Development of New Infrastructure and Integration of New Technologies in Guatemala's Electricity Sector:

Practical Lessons Learned by a Regulator in a Developing Country

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1. EXECUTIVE SUMMARY

The timely development of new infrastructure and the incorporation of new technologies are fundamental elements for the improvement of the functioning of any public service sector. Electricity markets can benefit from this, as the development of new infrastructure and the introduction of new technologies can help the general public by having a more efficient, reliable and competitive public service.

Many challenges that regulators face are common, so sharing practical experiences on how regulators in different parts of the world have dealt with many of these common challenges can help improve the regulatory process. An excellent way to share this information is through case studies that are discussed in a global way through the aid of efficient platforms like ICER [1].

The objective of this document is to share, in a non theoretical way, some practical experiences that a regulator in a developing country has had, and the decisions that have been taken, that are causing that in practice, the development of new infrastructure and the incorporation of new technologies to the electricity grid are taking place. In order for the paper to be relevant to all of the regulators represented in ICER, an effort was made to describe the issues from the point of view of a developing nation.

In order to make this document easier to read, and for it to have a practical approach, it is divided in two case studies that describe some practical lessons learned by CNEE[2], Guatemala's electricity sector regulator, in two areas related to infrastructure development and integration of new technologies to the electricity grid. The two themes discussed in the case studies are the following:

1. Improving Electricity Access in Rural Communities: *A New Electricity Law and the Rural Electrification Plan in Guatemala.*

2. Transmission Infrastructure Expansion: *Reforms to the Regulation, Long Term Planning and Auction Mechanisms in Order to Promote Investments in Transmission.*

In the first case study, an explanation on how Guatemala has been successful in the construction of rural electrification projects, doubling the amount of homes with electricity service in approximately ten years, due to a combination of a well defined regulatory structure, founded on a new Electricity Law, and the implementation of a transparent and well funded rural electrification plan, is presented.

The second case study explains that the electricity demand growth in the country, the desire to develop new renewable energy generation projects and the necessity of improving the quality of electricity service, required considerable new investments in transmission infrastructure. The focus of this case study is on how the regulator responded to a series of challenges and was able to do the long term planning of the expansion of the transmission system, and

1. International Confederation of Energy Regulators: http://www.icer-regulators.net
2. From: "Comisión Nacional de Energía Eléctrica" in Spanish (in English).

more importantly, went from the planning, to the design and implementation of an efficient auction mechanism that led to the construction of the required infrastructure.

To contextualize the case studies, a summarized explanation of the history of the electricity sector and its reforms are also described, as they are common to the two case studies developed and their description is necessary as the new regulatory framework from 1996 was the foundation of the activities described in this document.

Although during the description of the two case studies, the theme of incorporating new technologies to the grid is discussed, at the end of the document, a specific section will explain some practical experiences related to new technology introduction in the electricity grid in Guatemala. Also, the importance that developing countries learn how to prioritize investments in this area of new technology introduction, taking into consideration the social and economical realities of the country and the situation of their electricity market will be described.

One of the conclusions presented at the end of this document is that regulators, having the public interest and the efficiency of the markets as a foundation of their decisions, should continue to make efforts to incentivize, through efficient and transparent regulatory mechanisms, the construction of new infrastructure and the incorporation of new technologies to the electricity grid.

II. INTRODUCTION

Many regulatory entities are doing their best efforts to induce the performance of the different market players in order to integrate new technologies to the grid and to develop new infrastructure in the public sector they regulate. For example, this document will describe how Guatemala's electricity sector authorities, implemented a successful rural electrification plan, based on a new Electricity Law, that allowed 607,914 new homes to be connected to the distribution grid in little more than ten years, going from a total of 700,000 homes with electricity access in the rural area in 1999, to close to 1.4 million homes in 2011. This document will also explain how did the introduction of new technologies to the electricity grid was prioritized by taking into consideration the complaints that the public had about the quality of technical and commercial service of the electricity distribution companies.

However, this document will try to contextualize the discussion about "integration of new technologies and development of new infrastructure" by differentiating, through the explanation of some practical experiences, what developing countries can do, are doing, and must do, so this can be compared in the future with information on what developed countries can do, are doing, and must do. Things that are being accomplished in both groups of countries are of upmost importance for the development of their societies, but when a detailed examination of the things that can be done in each country is made, the prioritization of things that must be done takes relevance, as the two groups of countries differ largely due to their social, institutional, market and economical realities.

For example, the development of smart grids or the implementation of state of the art technologies in order to promote energy efficiency may be at the top of the priority list of some countries, and this is understandable and very good for the development of the electricity sector as a whole, but does it mean that it is more important than the introduction of electricity through conventional grid expansion in rural communities of countries were 1 out of 2 people are living without this basic service?, or more important than implementing auction mechanisms to promote the construction of new transmission infrastructure in order to unblock the development of remotely located renewable energy resources?
Discussing the answer to these questions, in practice, is not relevant, as most people would agree that the answer is no, that one thing is not "more important" than the other. The relevant thing, or at least for the focus of this paper, is that all of the things related to incorporating new technologies and building new infrastructure are important and that when to do one thing or the other is a matter of time for each country, it is a priority issue. For some countries the priority may be a or b, and for other countries the priority may be c or d, but all things related to incorporating new and efficient technologies are important.

It is fundamental then, to discuss how can regulators, each within its own reality and its legal competences, through their decisions and actions, can induce that current, and new participants in the markets they regulate, contribute in building new and efficient infrastructure in generation, transmission and electricity distribution, and how can new technologies be integrated to the grid. It is also desired that regulators perform this actions in a way that both the public interest is served and that the companies operate efficiently and have a fair and reasonable return on their investments.
The objective of writing this document is to share with other regulators and entities interested in the development of electricity markets in developing countries, practical experiences that a regulator has had in the past, that can help to develop more efficient, reliable and competitive electricity markets. This document is written with a practical approach

and it is divided in two case studies that describe some practical lessons learned by Guatemala's electricity sector regulator, in two areas related to infrastructure development and integration of new technologies to the electricity grid. The two themes discussed in the case studies are the following:

- Improving Electricity Access in Rural Communities: *A New Electricity Law and the Rural Electrification Plan in Guatemala.*
- Transmission Infrastructure Expansion: *Reforms to the Regulation, Long Term Planning and Auction Mechanisms in Order to Promote Investments in Transmission.*

Although this case study is about technical matters, about new infrastructure development and introduction of new technologies to the grid, and about practical experiences in solving some challenges that regulators face, a crucial element that needs to be present in all of the activities that regulators perform is the ethical values element.

