course participants with a clear understanding of what this activity entails.

Content: Clarification of the difference between “the regulated *remuneration* of the electricity supplier”, a utility typically, and “the determination of the regulated *tariff*” that the end consumers must pay for the service that they receive. The meaning of “cost of service”, “cost-reflective remuneration” and “cost-reflective tariff”. The differences between “prices” and “regulated charges” and the concept of “residual charges”.

Tariff design comprises two main tasks. First, to determine the “size of the pie”. Description and analysis of all the components that integrate the remuneration of the activities necessary to supply electricity: The contributions of generation, transmission, distribution, commercialisation; the cost of system operation, the regulatory authority, social programs, regulatory support to specific technologies, efficiency and any other costs or charges that the regulator decides that the end customer tariffs must pay for.

Second, to decide how to “slice the pie”. Calculation of the tariff to be assigned to each category of customers, depending on their voltage level, load profile, amount of consumption or contracted capacity. The format of the tariff (lump sum, proportional to the energy consumed, or to the power capacity contracted, variable in time, location dependent, or any other classification criteria, such as the level of income to identify vulnerable consumers). Subsidised tariffs and tariffs cross-subsidisation. Tariffs for customers with demand and also with internal generation and/or storage.

This lesson consists of the following modules:

Module 6.1. Principles of tariff design and basic tariff structures.

Module 6.2. The building blocks: Revenue requirement, end user tariffs, prices, regulated costs, residual charges, and subsidies.

Module 6.3. Electricity tariff design in practice.

Module 6.4. Dealing with distributed energy resources.

Lesson 7. Demand characterisation and energy efficiency

Meeting the demand for electricity is the sole objective of the electricity industry. The aim of this lesson is to understand electricity demand in its multiple dimensions: temporal patterns, sensitivity to price and reliability, the link between electricity and development growth, and

the potential of energy efficiency measures, all in the residential, commercial and industrial sectors. And the potential role of the retailer as a facilitator of beneficial use of electricity.

Content: The relationship between electricity demand and human and economic development, in both directions. Electricity access as an enabler of most of the Sustainable Development Goals.

Characterisation of electricity demand in the African context. Urban or rural, residential, commercial or industrial. Variability, patterns of change, predictability, elasticity to price and the capacity to respond to economic signals. Demand estimation and the underlying factors determining demand. The particular case of demand estimation for future customers yet without access.

The relationship between the reliability and quality of service of electricity supply, the willingness to pay of the customers and the level of consumption. The potential role of the distributor / retailer in stimulating the utilization of electricity for uses with economic, community or personal development and the regulatory implications.

The dual challenge of increasing the consumption of electricity per capita while using energy efficiently. Technologies, business models and regulatory approaches to promote efficiency in the use of electricity.

This lesson consists of the following modules:

Module 7.1. Electricity demand and economic development. Demand estimation.

Module 7.2. Electricity access: the modern energy minimum, productive and community uses. Demand estimation.

Module 7.3. The value of customer engagement, reliability and quality of service. Commercial losses and willingness to pay for electricity.

Module 7.4. The role of energy efficiency.

Lesson 8. Electricity access & off-grid distribution

According to well-known studies, in the least cost electrification plans more than half of Africa's population currently without access to electricity is served by minigrids and off-grid systems. However, most current regulatory and business models for minigrids and off-grid systems in poor rural areas are neither sustainable nor scalable. This lesson focuses on providing participants with an understanding of the basic regulatory frameworks, business model designs and financing approaches needed to achieve sustainability - from both the minigrid and off-grid developer and government perspectives - and scalability in off-grid electrification.

Content: According to the studies indicated above, a very large number of minigrids – between 160K and 200K, with an investment (only) cost of about \$25 billion –and of off-grid solar (OGS) standalone systems – more than 900 million users, at an investment (only) cost of about \$50 billion to achieve at least 300 kWh/year per household or tier 2 – would be deployed in Africa to achieve the goal of universal electricity access in the continent by 2030. Most of the large amount of capital required will have to come from private investors, and this will only be possible if business models for minigrids and OGS systems can be defined that are financially viable and can remain so in the long term, i.e. if the business models are sustainable. It is also necessary that these business models can be scaled up to the required scale, both in terms of the required financing and the technical and managerial capacity of

the developers, to install all the minigrids and OGS systems identified in an electrification plan.

Existing and proposed regulatory and business model approaches are evaluated. The lesson stresses that cost-of-service remuneration, uniform tariffs for on-grid and minigrid customers, targeted subsidies for OGS systems users, a focus on development of the electrified communities, and a long-term integrated financial plan contemplating the three electrification modes, are the key pillars to success of a universal electricity access plan.

The lesson highlights the importance of addressing the electrification process with an integrated perspective in several dimensions: i) jointly considering the three modes of electrification – grid extension, minigrids, and standalone systems – at the planning stage; ii) defining regulatory and business models for each mode that are easily compatible among these modes; and iii) using a single comprehensive approach to finance the entire electrification plan.

This lesson consists of the following modules:

[Module 8.1.](#) Addressing the challenge of electricity access in Africa.

