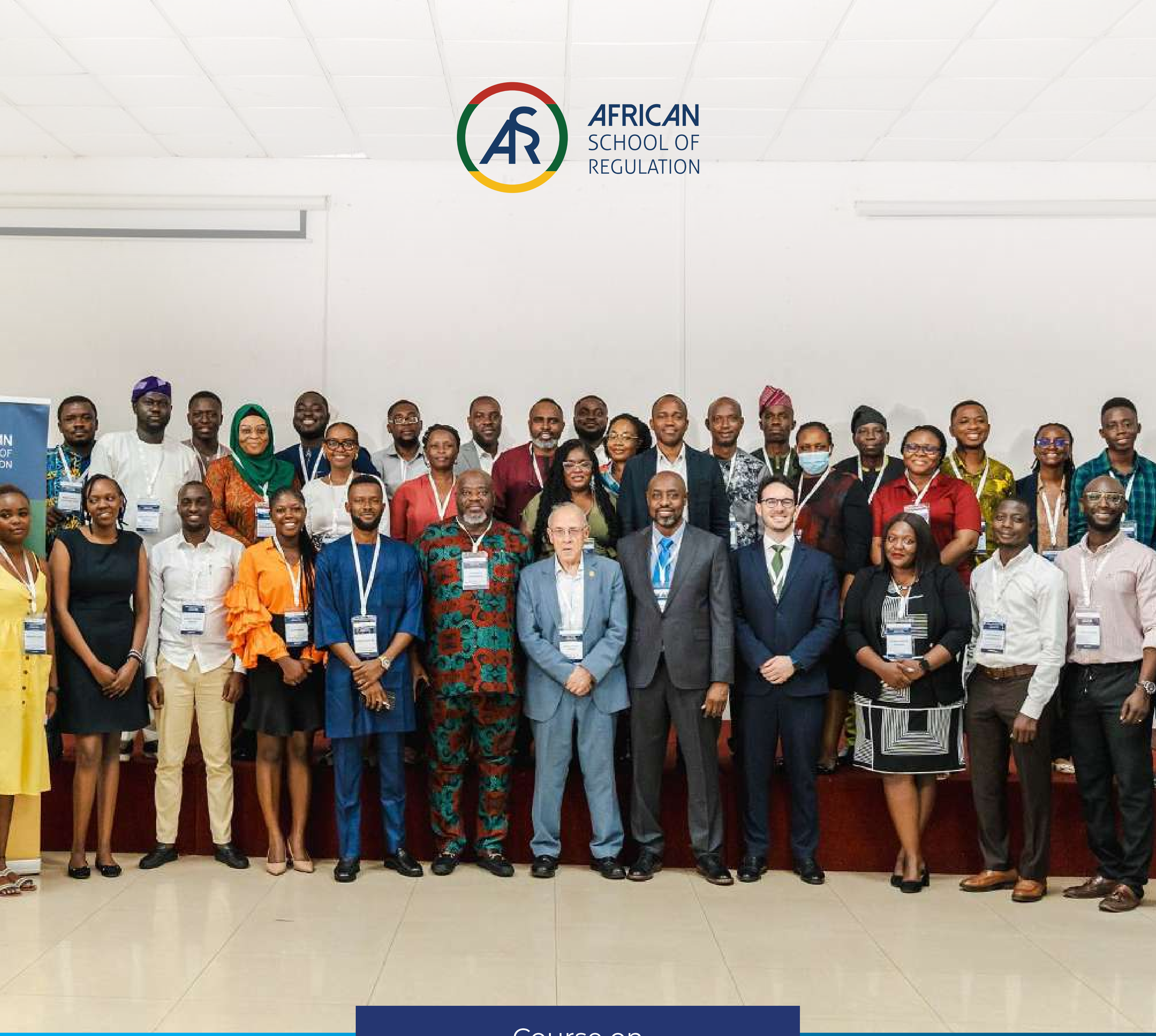


AFRICAN SCHOOL OF REGULATION

Course on

Power Sector Regulation in Africa

Starting date:

Monday March 23rd, 2026.