Having them as a foundation in all of the technical, legal and economical decisions that need to be taken will facilitate the regulators job. From the practical experience at CNEE, it is considered that this was a key element for the success of the processes described in the following document and that continuous efforts have to be made in order to have the ethical values as the foundation of all regulatory bodies. As so brilliantly exposed by Mr. Scott Hempling in his "must read" book for regulators: Preside or Lead, The Attributes and Actions of Effective Regulators, a regulator, in addition to being honest, diligent, objective, competent, etc., needs to have four additional attributes: "They are purposeful, educated, decisive, and independent…The purposeful regulator defines the public interest clearly and transparently, then promotes it by inducing performance - by aligning the utility's private behavior with the public interest. The educated regulator drives toward mastery – of regulation's six subject areas, its six legal sources, its five professions, its three processes, and it´s many local facts. The decisive regulator acts – when and where the public interest requires, regardless of discomfort to herself or the parties. The independent regulator recognizes and accepts the democratic forces of which no government official can be independent, but she remains alert to, and resists, those forces that undermine regulation's purpose."

Sharing some practical experiences in this document has the intention of benefiting the regulatory community with solutions applied in a developing country to overcome barriers in the development of new infrastructure and incorporation of new technologies in its electricity market.

III. CONTENT

This document has been divided in two case studies that describe some practical lessons learned by a regulator in two themes related to infrastructure development and integration of new technologies to the electricity grid. The two themes discussed are the following:

1. Improving Electricity Access in Rural Communities: *A New Electricity Law and the Rural Electrification Plan in Guatemala.*

2. Transmission Infrastructure Expansion: *Reforms to the Regulation, Long Term Planning and Auction Mechanisms in Order to Promote Investments in Transmission.*

These cases describe two challenges related to infrastructure development and new technology integration that have been faced in Guatemala's electricity sector and the practical experiences of CNEE, Guatemala's electricity sector regulator, on how these challenges were faced and solved.

In the first part of this section, a general explanation of the history of the electricity sector and its reforms, and some current key statistics of the country and the electricity market are presented, as they are common to the two subtitles or sub-cases explained later in the document. At the end of the document, a specific section will explain some practical experiences related to new technology introduction in the electricity grid in Guatemala.

A. Background

1. Brief History of the Electricity Sector in Guatemala

Although this paper is oriented to describe technical matters related to the introduction of new technologies to the electricity grid, and the development of new infrastructure, a brief explanation of the history of the electricity sector in Guatemala might be useful for regulators, as many countries have faced similar problems and have had similar structures, were the State has participated in the electricity market, and then the utilities have been privatized, restructured and regulated under a more efficient framework. The development of the electricity market, in the particular case of Guatemala, has been, in general terms, more efficient under the new regulatory framework approved in 1996 than with the State monopoly framework that existed before. In the following paragraphs, a brief description of the electricity market history and its reforms is presented.

To contextualize the case studies, Guatemala is a country located in Central-America, at the south of México, with a population of approximately 14 million people and a size of 109,000 square kilometers. It has a Gross Domestic Product (GDP) of US$42.5 billion and although the largest in the Central-American region, the country is still considered a developing country with the majority of its population living under poverty conditions. Guatemala's GDP per capita is still lower than US$3,000 per year. The country has an abundance of natural resources within its territory, which if developed efficiently, could help improve its economical and social parameters in the future.

In 1886, the first hydroelectric plant was installed in Guatemala. Eight years later, in 1894, Compañía Eléctrica de Guatemala was formed by a group of German Industrials as a generation and distribution company, and in 1919, after World War 1, the State took control of this company, and was later sold, in 1922, to a North American firm, which got a 50 year concession to generate and distribute electricity, the company operated under the name of Empresa Eléctrica de Guatemala. At this time, the demand for electricity was very limited and was mainly distributed in the urban areas, especially in Guatemala City.

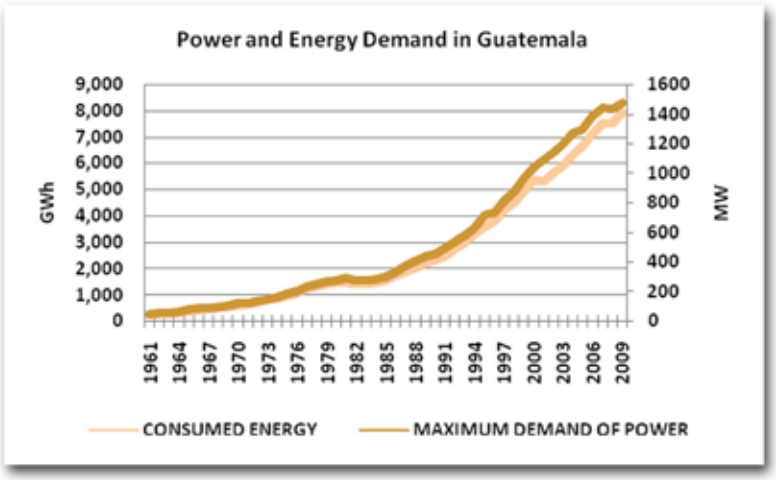
In regards to new generation capacity from renewable resources, the Santa María Hydroelectric project was built in the west of the country in 1927, with the main objective of giving power to an electric railroad located in the region, and afterwards, to give electricity to local towns.

In the 1950's and 60's, a considerable amount of new generation plants were installed in the country to meet the growing demand for electricity. This demand for electricity was not only located in urban areas of the country but started to grow in the rural communities and the lack of an Institution in charge of electrification was causing that this basic service was limited to few locations in the country. In response to this, at the end of the 50's decade, with the objective of expanding electricity service to all of the country, through the design, construction and operation of generation, transmission and distribution infrastructure, the Instituto Nacional de Electrificación (INDE), a State owned company, was created. INDE started to build new generation, transmission and distribution infrastructure. In the 1970´s and 1980´s large hydroelectric projects, like Chixoy (300MW) and Aguacapa (80MW), were built by INDE to meet electricity demand growth. Fortunately these large projects were built at the time as they are still an important part of the generation facilities available in Guatemala to supply the Nation's electricity demand.

In 1972, the contract with the North American company which owned Empresa Eléctrica de Guatemala ended, and the State took control of the company, so in practice, from this year on, the State of Guatemala, both through INDE and Empresa Eléctrica de Guatemala, had the responsibility to develop the electricity sector to meet the growing demand for electricity. As the new democratic era in Guatemala[3] arrived in 1985, the demand for electricity started to grow faster (see Graph 1). Construction of new infrastructure was lagging due to numerous reasons, and the State was not able to supply the growing demand, so by the end of the 1980´s and the beginning of the 1990´s, the country faced prolonged and continuous power outages, and electricity access in the country was less than 50% .

3. Information from: "Changes in the Regulatory Framework in Order to Promote Distributed Renewable Generation in Guatemala", by Carlos Colom.

