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GEOTHERMAL TRAINING PROGRAMME



ELECTRICITY MARKETS

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ABSTRACT

This document addresses the evolution of the electrical systems, which have been designed initially from being a vertically integrated monopolized system (usually property of the state) to being a diverse set of public and private systems. In general, generation and commercialization are carried out by competition, while transmission and distribution require the regulation from the state. The evolution of the systems requires special attention due to the challenges currently presented by distributed generation and the interconnection between different systems that need to be harmonized.

1. FROM MONOPOLIES TO COMPETITIVE MARKETS

Due to the importance and strategic role of the electrical sector for the development of the economy, the state has assumed the responsibility in the development of electrical systems since the first half of the 20th century.

In most cases, the local, state, or national governments are responsible for the electrical supply of the countries. One of the most important cases is the Tennessee Valley Authority created in 1933 to develop the hydroelectric resources; however, it is recognized for its role in the generation and distribution of electrical power, making it one of the most famous government initiatives pioneering in large-scale electrical systems.

During most of the 20th century, the governments envisioned the electrical supply as a challenge for development and therefore facilitated the construction of large hydroelectric projects (many of which would be difficult to develop by private companies) requiring agreements between various governments since these were located on the border among different countries.

Large generation projects usually far from the center of consumption made it necessary to develop an increasingly, large transmission network (with higher levels of electrical tension), which made it possible to interconnect different systems that had previously operated individually. At the same time, the growth of cities and the interest in electrification of urban and rural areas opened the doors to the development of distribution systems.

As a result of the 2nd world war, the development of nuclear energy for the generation of electricity in the 60's and 70's, especially after the oil crisis, forced many governments to develop policies aimed at reducing dependence on fossil fuels. The large capacity of nuclear power plants and the technological

difficulties inherent to the modulation of the generation led to the construction of pumping stations that took advantage of surplus generation during off-peak hours.

However, much of the growth in demand was supplied by coal and then natural gas, especially when significant pipeline transportation projects were developed.

In the 80's, most state enterprises had few resources to invest in the energy sector. Many of them were indebted due to recent large generation projects, which together with the fiscal deficit of many governments (especially those in Latin America) led to a radical change in the development of the electrical systems, allowing the participation of the private sector.

During the last decade of the 20th century, the liberation of many electricity markets was initiated by Chile and followed by Latin America, Europe, and the USA. The liberation was linked to a full or partial privatization of the assets that were owned by the state and the vertical management of firms.

In this new context, the generation and commercialization of electrical system are carried out under free market conditions, while the operation of energy transmission and distribution are usually monopolized and regulated by the state, creating geographic limit in some cases.

At the same time, consumers in the retail market have the freedom to choose between different suppliers in order to select the one that provides the greatest added value.

The new structure requires a manager of market transactions known as Market Manager, who is responsible for receiving bids from vendors and buyers of energy in order to establish an efficient offer for both energy and established auxiliary services.

Furthermore, the System Operator is responsible for the technical coordination in order to ensure the physical completion of transactions as well as quality control and safety. Both the Market Manager and the System Operator are usually entities independent from the other participants.

Figure 1 shows the breakdown of the various activities of the electricity sector in cases where there is a vertically integrated monopoly versus a competitive market (with several participation of different sectors in order to generate competition).

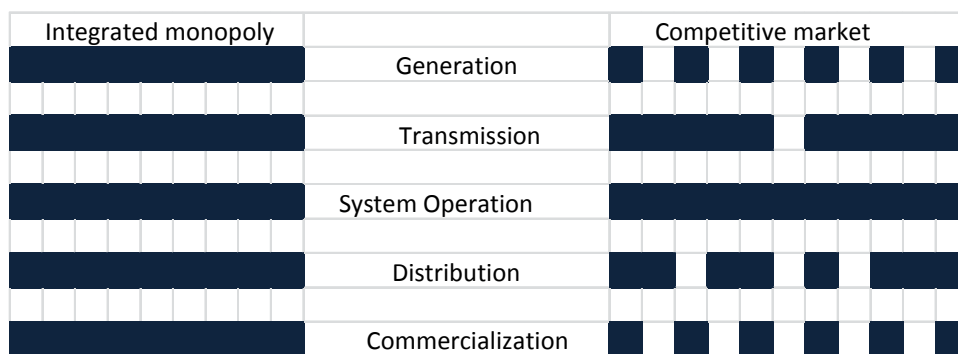


FIGURE 1: Breakdown of activities in the electric sector

The deal among different systems corresponds mostly to economic transactions, rather than a relation to their quality and safety. International trade regulations are established and transmission network management restrictions are established for this purpose.