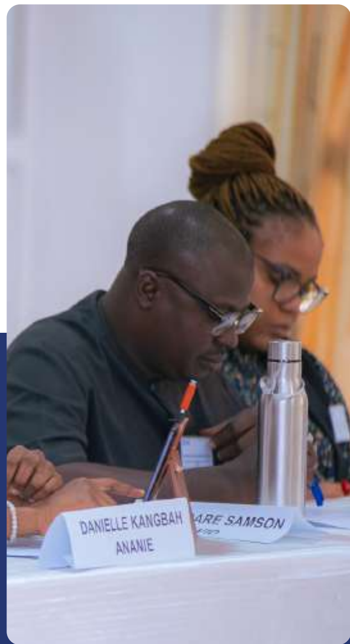
Objective

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.

Language

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



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 twelve 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 (Online)

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 ten lessons covering a specific thematic area. Each week begins with a brief podcast introducing the objectives for the lesson and the main topics to be covered. The learning contents are 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.

Each lesson will have a live class (office hour) with one of the lesson's instructors. This gives the participants an opportunity to ask questions and learn from experts. Additional live session (doubt-clearing session) with the course director and/or relevant guest experts will also be organised to clarify doubts on the content that has been presented in the lesson. Quizzes will be provided to enable participants to test their level of understanding of the lesson's learning material.

A key feature of the e-learning experience is the inclusion of interactive tools that bring theory to life. Notably, participants will engage with an electricity market simulation developed by Stanford University. This hands-on component allows learners to experience bidding, dispatch, and settlement in a simulated wholesale market environment, deepening their understanding of how electricity markets function in practice.
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 session 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.

Price

$1450 for the online course.

$950 for the optional one-week in-person training in Accra (this price does not include travel, accommodation and subsistence costs, but it includes lunches, social dinner and any other social activities).

Registration period | December 11, 2025 (00:00) to March 13, 2026 (24:00)

Discounts

Each discount applies separately and cannot be used in conjunction with others.

Early Bird:
10 % reduction for participants who complete registration by January 16, 2026 (24:00).

Group Offer:
10 % reduction for organisations registering five or more participants together in a single coordinated submission by March 06, 2026 (24:00).

Alumnus:
10 % reduction for alumni of ASR courses; valid until March 06, 2026 (24:00).

Student Fee:
$ 400 for participants who provide proof of current student status.
Please note that only one discount may be applied per participant.

Course Content

Introduction to the Course (Lesson 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 lessons 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.

Lessons. The introductory 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. Office hours or live classes 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 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.

Lesson coordinator: Daniella Ngarambe, African School of Regulation.

The lesson consists of four modules:

Module 1.1. Traditional vs. market-based regulation. Opposite or complementary?

- The "traditional" business model for the power sector that prevailed globally before 1990 was challenged by a new regulatory approach, the so-called "standard" model, which is open to competition.
- Traditional power sector regulation. The transition to market-based regulation.
- Market-based regulation of the power sector. The standard model.
- The debate regarding whether these two approaches conflict or complement each other.

Instructor: Peter Twesigye (Power Futures Lab/University of Cape Town).

Module 1.2. Power systems in developing countries.

- Countries around the world have responded in different ways to the power sector reform that was adopted by many countries in the world in the 1990s and 2000s, depending on a variety of factors.
- Some common patterns can be identified in developing countries, most of which have not fully - or not at all - adopted the standard model.

Instructor: Peter Twesigye (Power Futures Lab/University of Cape Town).

Module 1.3. Development of the power sector in Africa. The African way.

The focus is placed now on African countries and the present situation.

- The current structure and organisation of the power sector in African countries. The different patterns of partial adoption and departure from the standard model.
- Sources of generation and level of development of generation, transmission and distribution infrastructures. Interconnections among countries. Level of electricity access.
- Present trends. Lessons learned.