Graph 1: Evolution of Electricity Demand in Guatemala



As mentioned above, by the beginning of the 1990´s, not only did Guatemala experienced continuous and prolonged programmed power outages due to the lack of available power generation capacity, but the country also had an electrification level of less than 50%. At this time, under emergency conditions, and a lot of pressure by the population, the State, through its distribution companies, had to sign power purchase agreements with private generators that used fossil fuels to generate electricity to help cut the outages; the terms of the contracts reflected that they were signed under emergency conditions.

In response to this situation, discussions to de-monopolize the sector and to adopt a modern and competitive regulatory framework to promote investments began.

In 1996, after many discussions between the different actors interested to have a more efficient electricity sector, the General Electricity Law (Electricity Law) was approved by Congress. The Law created two entities that are critical for the efficient and transparent functioning of the electricity market, and that serve as a guarantee to promote investments in the sector. These entities are: an independent regulator called Comisión Nacional de Energía Eléctrica (CNEE) and an independent system and market operator called Administrador del Mercado Mayorista (AMM) that operate under the rule of the Electricity Law and the new regulatory framework.

After the approval of the Law, between 1997 and 1999, the State owned distribution assets are sold to private companies in open and competitive processes that are completed successfully. Generation and transmission assets are kept by INDE, but it´s percentage of participation in both of these activities starts to fall due to increased investments by private companies, mainly in power generation.

An important experience is that the Electricity Law created a technical and independent regulator, called CNEE, and a technical and independent system and market operator, called AMM. Both entities, each doing what the Electricity Law establishes them to do, serve as a guarantee that the electricity market is operated in a technical and efficient way, and that commercial transactions are clear and transparent. With almost fifteen years of operation under this regime, no single agent of the electricity market has been unpaid for their respective services.

2. Reforms to the Electricity Sector in Guatemala

As mentioned above, the electricity sector was going through a difficult crisis in the early 1990's, and in 1996, the sector is completely reformed with the approval of the Electricity Law. In the years that followed the approval of the new regulatory framework, the State owned distribution companies were sold to private investors in open and competitive processes. Generation and transmission assets were kept by INDE, and entry of new investors in generation started to grow rapidly.

The introductory part of the Law clearly reflects the situation of the country at the time:

"The electricity needs of most Guatemalans is not currently being met; electric power supply is not keeping pace with the growth and the present demand; and the industry's shortcomings are impeding the Nation's development, therefore, it is necessary to liberate the electric power sector so as to boost the output and expand the transmission and distribution of electric energy".

The translation of the rest of the introductory part continues to help explain the situation:

"…it is necessary that power transmission and distribution systems be rapidly decentralized and de-monopolized, so that the power supply may be expeditiously increased in order to meet the social and production-related needs of Guatemalans, and thereby raise their standard of living, specially the living conditions of poor residents in rural areas that have no electric service at this time. The country must create a body of basic laws and regulations to expedite the workings and make for optimum performance of the various components of electric service, and to that end, requires that there be an expert technical commission established…"

With this introduction, the Electricity Law was approved in 1996, and it is the fundamental Law that regulates the electricity market in Guatemala. It is a General Law with 81 Articles, distributed in 7 Titles, which cover the following issues: General Principles and Definitions; Installation of Generation, Transmission and Distribution Infrastructure; Operation of Generation, Transmission and Distribution Infrastructure; Pricing Regime; and Sanctions.

It is important to describe the Electricity Law in this document, as it is the cornerstone of all of the activities related to the electricity sector that have been developed in the country since 1996. It is also considered by international experts as a modern and clear Law that promotes efficiency in the electricity market.

The Electricity Law has the concept of "efficiency" embedded trough out all of its body, the activity of generation is supported on a centralized dispatch based on marginal costs, were the most efficient generators (least cost of production) are the first ones to be called to supply the demand, and the least efficient generators (higher cost of production), are not called to supply the demand, and have a penalty for this inefficiency reflected in the amount of capacity they can offer in the market the next year; transmission's wheeling charges are regulated and based on the costs of an efficient and "economically adapted" company; and distribution's wheeling charges are also regulated based on the operation of an efficient distribution company with efficient infrastructure and operation costs. A regulated and efficient rate of return is used to calculate both transmission and distribution rates.

The Law is supported on the following principles:

- Anyone can perform the activities of electricity generation and no authorization or special condition is required by the State, only those recognized by the Constitution of Guatemala and the laws of the country. However, the use of the State's property (for hydroelectric and geothermal project´s development) will require the proper authorization by the Ministry of Energy and Mines when the project's capacity exceeds 5 MW.

- Anyone can perform the activities of electricity transmission and distribution, but the ones that imply the use of public dominium properties are subject to authorization.

- The prices for transmission and distribution services are regulated and defined by CNEE.

- An independent regulator (CNEE) and an operator of the market and the system (AMM) are created.

- Vertical integration of companies is not allowed.

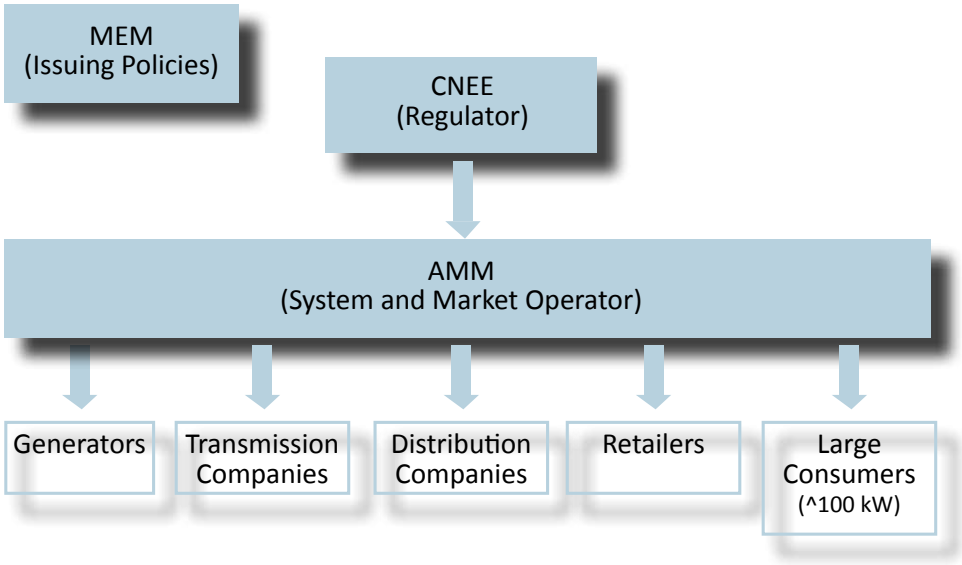
As mentioned above, the Electricity Law created an independent regulator and an independent system and market operator, which are crucial elements for the good functioning of the market. The sector is structured as follows:

- Ministry of Energy and Mines (MEM): Formulation and coordination of policies.