2. ACTIVITIES DEVELOPED IN COMPETITION

For a liberated market to function properly, the participation of various competitors is necessary which brings about the establishment of prices. Due to the fact that there were few firms involved in the electric industry and in many cases they were vertically integrated, it was necessary to dissolve the existing firms and allow the participation of new sectors.

2.1 Generation

In electricity markets, the various generators must compete with each other through a bidding process scheduled for a short term, in which those offering lower prices or lower production costs will end up selling electricity. The bidding process is usually carried out on an hourly basis. In some cases, economic performance may be affected by technical restrictions of the units, transmission, energy quality conditions, security for the system, etc.

The efficiency and the development of cheaper technologies is promoted with this model, thus favoring the construction of large capacity plants to obtain lower production costs.

In today's electricity markets, there are some systems with pricing models. In this case, the electricity generating companies (or generators) present the required price for each of its generating units to the Market Administrator, with the freedom to define their offering price. This type of model works successfully where there is an abundance of competition and therefore, generators offer a price close to their variable costs of production in order to avoid being displaced by other generators.

On the other hand, there are systems that operate under cost-based production, in which case the generator is subjected to an audit of costs, and the variable cost of production is defined usually associated with energy models as well as operation and maintenance of their equipment. There are usually periodic adjustments based on changes in fuel prices as well as inflation, in which case, there is only a declaration of availability from generators, because its sale offer is conditioned to the value resulting from the audit.

In both cost and price markets, the Market Administrator defines the market "spot" price as the last unit to meet the demand, following the merit order of price/cost. This value is used to compensate to all generators and simultaneously charge buyers in the market.

The establishing of price is based on classical economic theory developed in the 19th century, which in a perfectly competitive economy, the marginal cost of production is equal to the product price, maximizing social well-being for sellers and buyers. This requires establishing a supply and an associated demand curve, as indicated in Figure 2, the point of intersection being the equilibrium point where the price of the good is defined.

This results in maximizing social welfare, which corresponds to the sum of producer surplus plus consumer surplus. Producer surplus is understood as the difference between what the producer actually receives (price P) and what it costs producing goods (supply), while consumer surplus is defined as the difference between what the consumer is willing to pay (demand) and what he pays for the goods (price P).

Although this economic logic has been applied to electricity markets to define the hourly price of electricity, one important detail is that consumers

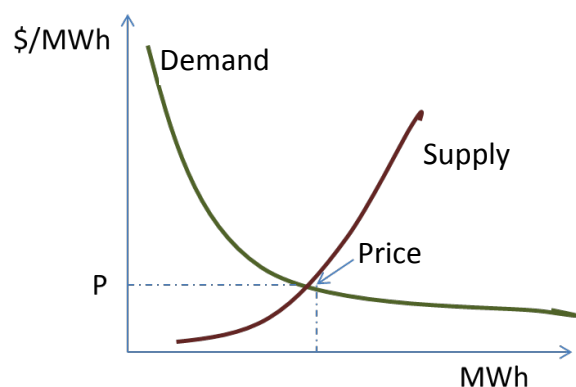


FIGURE 2: Supply and demand curves

don't have prior knowledge or the possibility of an option to purchase electricity which has limited behavior, i.e. it does not immediately change its behavior with regards to the response to changes in the price.

Marginal prices from 2003 to 2013, for some Central American countries are shown in Figure 3. All countries have experienced an increase in spot prices due to international oil prices, due to Central America's power system has a large dependence to bunker.

Related to the spot market, various types of bilateral medium and long-term contracts are established in which there is a free deal between the demand and generation. Agents who can trade in these markets are generators, authorized consumers, traders, and distributors.