Instructor: Peter Twesigye (Power Futures Lab/University of Cape Town).

Module 1.4. The power sector within the broader energy sector.

- Energy transformations in Africa, from primary energy to energy utilisation. Energy resources. The contribution of the power sector.
- Energy trends in Africa today. Demand growth. Renewables. Urbanisation. Industrialisation. Heating and cooking. Transport. Urban versus rural areas.
- Global challenges: climate change, universal energy access, industrialisation.

Instructor: Rita Madeira (International Energy Agency, IEA)

Office hour. Pros and cons of following the “standard model” in developing countries.

Readings, Self-assessment test, Forum.

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.

Lesson coordinator: Charly Gatete, African School of Regulation.

This lesson consists of four modules:

Module 2.1. Principles and approaches of economic regulation.

- What is regulation? The rationale of regulation.
- Classical regulation of public utilities: control of entry, price fixing, prescription of quality and conditions of service, and obligation to serve under reasonable conditions.
- Deregulation and the limits that result from the characteristics of the activities involved in the electricity supply chain and the actual size, structure and ownership of the electricity sector.

Instructor: Geoffrey Mabea (Energy Regulators Association of East Africa).

Module 2.2. Regulatory institutions.

- Energy policy and power sector regulation. The hierarchy of legal instruments.
- The role of governments, regulatory authorities, national agencies (rural electrification, planning, others), and multinational organisations.
- Regulatory authorities: functions, independence, executive power, responsibilities, transparency, accountability.
- Implementation. Regulation in theory and in practice.

Instructor: Geoffrey Mabea (CEO, COMESA Secretariat).

Module 2.3. Economic regulation of monopolistic activities. Cost of service regulation.

- Natural monopolies of public goods and services, and the need for regulation.
- Determination of the regulated remuneration of a monopolistic activity. Overcoming the information asymmetry. Tenders, cost standardisation, benchmarking, computer models. The implicit incentives in every approach.
- The efficient cost of service – subject to prescribed performance conditions – as the guiding principle. CAPEX and OPEX. The rate base. The cost of capital. The standard method to determine the revenue requirement.

Instructor: Peter Twesigye (Power Futures Lab/University of Cape Town).

Module 2.4. Incentive-based regulation. The RPI–X method.

- The incentives behind any remuneration method. The design of adequate incentives to improve the efficiency and the performance of distribution operators. Review of performance-incentive methods.
- The RPI–X method. How to handle its strong and weak features when applying it to the regulation of electricity distribution.

Instructor: Peter Twesigye (Power Futures Lab/University of Cape Town).

Office hour. Review of relevant regulatory topics: from the executive power of regulatory authorities to the difficulties of regulating natural monopolies.

Readings, Self-assessment test, Forum.

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 are 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. The course will include hands-on practice using an electricity market game developed by Stanford University, allowing participants to experience bidding, dispatch and settlement in a simulated wholesale market environment.

Lesson coordinator: Nutifafa Fiasborgor, African School of Regulation.

This lesson consists of four modules:

Module 3.1. Technologies for large-scale electricity generation.

Historical, economic, technical and strategic reasons that explain the present mix of generation technologies in each country.

- Technical and economic characterisation of the diverse large-scale generation technologies that are present in African countries and worldwide.
- Complementarity of these diverse technologies to meet the demand reliably and efficiently.

Instructor: Carol Ofafa (African School of Regulation).

Module 3.2. Centralised planning versus marked-based individual decision making.

- The least-cost generation mix to meet electricity demand under short and long-term perspectives.
- Centralised planning and market-based decision making as alternative approaches to meet global social objectives.

Instructor: Keno Shiferaw (African School of Regulation)

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

Traditional cost-of-service and market-based regulation are the two main alternative approaches, with competition for entry via a power purchase agreement (PPA) as a middle ground.

- Long-term contracts in wholesale electricity markets.
- The role of power purchase agreements in the power systems of African countries.

Instructor: Nnaemeka Ewelukwa (Nigerian Bulk Electricity Trading Plc).