- National Commission of Electricity (CNEE): It is the electricity sector Regulator. The Commission is an independent and technical agency, responsible for the fulfillment and enforcement of the Electricity Law, it can issue technical norms related to the sector, it has to establish electricity tariffs and the methodology for calculating them, and it has to watch over the market in order to ensure its competitive functioning, within other activities. It is integrated by three Commissioners, appointed through a defined process in the Electricity Law to a five year term.

- Wholesale Market Administrator (AMM): Entity created by the Electricity Law. It is the commercial and technical operator of the electricity market and system. Has to operate the market at the lowest possible cost, guaranteeing competition and the continuity of electricity service.

The Wholesale Market participants or Agents are the following: Generators, Transmission Companies, Distribution Companies and Traders. The Law also contemplates the figure of Large Consumers, which are consumers that have a capacity demand higher than 100Kw and that have freedom to buy electricity from any producer or Trader.



Trading of electricity is mainly done on a medium and long term bilateral contract system between Generators and distribution companies and Generators and Traders. In the case of the distribution companies, they have to make an open bidding process to contract the energy and capacity for their clients, ideally with sufficient anticipation to allow for efficient contracting.

The contracts between Generators and Traders and with Traders and Large Consumers are done with no restrictions and they can negotiate their prices and the rest of the conditions. Large Consumers, as mentioned above, need to have a capacity demand of 100 Kw or more in order to access this market, the rest of the consumers have regulated tariffs.

There is also an opportunity or spot market,[4] with hourly set energy prices based on a marginal cost dispatch. As of 2010, about 90% of the energy was traded in the bilateral contract market and 10% in the spot market , which in concept, was designed to serve as a "closing market".

The legal structure that regulates the electricity sector is based on the following legal documents:

- Political Constitution of the Republic.
- General Electricity Law.
- Rules of the General Electricity Law.
- Rules of the Wholesale Market Administrator.
- Operative and Commercial Coordination Norms for AMM.
- Technical Norms.

3. Current Statistics of the Electricity Sector in Guatemala

The following table contains some of the most important statistics from the electricity sector in Guatemala as of 2010.

Table 1: General Statistics of the Electricity Market

ELECTRICITY STATISTICS (2010)		
Local generation	7,913.91	GWh
Local demand	8,137.28	GWh
Exports	138.93	GWh
Imports	362.30	GWh
SPOT Price (Average)	103.83	US$/MWh
Peak Load	1,467.88	MW
Load Factor	61.41	%

In 2010, the electricity was produced in Guatemala in the following way: 45.5% with hydroelectricity, 22.5% with internal combustion engines that use heavy fuel oil, 12.6% steam turbines that use coal, 11.8% by co-generators that use sugar cane bagasse (also steam turbines), 3.1% by geothermal generators and 4.4% was imported from México.

4. Information from: "Changes in the Regulatory Framework in Order to Promote Distributed Renewable Generation in Guatemala", by Carlos Colom

The potential for building power plants that use renewable resources in Guatemala is considerable; the following table represents this potential:

Table 2: Renewable Energy Potential in Guatemala

TYPE	ESTIMATED POTENTIAL	CURRENTLY USED
Hydro	5,000 MW	13.01%
Geothermal	1,000 MW	2.65%
Wind	7,800 MW ≥ class 4	0%
Solar	5-6.5 kWh/m2/day	0%
Biomass	-	300.16

The goal established in the National Energy Policy and in the Long Term Generation and Transmission Plans done by CNEE, is to have at least 70% of the energy generated in Guatemala produced with renewable resources by 2022.

B. Case Studies

1. Improving Electricity Access in Rural Communities:

A New Electricity Law and the Rural Electrification Plan in Guatemala.

As mentioned earlier, the General Electricity Law was approved by Congress in 1996 and it established the new regulatory regime for the electricity sector. With this new regulatory framework in place, the government also decided to privatize its distribution assets, owned at the time by three public companies. The geographical areas that the State owned distribution companies covered at the time was the following [5]:

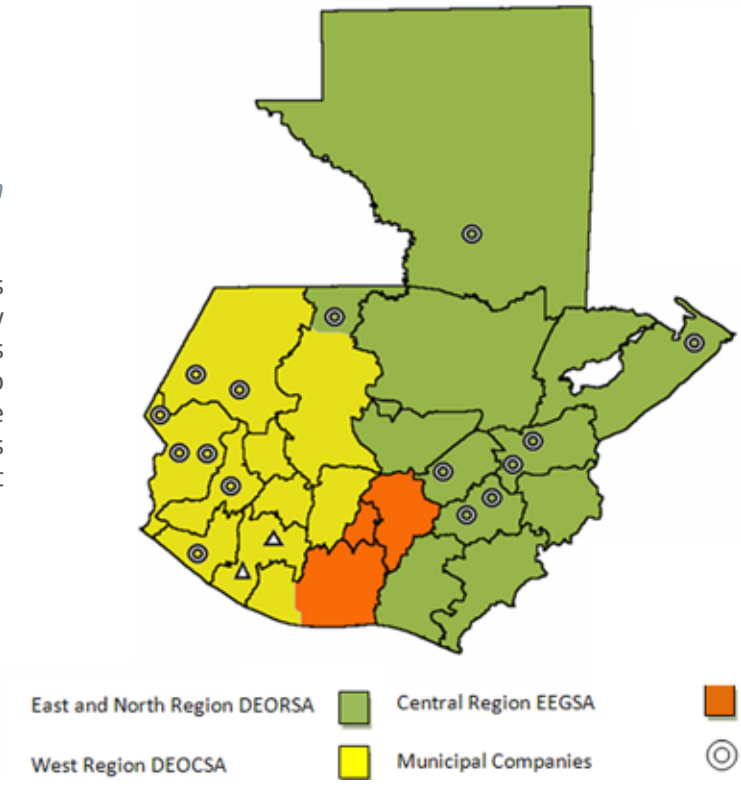


Figure 2: Area of Coverage of the Three Largest Distribution Companies in Guatemala

5. Currently, the geographical area that the 3 privatized distribution companies cover is the same, although the amount of clients has increased considerably.

The focus in this case will be in Distribuidora de Electricidad de Oriente S.A. (DEORSA) and Distribuidora de Electricidad de Occidente (DEOCSA), the companies that distribute electricity in the green and yellow areas represented in the map above, and that were owned by INDE, the State Utility, at the time[6]. The focus of this case will be on them, as the Rural Electrification Plan (PER, for Plan de Electrificación Rural in Spanish) was carried out in the area they are authorized to cover.