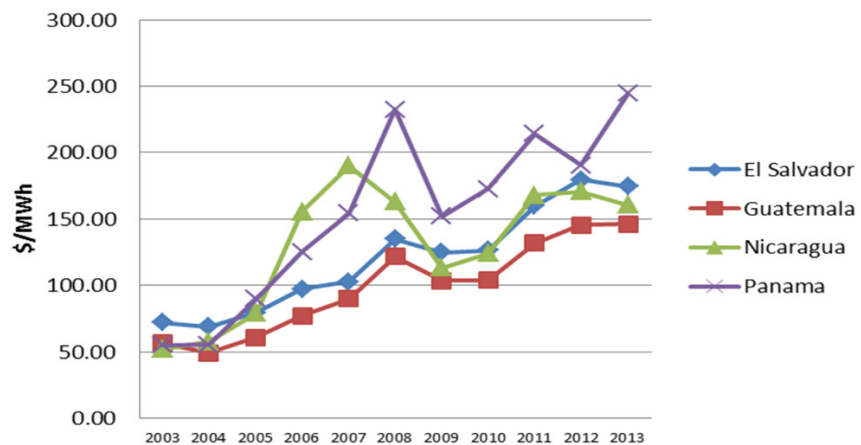


FIGURE 3: Marginal electricity prices in selected Central American countries, 2003-2013

In many cases, contracts represent financial commitment and do not require the physical delivery of electricity, so that if there is another participant with a lower price than the supplier, the supplier can honor its commitment by buying from this lower-priced participant.

Another unique feature of electricity markets is that there is no storage and it is necessary to maintain a constant equilibrium between demand and generation because the system does not tolerate significant differences for periods of time greater than fractions of a second. The resource needed to achieve this balance, taking into account the inevitable disruptions that occur in real time is called "Auxiliary Services" or "Ancillary Services." Also considered in this category are other resources to ensure the voltage level and other technical restrictions, which in many cases may have market mechanisms similar to those of the energy market.

2.2 Commercialization

Broadly speaking, one can say that the commercialization of electricity is the process by which an intermediary (the supplier) provides energy for a consumer in exchange for certain compensation. Furthermore, this process is often associated with provision of other services, such as advice on the use of energy, metering, etc.

There are several types of commercialization, classifying them according to the type of regulation that is applied, such as:

- Free trade: Where trading agents compete freely with each other and the restrictions imposed by the regulator to the prices they charge customers or the way marketers acquire energy are much reduced and are limited to monitoring the operation of the market.
- Commercialization per rate (or regulated): Corresponds to customers for which commercialization has not been liberated. In this case, the prices to be paid by end customers are administratively set by the market authorities and generally, conditions are established on how regulated suppliers make their purchases (e.g., only buying energy at the wholesale

market on a daily basis) and as to which supplier must serve each of these customers. Typically franchises or territorial concessions —as in traditional systems— are set so the distributor in the area should act as the regulated supplier for customers located in that area.

- **Default rate:** This is a protection model that is applied when the market has been fully liberated and all retail customers are able to choose their supplier, however, the regulator maintains administrative mechanism that works as a safety protection to prevent unreasonable retail competition. In this case, the governing conditions similar to the previous regulated rate are defined, with the difference that the consumers now have the option to give up anytime and choose a free supplier. However, free and regulated suppliers coexist for the same type of customers, which in this case it will be known as default rate providers.

The vast majority of markets have started the process of liberation, keeping all demand under a regulated rate. Further on, as the operation of the wholesale market becomes stable, different consumer segments could be liberated.

There are systems in which all consumers, from high demand (usually industrial) to residential are free to choose their supplier, while in other cases, a minimum level of consumption is required to freely choose a supplier.

3. REGULATED MONOPOLIES

Infrastructure in networks is characterized by heavy investments related to the physical space as their location for long periods of time. It is not advisable to have competition for two companies to construct buildings at the same site providing the same service. The networks would be redundant and the users would have to pay double for the same service.

It is considered that the network services of transmission and distribution are considered as legitimate monopolies and therefore the presence of a regulator defining the rates is justified, preventing the sole supplier of that service from setting higher costs that will result to a loss of economic efficiency to the society as a whole.

The regulator should set rates for distributors and transmitters for the companies to cope up with all the costs of operation, maintenance, expansion or make new investments to increase coverage or improve the quality of supply, and at the same time obtain a reasonable return for the industry, thus facilitating the economic and financial viabilities of the companies for the medium and long term.

The two methods used by regulators to set rates for owners of network companies are:

- a) **Regulation according to service costs:** Also known as rate of return. In this method the user must have the access to the accounting information of the company, thereby determining the appropriate level of expenses to repay the rate of return on invested capital. Under this method, the company is encouraged to be more efficient in spending so as to increase its profitability; rate definition is periodic, usually one or two years.
- b) **Regulation through incentives:** under this method it is possible to define an ideal company whose expenses are associated with the standardized values for the industry and adapted to the reality of the company taking into account the investment needed to expand the network and meet the quality criteria. This process is performed at a frequency of 4-6 years, establishing annual adjustments for inflation so there is an incentive for efficiency and lowering costs, which will be recognized in the next rate review.