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

- Operation of power systems with large penetration of wind and solar generation. Representative case examples.
- The need for flexibility. Characterisation of flexibility resources in demand, supply and storage.

Instructor: Henry Odedeh (Kenya Electricity Transmission Company, KETRACO)

Office hour. The experiences of System Operators of systems with a very diverse generation mix including variable renewables. The cases of the WAPP and Spain.

Readings, Self-assessment test, Forum.

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.

Lesson coordinator: Carol Ofafa, African School of Regulation.

This lesson consists of the following modules:

Module 4.1. Electricity transmission: Technical, economic and regulatory characterisation.

- The physical, economic and regulatory implications of the transmission network: technical losses and operation constraints.
- The cost of the transmission activity.
- Regulatory characterisation of the activity of electricity transmission. Transmission as a natural monopoly: economies of scale and market power.
- The situation of the infrastructure for the transmission of electricity on the African continent.

Instructor: Henry Odedeh (Kenya Electricity Transmission Company, KETRACO)

Module 4.2. Transmission expansion planning.

- The allocation of responsibilities and criteria for transmission expansion planning.
- The golden rule of transmission expansion planning under cost-of-service and market-based regulation. Responsibility for transmission expansion planning: the interplay between the (transmission) system operator and the regulator.
- The importance of transmission under market-based regulation. The need for an independent system operator. Arguments for and against unbundling

transmission ownership and system operation.
- Business models for investment in transmission. The role of private investment in transmission.

Instructor: Chris Flavin (Gridworks).

Module 4.3. Transmission cost allocation.

- The allocation of transmission costs is relevant and linked to other aspects of transmission regulation.
- The sound principles identified by experts, which are not universally followed, are: i) beneficiaries pay; ii) transmission charges must not be linked to commercial transactions; iii) transmission charges must be announced ex ante with sufficient advance notice; iv) the format of the transmission charges is important.
- Experience in implementing these principles and pragmatic guidelines for implementation.

Instructor: Mohamed El Abbas (Comillas University).

Module 4.4. Transmission congestion management and system operation.

- The optimal load flow as a guide to efficient power system operation.
- Physical bilateral contracts, security of supply, efficiency distortions and how to avoid them.
- Transmission rights, the creation of “congestion rents” and how to use them.

Instructor: Stephen Dihwa (Southern African Power Pool – SAPP Coordination Centre).

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

Regional power trade as an extension of power system operation at national level, with additional complications.

- An additional principle: the “single system paradigm”. Implications.
- Regional institutions: the regional regulatory authority and the coordination of regional system operation and transmission planning.
- Security of supply from a regional perspective versus national sovereignty in generation adequacy.
- Cost allocation of new cross-border transmission investments and the regional transmission grid.
- Review of the African power pools and best international experiences.

Instructor: Instructor: Mohamed El Abbas (Comillas University).

Office hour. Office hour: The Africa Continental Master Plan. Current status and expected outcomes.
Readings, Self-assessment test, Forum.

Lesson 5. On-grid distribution

Virtually none of the electricity utilities in sub-Saharan Africa is 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.

Lesson coordinator: Keno Shiferaw, African School of Regulation.
This lesson consists of the following modules:

Module 5.1. Electricity distribution: Technical, economic and regulatory characterisation.

- Regulatory characterisation of the activity of electricity distribution. Distribution as a natural monopoly. Retailing (or commercialisation) is a different activity, although frequently performed by the same company. The physical, economic and regulatory implications of the distribution network: large number of assets, reliability, quality of service, technical and commercial losses, and distributed energy resources.
- Some notes on the regulatory characterisation of retail.

Instructor: Peter Twesigye (Power Futures Lab/University of Cape Town).

Module 5.2. Performance of distribution companies in Africa.

This module will focus on the situation of the distribution activity in sub-Saharan Africa.