The particular case of both DEORSA and DEOCSA at the time (1990's) was critical, the technical and non-technical losses were high, the rural electrification coverage was low, and the levels of quality of service, both technical and commercial were also low.

In 1998, the government of Guatemala, through INDE, went forward with a formal process to sell DEOCSA and DEORSA through an open and competitive auction mechanism. An investment bank that served as a technical and financial advisor was hired. The chosen advisor was J. Henry Schroeder & Co. Limited and Citibank NA. An invitation was sent to potential buyers to participate in the bidding process to buy the distribution companies; a formal data room was established and a road show in numerous countries was performed. The selling of the distribution assets also incorporated, as an incentive to potential buyers, the Rural Electrification Plan or PER.
The PER had the main objective of improving the quality of life of Guatemalans in the rural areas through the introduction of electricity to their communities. It had the goal of expanding electricity access to 2,633 new communities, which included 280,629 new homes that housed approximately 1.5 million persons. Also, it included the construction of 1,283 kilometers of 69Kv and 374 kilometers of 230Kv new transmission lines, and 28 new power substations to support an aggressive electrification plan. In total, the goal was to introduce electricity to 1.5 million homes.

To fund the PER, the government guaranteed the potential investors that all of the funds obtained from the sale of DEOCSA and DEORSA will be re-invested in the PER through a transparent Trust Fund, and, if required, additional funds will be available to reach the amount of the US$333 million required to achieve the objectives described in the preceding paragraph.

At the time, as seen in the map above, INDE, through DEOCSA and DEORSA, covered the electricity distribution service in 19 of 22 Departments of the Republic of Guatemala, with electricity coverage of only 52% and an average consumption of 93 kilowatt hours per month per client.

The incorporation of the PER to the selling of the distribution assets was considered a key element for the success of the process, as it helped attract potential buyers because:

- The amount of clients of DEORSA and DEOCSA at the time was low. Only 52% of electrification coverage in the areas of distribution of the two companies.

- The introduction of 280,629 new clients would expand the market of the distribution companies, making it a bigger and more profitable business in the future.

- The distribution companies would participate in the Trust Fund Board that would administrate the PER, and they would be in charge of the construction of the Plan, under pre-approved monetary amounts for the construction of the infrastructure.

For the government, it was also an attractive mechanism to include the incentive of the PER in the privatization process because:

- It had the need and the desire to embark in an aggressive electrification plan to help improve the quality of life of Guatemalans.

- There was a high unsatisfied electricity demand in all of the country and the number of requirements from rural communities for new projects was reaching the thousands at the files of INDE's Gerencia de Electrificación Rural or Rural Electrification Office (GERO).

- The traditional forms of electrification had not worked efficiently in the past, due to a number of reasons, like political intromission, lack of transparent processes, lack of clear technical and financial goals and lack of a continuous, transparent and armored financial mechanism to fund the infrastructure that transcended governments.

6. Empresa Eléctrica de Guatemala S.A. (EEGSA), also owned by the State at the time, distributes electricity in the central part of the country, the orange area, and it was also sold to private investors in 1998 (approximately 80% of the shares).

Selling two distribution companies that serve a small market (52% of coverage), have high technical and non-technical losses, low per capita consumption and low quality levels might not have been attractive to potential investors and keeping the companies as State owned utilities was causing the above mentioned problems to grow as time passed, so selling them was essential.

- Rural electrification was not easy to expand due to the orographical, geographical and topographical conditions of the market served by DEOCSA and DEORSA, as it was generally mountainous and the dispersion of communities to be electrified was high.

As mentioned above, rural electrification projects were difficult to build in Guatemala's rural area due to:

- Lack of funds.
- Long distance between communities and between houses to be electrified.
- The orography of the rural area, mainly mountainous.
- A weak high voltage transmission (69Kv and higher) and mid-voltage distribution (34.5Kv and lower) lines that caused a lot of restrictions[7].

The rural electrification projects had been built in the past by different entities such as INDE, NGO's, the communities, municipalities and other developers, with no centralized planning. However, the lack of planning, and other related issues caused technical and financial problems in the development of the projects and generated confusion in the communities and interested parties as to who was responsible for the construction of electrification infrastructure.

Other rural electrification plans had been developed in the past by INDE, but they lacked the ambitious goal of PER of electrifying more than 250,000 new homes in a short period of time and the funding mechanism like the one designed for the PER program. Also, these other plans didn't have the new regulatory foundation provided in the Electricity Law that helped to speed up the rural electrification process. Other rural electrification plans included:

- PER1: Executed between 1971 and 1978. It brought electricity service to approximately 25,000 new homes. It covered 5 of the 22 Departments in Guatemala.
- PER2: Executed between 1979 and 1989. It introduced electricity to approximately 90,000 new homes, in 536 communities in 20 Departments of the country.
- PER3: Concluded in 1996 and it electrified 37,000 new homes in 232 communities.

As described above, the three previous rural electrification plans were executed in more than 25 years and introduced electricity to approximately 152,000 new homes. The total cost of the three projects is difficult to estimate, but the time it took to build the infrastructure was considerably long. The new PER program, under the new Electricity Law, was considerably more ambitious both in terms of quantity of new services connected and the time to do so.

Due to these problems, and under the new provisions of the Electricity Law, the government and INDE decided to go forward with an aggressive rural electrification program, with the funds provided by the sale of the shares of the distribution companies, and additional funds provided by Government and INDE. Another benefit from this structure was that the new owner of the distribution companies would be motivated to build and operate the rural electrification plan, through its participation in the PER structure and the Trust Fund Board, ensuring that the market he would serve would be bigger and that he would participate in the construction of the new infrastructure.

The possibility for the government to subsidize new electrification plans and to assign a monetary amount for this purpose was adequately established in the Electricity Law, and this also gave certainty to the parties interested in rural electrification (new users, investors, etc.).