[Module 8.2.](#) Regulation of off-grid electrification.

[Module 8.3.](#) Sustainable and scalable business models and challenges

[Module 8.4.](#) An integrated approach to electrification.

Lesson 9. Current policy issues on clean/just development of the energy sector

The natural gas sector is very important in many African countries, mainly as a fuel for power generation, but also for other uses. The gas sector, like the electricity sector, relies on network infrastructure and therefore requires regulation. It is widely accepted that power generation from gas-fired power plants will be necessary for the industrialisation of many African countries and as a bridge to a future decarbonised economy. Drawing on what has been learnt so far in the course, this lesson aims to introduce the regulation of the gas sector in those aspects that relate to the electricity sector.

The lesson also presents the key elements that need to be considered when making policy and regulatory decisions on the path to electrification, industrialisation and decarbonisation of Africa's energy sector, as well as the current lack of investment and how regulation can be an enabling factor to address this pressing issue.

Content: The relevance of natural gas as an energy vector in Africa, in particular for power generation. A review of the regulation of the gas sector, mainly in relation to the power sector: upstream production, different modes of transport, including liquefaction and regasification facilities, and the use of network infrastructure. Similarities and differences in technical, economic and regulatory requirements with the electricity sector. What to regulate and what not to regulate in the gas sector.

Current key policy issues for energy in Africa in the global context, particularly in relation to climate change and the need for the continent to develop economically but in a sustainable manner.

This lesson consists of the following modules:

[Module 9.1.](#) Regulation of the gas sector: networks.

Module 9.2. Regulation of the gas sector: production and supply.

Module 9.3. Trade-offs in the development of the energy sector in African countries.

Module 9.4. Regulatory support to financing power sector development in African countries.

Lesson 10 Emerging Issues & Course Wrap Up

This final lesson provides an opportunity for course participants to explore emerging issues in the energy sector in Africa, while recognising their importance in the global context. It will also be an opportunity to take stock of the progress made and how much remains to be learned and put into practice.

This lesson consists of the following modules:

Module 10.1. Urbanisation.

Module 10.2. Electronic waste disposal.

Module 10.3. Green hydrogen.

Module 10.4. E-cooking and e-mobility.

Module 10.5. The power utility of the future.

Presential week: Case studies in power sector regulation (optional).

The course concludes with a residential week largely devoted to the discussion of applied case studies, the presentation of some other topics of interest, and a final one-day workshop on equitable and sustainable development of the energy sector in Africa.

Whereas the e-learning part of this training provides the key understanding of the topics covered in the course, it is recommended that course participants consider attending this additional week which gives the opportunity to meet and interact in person, facilitating networking and sharing of experiences. It brings together some of the course instructors and other experts to present and discuss with participants, case studies and experiences that help to understand the practical issues involved in implementing the material covered during the course. Examples may include tariff design in practice, performance incentives in distribution, power purchase agreement contracts, implementation aspects of wholesale electricity market, experiences with private investment in transmission, deployment and operation of sustainable minigrids, allocation of transmission costs in regional markets, distribution concession contracts, implementation aspects of energy efficiency measures or financial plans for national electrification strategies.

Course Organisation

This section expands on what has been already introduced in the first part of the present document.

Structure of the lessons

A lesson comprises:

- An **introductory (video or podcast)** with the justification of the relevance of the topic, a brief overview of its content and the presentation of the objectives to be achieved by the participants by the end of the lesson.
- Several **video lectures** of about 10 minutes in duration. Several of the videos will include polls and questions which participants can engage in. All video lectures have transcripts available in PDF, with subtitles and transcripts in other languages. The main language of the course is English.
- **Required readings** will be provided for each lesson. These are foundational to understanding the topic concepts in each lesson and complement the video lectures.
- **Optional readings** (and links to relevant podcasts and/or videos) are provided for participants who would wish to learn more on the theme of the Lesson.
- **Discussions forum** typically involving participants responding to a question posed in the discussion forum within the e-learning platform. The forums also provide participants with the opportunity to engage with each other's contributions.
- **Live classes** are held at least once every two weeks and will comprise the live interactions with the course instructor to answer questions posed by course participants or clarify on aspects of the course content.
- A **self-assessment test** is provided at the end of each lesson with multiple choice and 'true/false' questions. An explanation for each answer is provided. A minimum mark must be achieved to pass the test, but there is no limit to the number of times a participant can take it.
- Participants may undertake an individual **Course Project**, which will be based on a topic to be provided by the course instructor.

Activities and evaluation policy

Course participants may take the course at various levels with the corresponding certificates, and with the following estimated time commitments:

- 1) **Investigator Level.** 3-4 hours per week, devoted to learning and understanding the course content by watching the video lectures, reading the required texts and take the weekly test.
- 2) **Advocate Level.** 4-6 hours per week, corresponding to adding to the investigator level the participation in the discussion forums and/or live classes.
- 3) **Master Level.** 6-8 hours per week, corresponding to adding to the advocate level the delivery of a Course Project.