- The situation of distribution companies – or the distribution segment of vertically integrated companies – on the African continent: financial deficit, technical performance and progress in providing access.
- A vicious cycle: regulated tariffs below costs; non-financially viable distribution companies; lack of investment and poor service; unhappy customers; theft, unpaid bills, back-up generation and grid defection; more deficit.

Instructor: José Guerra (Smarteec)

Module 5.3. Distribution remuneration.

- The cost of the distribution activity. Asymmetry of information between the company and the regulator. The need for a dependable method to estimate the efficient cost of the distribution activity.
- A review of methods to estimate the efficient cost of the distribution activity. Application of the RPI-X method.
- The regulatory approach to determine the regulated revenue requirement.
- Challenges to the remuneration method derived from the substantial presence of distributed energy resources (DERs).

Instructor: Peter Twesigye (Power Futures Lab/University of Cape Town).

Module 5.4A. Regulatory and business models for distribution.

- The financial situation of the utilities – and the distribution segment in particular – in sub-Saharan Africa.
- Performance-based regulation: reliability, quality of service and losses, both technical and commercial.

Instructor: Peter Twesigye (Power Futures Lab/University of Cape Town)

Module 5.4B. Regulatory and business models for distribution. Case example.

- New approaches for on-grid distribution. The case of Premium Grids in Nigeria.

Instructor: José Guerra (Smarteec)

Module 5.5. Distribution concessions.

- The concession business model. Different types of concessions. Focus on full concessions and “affermage” (responsibility on operation, maintenance, revenue collection and small routine investments).
- Review of concessions for electric utilities in Africa and other international experiences.
- Conditions for the successful utilisation of distribution concessions in sub-Saharan Africa.

Instructor: Christian de Gromard (former Energy Advisor, French Development Agency, AFD).

Office hour. Experience with distribution concessions in Africa.

Readings, Self-assessment test, Forum.

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.

Lesson coordinator: Nutifafa Fiasborgor, African School of Regulation.

This lesson consists of the following modules:

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

- The "regulated revenue requirement" of electricity supply. Cost reflectiveness of the revenue requirement and the viability of the electricity supply company.
- The "end-customer electricity tariffs". The principles of end-customer tariff design: economic sustainability, equity (i.e., non-discrimination), economic efficiency, transparency, stability and simplicity. Compatibility of the principles and priority among them.
- "Integral tariffs" versus just "access tariffs" when the end-customers have the freedom to choose their electricity supplier.

Instructor: Mohamed Fayed Hendam (EgyptERA)

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

- The structure of the tariff: Differentiation by time, voltage, usage and/or location. Energy ($/kWh), capacity ($/kW) and fixed ($) components of the tariff.
- The components of the end-customer tariff: The energy component. Differences between market-based and cost-of-service regulation. Price versus cost of energy.
- The components of the end-customer tariff: The distribution and transmission regulated network charges.
- The components of the end-customer tariff: Other regulated charges.
- Addition of components to build the integral tariff and the access tariff consistently with the adopted tariff structure.

Instructor: Mohamed Fayed Hendam (EgyptERA)

Module 6.3. Electricity tariff design in practice.

- Consistency between the structure adopted in tariff design, the existing metering devices and the expected response of the end-customers. Recommended simplifications.
- The importance of the final allocation of the cost to the volumetric energy component ($/kWh), the capacity component ($/kW) and the fixed component ($/month).
- Justification of tariff subsidies and cross-subsidisation. Tariff subsidies and cost reflectiveness of the end-customer tariffs.

Instructor: Mohamed Fayed Hendam (EgyptERA)

Module 6.4. Dealing with distributed energy resources.

- Distributed energy resources modify the cost of the distribution activity and the methods to estimate the efficient distribution revenue requirement.
- Pragmatic approaches to deal with these challenges. Some mistakes to be avoided. The case of net metering.

Instructor: Mohamed Fayed Hendam (EgyptERA)

Office hour. Adapting power sector regulation to the presence of distributed energy resources. Distribution remuneration, tariff design and participation in markets.
Readings, Self-assessment test, Forum.