Article 47 of the Electricity Law established the following:

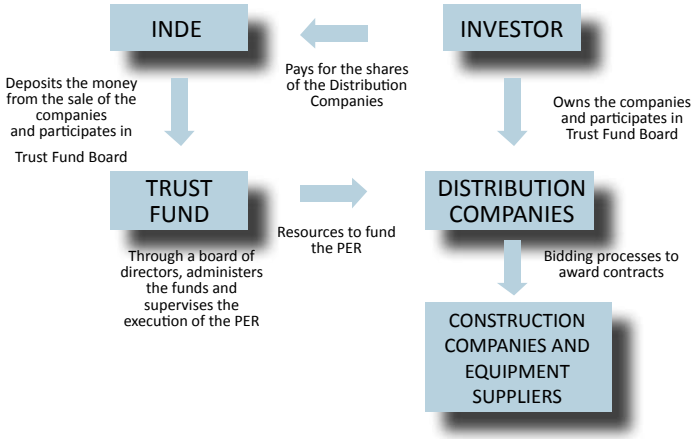
"*The State may provide funds to pay in full or in part, the cost of rural electrification projects serving a social or public interest and which are located outside the boundaries of defined service territory. Such State funding shall be considered a subsidy, and shall not be passed on to users as a cost. Facilities built using such funds shall be administered and operated by the franchisee, which shall maintain them in perfect operating condition. State*

7. According to the regulation, a "line" is the physical mean that allows electric power conduction between two points. The lines can be for transmission or for distribution, in accordance with their activity. The classification of transmission or distribution lines will be a responsibility of the Commission based upon technical criteria furnished by the Wholesale Market Administrator. In practice, a transmission line is a line with a voltage higher than 60Kv and a distribution line is a line with a voltage between 1Kv and 60Kv. The common voltage for transmission in Guatemala is 69, 138 and 230KV and for distribution, 13.8 and 34.5Kv.

funding for a project as provided in this article will not be awarded without a favorable socioeconomic assessment of the project from the Ministry of Energy and Mines."

As mentioned before, the creation of a Trust Fund was essential for the well functioning of the PER, as it provided an armored[8] and transparent administrative mechanism with guaranteed funding from INDE and the government. Also, it had a well balanced and representative Board of Directors that prevented political interference in the development of the Plan. The Trust Fund structure is described below:

Figure 3: PER Trust Fund Structure



In the preceding Trust Fund Structure, the participants are the following

1. Trust Bank.
2. Trustees: Distribution Companies.
3. Trustor: INDE.

The Trust Fund has a Board of Directors called the "Technical Committee for the PER Administration" and it is integrated by two representatives from the Ministry of Energy and Mines, INDE and the Distribution Companies. They meet on a regular basis to administer the funds, supervise the construction of the Plan, etc.

The base-line projects that would be included in the PER (the 280,629 new homes) were taken from the files at INDE's Rural Electrification Office (GERO) as well as the ones at the Ministry of Energy and Mines. The Plan was structured with projects that were located in the rural areas with the highest needs for electricity and with the poorest conditions.

8. Necessary condition when amounts in the order of US$333 million are being administered.

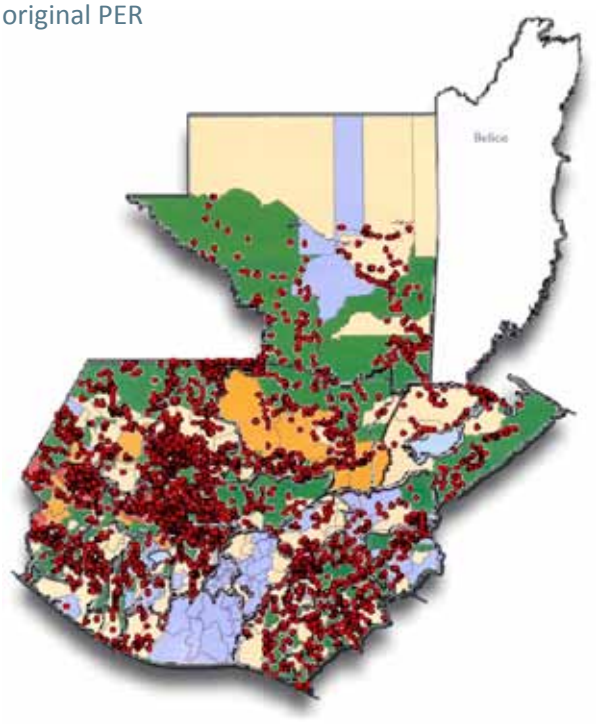
The methodology to design the PER was the following:

- Revision of the files at GERO and the Ministry of Energy and Mines in order to incorporate all the applications for the introduction of electricity from communities around the country. As seen in the map below, the areas with the highest demand for electricity and need for new electrification projects in both the east and west of the country were studied.

Figure 4: Map of the Areas were PER was Implemented

- Study of the existing conditions of the transmission and distribution infrastructure, reflected that considerable investments were required not only in distribution but in transmission facilities.
- Analysis of the costs of materials, labor, etc. required for electrification, in order to produce a unit cost that would serve as an efficient representative cost to electrify a new home so as to value the financial requirements to electrify the 280,629 new homes included in the Plan.
- Revision of the cost variation according to the location of the communities, the dispersion of the houses to be electrified and the orographical conditions of the different sites.
- A detailed list with the name, location and number of families in each community to be electrified under the PER was elaborated. This helped to de-politicize the process as the beneficiaries were defined from the beginning of the program, making it easier to meet the goals by not having to constantly change beneficiary communities due to political pressure. The 2,633 communities are represented in the following map with a red dot. The colors red, orange, green, white and light blue at the back of the map represent, respectively, the areas of the country with the highest to lowest poverty conditions.

Figure 5: Communities to be Electrified under the original PER



To value the cost of the PER, the two main cost components, transmission and distribution, were divided. The total cost of the transmission infrastructure needed to back up the construction of the distribution infrastructure was approximately US$151 million[9] (45%) and the total cost of the distribution component was US$182 million (55%). The following table summarizes the required investments and beneficiaries from the PER in both DEOCSA and DEORSA:

Table 3: Details of the PER

REGIONAL PROGRAM	CLIENTS	INHABITANTS	COMMUNITIES	MILLION US$
Eastern Distribution DEORSA	123,315	690,564	1,161	75.55
Western Distribution DEOCSA	157,324	881,014	1,472	107.04
TOTAL	280,639	1,571,578	2,633	182.59

In 1998, seven companies bought the right to participate at the privatization process and to have access to the data room; the companies had to meet the following requirements in order to participate:

- Operate an electricity distribution area with more than 280,000 users.
- Have assets valued at more than US$200 million.
- Have equity of not less than US$100 million.

Later in the same year, the sale of both DEOCSA and DEORSA was completed. Of the three firms interested, two submitted an offer and the buyer that won the bidding process was Union Fenosa, an electricity company from Spain. They took control of the companies in 1999 and paid US$101.1 million in the transaction for 80% of the shares, 7% of the shares remained in the hands of INDE's employees, which was a mechanism designed in order for the employees and the laborers union to support the privatization process. The remaining 13% was later bought by Union Fenosa, giving them, by the year 2000, a 90.83% participation in DEOCSA and a 92.84% participation in DEORSA.

When the new owner took control of the two distribution companies in 1999, the execution of the PER began successfully. Three contracts were signed to guarantee the development of the PER program: a first one for the sale of 80% of the shares, a second one for the creation of the Trust Fund and a third one for the construction of the infrastructure. The government immediately deposited the US$101.1 million acquired from the privatization of both DEOCSA and DEORSA in the Trust Fund plus and additional amount of US$56 million from the sale of Treasury Bonds. This provided sufficient monetary funds to go forward with the PER.