In both cases, the pursuit of efficiency and thus increase in profitability of the companies should not lead to a decrease in the quality of service (continuity, voltage levels, frequency, waveform, commercial service, etc.). Because of this, the regulator typically sets parameters for loss levels and quality in order to identify the good service of the company. Otherwise, penalties are given to create incentives to achieve the quality level established in the rate of parameterization.

4. ROLE OF THE STATE

In liberal markets, the state must develop policies, adopt rules and monitor the proper performance of markets. In certain cases, it also acts as another participant subject to the same conditions and rules.

Generally, the state plans the development the electricity sector, defining the required expansion in generation, transmission, and distribution. In the case of the generation (as this is indicative, i.e. there is no obligation for the people involved to comply with the proposed plans of expansion), the state must look for ways to provide guidance and appropriate signals so that private sectors could undertake proposed investments. Such mechanisms may be fiscal, regulatory, contractual, etc.

In the case of transmission and distribution, the state will recognize new investments to be made by companies within the future rate review. In some cases, it may promote competition in the development of new lines, usually transmission, where it is subject to competition from investors.

Regulation is an essential characteristic in new markets when there is an entity in charge of monitoring compliance with regulations and applying appropriate sanctions for noncompliance.

In some cases, the same entity or another in particular is responsible for monitoring market competition and preventing the abuse of market dominance that could distort the market for an advantage. In order to reduce market power, vertical integration of enterprises is limited or at least separate account requirements are established in cases where regulated activities and simultaneous competitions are carried out.

5. NON-TRADITIONAL RENEWABLE RESOURCES

With new markets, generators are exposed to the changes in supply and demand, especially affected by fuel prices for thermal power plants. This creates a significant disincentive to renewable energy sources that mostly possess high investment costs and low operation and maintenance costs. At the same time, investors look to reduce their risk and regain their investment in the shortest possible time, which is why thermal power plants are favored in many cases.

In this context and in especially in systems that improve the economies of scale, it is necessary to create other incentives as well as revenues complementary to those obtained in the market that can make invest in non-traditional renewable energy sources attractive.

As part of state policy, many governments have created incentives to provide additional renewable energy sources into the markets and complement the resources needed to make them competitive. Under this approach, wind and solar energies have had remarkable development both commercially and technologically. In many cases, modifications are necessary to prioritize the release for these sources, due to their randomness, they cannot be programmed similarly like hydroelectric, thermal, or geothermal plants, whose availability is determined in advance and may be scheduled.

6. NEW CHALLENGES

There are developments in electrical systems that require changes in the regulation of markets to adapt to new trends, among these are:

- a) Distributed generation: With the development and introduction of renewable energy sources such as solar, wind, small hydroelectric plants and others with lower production, they are distributed within the electrical systems, which contribute to the load on networks and usually require coordination with the distribution company as they are not managed by the system operator due to their large size.
- b) Interconnections with other systems: This corresponds to interconnections between countries which facilitates the continuity of supply, making the systems stronger and reliable. By taking advantage of the surplus, markets begin to grow and provide projects for regional generation that can achieve economies of scale, and therefore can be cheaper. However aside from requiring infrastructure, the creation of a market with clear and harmonized rules for the different sectors should be considered.

BIBLIOGRAPHY

Hunt, S., 2002: Making competition work in electricity. John Wiley & Sons, Inc., New York, NY, United States, 450 pp.

Barquín, J., 2004: *La regulación del libre mercado, generación y mercado mayorista (Regulation of the free market, generation and wholesale commercialization)*. Universidad Pontificia de Comillas, Madrid, Spain, Course on the regulation of the electrical sector (in Spanish), Module 4.

Gómez San Román, T., 2004: *Instituciones y economía de la regulación, fundamentos económicos de la regulación (Institution and economy of regulation, economic fundamentals of regulation)*. Universidad Pontificia de Comillas, Madrid, Spain, Course on the regulation of the electrical sector, Module 2.

Friedel, R., Casey, R., Bedi, J., 1984: *A century of electricals - A brief history of electrical engineers 1884-1984*. IEEE Center for the History of Electrical Engineering, New York.

Rivier, J., 2003: *La regulación tradicional de sector eléctrico (Traditional regulation of the electrical sector)*. Curso CEDDET-Comillas, Instituto de Investigación Tecnológica, Madrid, Spain.