Lesson 7. Demand characterisation and energy efficiency

Meeting the demand for electricity is the objective of the power sector. 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.

Lesson coordinator: Kokou Amega, African School of Regulation.

This lesson consists of the following four modules:

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

- The mutual relationship between electricity demand and human and economic development. Electricity access as an enabler of most of the Sustainable Development Goals.
- Characterisation of electricity demand in some representative African contexts. Breakdown of total demand into the residential, commercial and industrial components. Urban and rural demand.
- Demand estimation and the underlying factors determining demand. Current estimates of electricity demand growth in Africa and African countries.

Instructor: Stephen Lee (Massachusetts Institute of Technology, Center for Energy and Environmental Policy Research)

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

- The situation of electricity access in African countries. The difference between urban and rural areas.
- The particular case of demand estimation for future customers yet without access.
- The definition of electricity access. The multi-tier framework. Minimum conditions for an "acceptable" access. The definition of a modern energy minimum and its dependence of the specific context.
- Accounting for the demand of productive and community uses in rural communities still lacking access. Demand elasticity to price and the capacity to respond to economic signals.

Instructor: Nico Peterschmidt (INENSUS)

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

- The relationship between the reliability and quality of service of electricity supply, the willingness to pay of the customers, the level of consumption and the volume of illegal connections and nonpaid bills.
- Successful experiences with engagement with the end customers and the communities, in particular rural communities and deprived peri-urban communities.
- 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. Successful experiences.

Instructor: Rose Mutiso (Energy for Growth)

Module 7.4. The role of energy efficiency.

- The potential of energy efficiency measures in the residential, commercial and industrial sectors. Technologies, business models and regulatory approaches to promote efficiency in the use of electricity. Best practices and successful experiences.
- The dual challenge of increasing the usefulness and consumption of electricity per capita in poor rural communities with recent access to electricity, while using energy efficiently. Facilitation of the acquisition of efficient appliances.

Instructor: Fenwicks Musonye (Energy & Petroleum Regulatory Authority, Kenya)

Module 7.5. Access to electricity enabled services: productive and community uses.

- The potential of customer engagement in the adoption of measures to promote the efficient and effective utilisation of electricity for residential, commercial and industrial customers in “the last mile” of on- and off-grid rural distribution.
- Technologies, business models and regulatory approaches to promote productive and community uses of electricity in rural areas.
- Best practices and successful experiences.

Instructor: Sumaya Mohamed (Power Africa Empower East and Central Africa, EECA; RTI International)

Office hour. Beyond access. Electricity access as enabler of demand growth for human and economic development.

Readings, Self-assessment test, Forum.

Lesson 8. Electricity access & off-grid distribution

According to well-known studies, least cost electrification plans estimate that more than half of Africa's population currently without access to electricity should be served by minigrids and off-grid systems in addition to the traditional approach of extending the main grid. 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, 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. However, most current regulatory and business models for minigrids and off-grid systems in poor rural areas are neither sustainable nor scalable and most distribution companies in countries without universal electricity access are in a dire financial situation.

Content: This lesson presents an approach – the integrated distribution framework, IDF – that addresses the electrification process from a holistic perspective – jointly considering the three modes in the least cost technoeconomic plan and in the financial plan – and adhering to a few solid principles that guarantee universal access, the efficient integration of the electrification modes, overall and individual financial viability, and a focus on community development.

For the implementation of these principles, 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 technoeconomic planning stage; ii) defining regulatory and business models for each mode that are easily compatible with the other modes; and iii) using a single comprehensive approach to finance the entire electrification plan.

Suitable regulatory and business models for grid extension were examined in lesson 5, with a special focus on distribution concessions. This lesson completes the job, by 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.

Lesson coordinator: Daniella Ngarambe, African School of Regulation.

This lesson consists of the following modules:

Module 8.1. The integrated distribution framework, IDF.