An important element to be considered is that once the infrastructure is constructed, the transmission assets are given to INDE and the Institution owns them and the distribution assets are kept by the distribution companies but they cannot charge a cost of capital on them to the users, only a replacement value is allowed to be passed to tariffs by the regulator on these subsidized distribution assets.

Looking back, and judging from the results, it can be concluded that the PER was a successful project and that the design of a transparent and armored Trust Fund, exclusive for the financing of rural electrification, the financing of the Plan through the re-investment of the funds acquired from the sale of the distribution companies in rural electrification and the definition of clear and objective goals from the beginning were critical elements to make the process successful.

Up to 2008, the PER had introduced electricity to more than 205,000 new homes located in 1,910 rural communities. This required the installation of 1,000,000 kilometers of cable for the mid voltage grid (13.8 and 34.5Kv) and 10,000,000 kilometers for low voltage connections, 14,000 new transformers and 164,000 electricity poles.

9. The unit price per new home was determined at US$650.55, and this, when multiplied by the 280,629 users, gives the amount of US$182 million. The cost includes the studies, designs, right of way, construction of the distribution grid, the meter and its connection to the grid.

In transmission infrastructure (69 and 138Kv), the grid has been greatly reinforced through the construction of 777 kilometers of 69Kv lines, 184 kilometers of 138Kv lines, 22 new power substations and refurbishment of 10 existing ones.

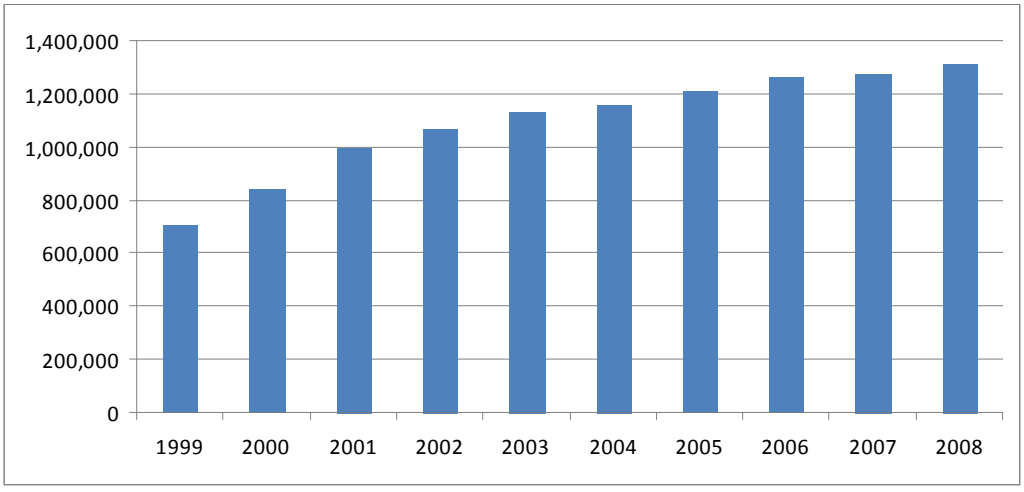
In the last two years, the government has contracted two loans in the order of US$100 million with multilateral agencies in order to continue with the rural electrification process.

The implementation of rural electrification plans has also contributed to the improvement of the environment in Guatemala, as electricity in new homes has helped to displace the use of fire wood for cooking, although for cultural reasons, this displacement has not been as strong as originally thought.

As seen in the following table, the amount of clients that the two distribution companies serve has nearly doubled since the distribution companies were privatized in 1999.

Table 4: Number of Households Electrified Between 1999 and 2008

Company	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total
DEORSA	249,466	292,824	345,228	383,213	415,171	421,281	448,614	469,671	476,179	489,978	-
DEOCSA	460,122	547,912	653,050	685,893	415,171	740,511	763,369	796,298	803,881	827,524	-
TOTAL DR+DC	709,588	840,736	998,278	1,069,106	1,135,340	1,161,792	1,211,983	1,265,969	1,280,060	1,317,502	-
% Increase Year	-	18%	19%	7%	6%	2%	4%	4%	1%	3%	86%
# Increase Year	-	131,148	157,542	70,828	66,234	26,452	50,191	53,986	14,091	37,442	607,914



In total, 607,914 new homes were connected to the distribution grid in the period 1999-2008 and by the middle of 2011, DEOCSA had 869,729 clients and DEORSA 514,563 clients, with a combined total of 1,384,292 clients, almost doubling the amount of new connections or new clients in little more than ten years!

As mentioned above, the goal of the PER was to introduce electricity to 280,639 new clients, and the current amount of clients is much higher than that. So how did this happen?

It happened because some municipalities, development councils, NGO's, etc. continued to perform some rural electrification projects. However, the key element for accomplishing this successful doubling of new services connected in a short period of time, are the provisions related to electrification under the new Electricity Law, of course, combined with the PER's success.

The Electricity Law clearly establishes that the distribution companies are obliged to connect every new home that is located at a distance of 200 meters (656 feet) or less of the existing distribution infrastructure, without any cost to the interested person. Also, the Law establishes a maximum number of days for the distribution companies to connect new users and a maximum, reimbursable amount, which they can charge for the new service to interested persons that are located at distances bigger than 200 meters from the existing grid. This value has to be approved by CNEE and sanctions can be imposed if they don't meet these requirements. From practical experience, these provisions on the regulatory framework have been one of the most important tools to expand electricity access in the rural areas of the country, and CNEE has been active in making the distribution companies comply with these provisions in many cases were users have requested a new service, and are located at a distance of less than 200 meters, and the distribution companies have not connected them.

Article 47 of the referred Law establishes the distribution companies obligation: *"A person that is located in the obligatory service territory of a franchisee, and wishes to obtain electric service, may require the franchisee to supply electric service, pursuant to this law and its regulations..."*

Article 65 of the Regulation of the Law compliments the previous article: *"Obligation to Supply: All the Distribution Companies authorized to render the service in one zone are obliged to connect to its grid, without cost, all of the persons that require the electricity service that are located within a distance, which shall not be less than 200 meters around its installations."*

In regards to costs and the maximum days to connect new services, articles 48 of the Law and 68 and 71 of the Regulation of the Law, respectively, establish the following:

"Article 48: If a franchisee requires that persons seeking electric service contribute funds to obtain the service, the franchisee shall reimburse those persons for their contributions within the terms and under the conditions prescribed in the regulation. Such contributions may not exceed the maximum value that for such purposes is set by CNEE."