- IDF principles for the last-mile component of a comprehensive national electrification strategy, whose purpose is to achieve universal electricity access by a reasonable deadline.
- The implementation of these principles to define i) what must be done and at what cost, ii) who must implement the plan and with what regulatory and business models and iii) how to finance the plan.
- Key regulatory aspects: remuneration anchored in cost-of-service principles, unified tariffs for on-grid and minigrid customers, cross-subsidisation inter electrification modes, focus on the development of electrified communities, and a long-term comprehensive financial approach.

Instructor: Ignacio Pérez-Arriaga (African School of Regulation).

Module 8.2. Least-cost integrated electrification planning.

- The need for a computer-aided and geospatially-based least-cost electrification plan for the entire national territory that integrates on- and off-grid modes of electricity supply to end customers: a techno-economic electrification plan.
- A techno-economic electrification plan must determine the least cost mix of grid extension, mini-grids and standalone systems that will supply each individual customer, deployed over several years until complete electrification is achieved, with complete information on bills of materials and costs, broken down to any desired level of detail.

Instructor: Andrés González (Waya Energy and MIT-Comillas Universal Energy Access Lab).

Module 8.3. Regulation for sustainable and scalable minigrid business models.

- The design of regulatory frameworks that enable sustainable and scalable business models for electricity supply with minigrids. Cost-reflective remuneration, affordable tariffs and subsidies. Tariff cross-subsidisation and other methods to achieve affordable tariffs. Concessions for minigrids.
- Approaches to facilitate the integration of minigrids with the other electrification modes. Minigrids under the grid.
- Minigrids for productive and community uses.

Instructor: Irene Calvé (Sustainable Energy for All)

Module 8.4. Regulation for sustainable and scalable business models for OGS standalone systems.

- The design of regulatory frameworks that enable sustainable and scalable business models for electricity supply. Cost-reflective remuneration, affordable tariffs and subsidies. Tariff cross-subsidisation and other methods to achieve affordable tariffs. Concessions for OGS standalone systems. Energy-for-service versus rent-to-own approaches.
- Approaches to facilitate the integration of OGS systems with the other electrification modes.
- OGS systems for productive and community uses.

Instructor: Collin Gumbu and Patrick Tonui (Global Off-Grid Lighting Association - GOGLA)

Module 8.5. An integrated electrification financial plan.

- Ensuring financial viability from the viewpoint of the developers of off-grid solutions, the incumbent discos and the government as ultimately responsible for the viability of the plan.
- The governmental perspective and the necessary integration of financing the three electrification modes.
- The utilisation of blended finance and the long-term view of a financial plan. The feedback loops with the techno-economic plan and the regulatory and business

Instructor: Santos Díaz Pastor (Institute for Research in Technology, Comillas University)

Office hour. Regulation to enable sustainable and scalable business models for off-grid electrification. A panel discussion with practitioners.

Readings, Self-assessment test, Forum.

Lesson 9. Current policy issues in the development of the energy sector in Africa. The case of natural gas.

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.

Content: Description of the industry of production, delivery and consumption of natural gas from an engineering and economic perspective. Drawing on what has been learnt so far in the course, this lesson introduces the regulation of the gas sector in those aspects that relate to the electricity sector.

The lesson also presents the key aspects to consider when making policy and regulatory decisions on the path to electrification, industrialisation and decarbonisation of the energy sector of African countries, and the role that natural gas can play in this process.

Lesson coordinator: Charly Gatete, African School of Regulation.

This lesson consists of the following modules:

Module 9.1. Introduction to the natural gas sector in Africa.

- The relevance of natural gas as an energy vector in Africa, in particular for electricity generation and for direct final consumption.
- A review of natural gas industry: upstream production, different modes of transport including liquefaction and regasification facilities, the use of network infrastructure and the demand for natural gas. 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.

Instructor: Obindah Gershon (Centre for Economic Policy & Development Research (CEPDeR), Covenant University).

Module 9.2. Regulation of the natural gas sector: networks.

- Transmission: regulatory characterisation, planning, investment and business model, remuneration, operation, access, capacity and cost allocation. Centrally planned versus market oriented approaches. Same in a regional context. Regulatory treatment of liquefaction, regasification and storage facilities.
- Distribution: regulatory characterisation, business model and remuneration, performance incentives, operation and access.
- Safety standards. End user tariff design. Integration of low carbon gases in the natural gas network.

Analogies with the power sector are used when appropriate.

Instructor: Sergio Ascari (Florence School of Regulation).

Module 9.3. Regulation of the natural gas sector: production and supply.

- Production (upstream): Licensing and exploration. Environmental compliance and safety standards. Market entry and exit, pricing mechanisms, and antitrust concerns.
- Supply (downstream): Market structure and competition issues. Gas prices and end consumer tariffs. Gas quality standards. Consumer protection and service standards.

Analogies with the power sector are used when appropriate.

Instructor: Sergio Ascari (Florence School of Regulation).

Module 9.4. Trade-offs in the development of the energy sector in African countries.

- Economic benefits (revenue from exports, job creation, industrialization) versus environmental impact (greenhouse emissions, contamination).
- Utilisation in clean cooking (health and deforestation benefits) as alternative to or in competition with electric cooking versus the environmental impact of greenhouse emissions.
- Energy security in electricity production for countries with natural gas resources versus volatility of gas market prices. Consideration of natural gas as a necessary transition fuel towards a decarbonised economy.
- Balancing these trade-offs requires careful planning, effective regulation, responsible corporate practices and engagement with any affected local communities.

Instructor: Rita Madeira (International Energy Agency, IEA)

Office hour. Experts in each field compare the regulations of electricity and natural gas.

Readings, Self-assessment test, Forum.

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.

Lesson coordinator: Crispin Beteryeb, African School of Regulation.

This lesson consists of the following modules:

Module 10.1. Urbanisation.

- Present data and estimates of future trends of urbanisation in African countries.
- Implications for the provision of basic services – water supply and sanitation, electricity, energy for heating and cooking, health, education. Challenges and opportunities.
- Experiences with electrification in peri-urban areas in African countries. Lessons learned.

Instructor: RES4Africa Foundation.

Module 10.2. Quality, interoperability and e-waste management.

- The relevance of quality standards in the off-grid solar systems and appliances. The provision of quality assurance via product certification.
- Interoperability. The lack of connector standards. The multiple advantages of a universal connector and software for SHS kits and appliances.
- Quality standards and interoperability reduce e-waste. Barriers to e-waste management. The need for regulation and the development of modern e-waste recycling infrastructure. Recycling. Successful experiences.

Instructor: Rebecca Rhodes (GOGLA).

Module 10.3. Green hydrogen.

- Integration of green hydrogen into national energy plans, focusing on sustainability, compatibility with renewable development, economic growth, and energy security.
- Environmental regulations during production: water usage and land impact. Standards for storage, transportation, and utilization.
- Regulatory support mechanisms: tax breaks, subsidies, or favorable tariffs for green hydrogen production and use.

Instructor: Eng. Nickson Bukachi Ongeri (AFREC).

Module 10.4. E-cooking.

- Consequences of traditional cooking methods
- Appraisal of the present situation in African countries.
- Potential of e-cooking and its regulatory implications. Experiences.

Instructor: Martha Wakoli (Manager, CLASP)

Module 10.5. E-mobility.

- Consequences of transportation based on fossil fuels.
- Appraisal of the present situation in African countries.
- Potential of e-mobility and its regulatory implications. Experiences.

Instructor: Mohamed Fayed Hendam (EgyptERA)

Module 10.6. Regulation for electric appliances.

- Promoting appliance energy efficiency.
- Appliance quality assurance.
- The role of regulation.

Instructor: Martha Wakoli (Manager, CLASP)

Office hour. Young African leaders present and discuss in a panel what they expect of the future African power sector and what is needed to achieve their goals.
Readings, Self-assessment test, Forum.

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.