"Article 68: The Distribution Company, prior to authorize the petition for the connection of a new electricity service and within seven (7) maximum days, counted from the date of the reception of the petition, shall determine whether the capacity of the respective distribution lines is sufficient to render the required service, or if it is necessary to make improvements. Within this period, the Distributor shall notify the interested party about the authorization for connection, the detail of the amount of payments and the guarantee deposit that shall be made.

At the moment that the interested party has made effective the payments and the deposit guarantee, the Distributor:

1. If improvements are not necessary, shall connect the required service in a maximum period of twenty eight (28) days.

2. If improvements are necessary, shall connect the required service in a maximum period of three months.
The non observance of the above mentioned terms will be deemed a serious fault and will be subject to a sanction and, in case of repeated violations; CNEE can request the Ministry the abrogation or cancellation of the respective authorization."

"Article 71: If improvements on the grid are required in order to connect new services, the Distribution Company will be able to request the users for a monetary contribution of reimbursable nature. These values shall be published by the Distribution Company in a national and large circulation newspaper and will be established upon the level of voltage, and they cannot exceed the maximum value stipulated by CNEE to these effects. The interested party shall give the contribution to the Distributing Company at the moment of the subscription of the respective contract.

For the case of installations developed according the Article 47 of the General Electricity Law, connections within the mandatory area of two hundred (200) meters, will be made by the Distribution Company without request of the reimbursable contribution to the user."

In order to promote new electrification projects and to clarify confusions between distribution companies and persons in the rural areas mainly, in 2009, CNEE actualized the values that the distribution companies can charge for these new connections through resolution No CNEE-02-2009:

Table 5: Reimbursable Contributions for Rural Electrification Expansion

TYPE OF CONSUMER	REIMBURSABLE CONTRIBUTION	
Consumers connected in low voltage with a contracted demand of less than 11Kw.	US$10.00	
Consumers supplied by a medium voltage grid (13.8Kv) with a contracted demand of more than 11Kw.	US$50.00 (Connected in Low Voltage)	US$100.00 (Connected in Medium Voltage)
Consumers supplied by a medium voltage grid (34.5Kv) with a contracted demand of more than 11Kw.	US$75.00 (Connected in Low Voltage)	US$125.00 (Connected in Medium Voltage)

In conclusion, it is considered that under the reformed regulatory framework approved in1996, Guatemala has been successful in the construction of rural electrification projects, due to a combination of a well defined regulatory structure, founded on a new Electricity Law, that defines the most important aspects regarding the State and the distribution companies responsibilities in relation to rural electrification, and the implementation of a transparent and well funded rural electrification plan (the PER).

Nevertheless, it is no secret that today, Guatemala still has approximately 15% of its population without electricity access, so CNEE is working on different innovative mechanisms, which will be the subject of another case study, which have the objective of contributing to reach the goal of electrifying these communities in the lowest possible time.

It is certain that many of the countries represented in ICER still have millions of homes, in thousands of communities, mainly in the rural areas, with no electricity access. This case study, although with summarized information due to its nature, it´s intended to help those country's authorities, with practical examples on how one country with limited resources, but with a great desire to help its inhabitants through electricity service expansion, carried out a reform in its regulatory framework to serve as a foundation to this effort and with this basis, designed and implemented a successful and innovative rural electrification plan, with seed founding from the privatization of the distribution assets in the country.

2. Transmission Infrastructure Expansion: *Reforms to the Regulation, Long Term Planning and Auction Mechanisms in Order to Promote Investments in Transmission.*

As explained before, the demand for electricity in Guatemala started to grow at a fast pace since the democratic era started in 1985, for the following 20 years, this demand growth required considerable new investments in generation, transmission and distribution infrastructure. This case will focus in the transmission system[10] infrastructure expansion in the country and how the regulatory authority responded to a series of complicated problems the transmission system was facing because no major investments were performed for many years.

The lack of investments in the transmission system was causing the following problems:

- High level of technical losses: According to the statistical report of the Wholesale Market Administrator, the losses in the transmission system in 2010 were in the order of 289.39 Gwh, representing 3.5% of the energy consumed and making the losses the highest single "consumer of electricity" in the country .[11]
- Low reliability of the electricity grid: Making it vulnerable to regional and national power outages[12]
- Lack of redundancy in the system: The system is radial, with no redundancy loops or "rings", making it vulnerable to outages.
- Low quality standards in the service provided: The quality of the electricity service to the final consumers was affected.
- Unsatisfied demand in parts of the country due to restrictions in the transmission system: The expansion of rural electrification plans was restricted and new industrial and commercial investments in many parts of the country were not possible because no transmission infrastructure was available or the available one was saturated.
- Restrictions in the economical dispatch of the generation plants: Guatemala's electricity market is based on a marginal cost dispatch founded in the operation of the system at a minimum cost. Restrictions in the existing transmission system caused that in some cases this criteria couldn't be satisfied.
- No incentive to the installation of efficient power plants that utilize renewable resources: A large portion of the renewable energy potential is located far from the existing transmission system (hydroelectric, eolic and geothermal), discouraging investors that have to associate to the construction of their power plant, the construction of big transmission lines with its respective cost.

10. A Transmission System is defined in article 6 of the Electricity Law as: The group of transformation substations and transmission lines between the generation delivery point and the point of off-take by the distributor or large customer, it consists of the main and secondary transmission systems.
11. Informe Estadístico 2010.
12. Between January of 2008 and October 2009, seven national power outages or national "blackouts" were registered due to failures in the transmission system.

Before the electricity sector was reformed in 1996, as explained before, one of the main reasons that transmission infrastructure was not built was that the State Utility, INDE, that should have been the entity in charge of this, was vertically integrated, with cross subsidies between generation, transmission and distribution, and had a difficult financial situation because the electricity tariff it charged to consumers was not determined in a technical and economical way. The costs recuperated through tariffs were not sufficient to invest in new, relevant, transmission infrastructure. Before 1996, the development of transmission infrastructure was not open to private investments, so the situation was critical, as INDE couldn't build the entire required infrastructure.

After the reform of the sector, the first article of the Electricity Law established that once the respective authorization was obtained, anyone could perform the activity of electricity transmission. It was expected that with this, the investments in new transmission infrastructure would flourish, but this didn't happened…

It didn't happen because of a number of reasons; some of the important reasons are the following:

- There was no centralized and mandatory planning of the required expansions of the transmission system, with a long term view.
- The process established in the Regulation of the Electricity Law, specifically in article 54, established a complicated way to carry out the extensions of the transmission system and the public auction for its construction. This provision of the Regulation didn't provide an efficient incentive for this to happen .[13]
- The associated risks of constructing a transmission line were perceived as high by investors: The most important risks perceived were obtaining environmental approvals and obtaining the rights of way for the construction of the infrastructure.
- The State utility, INDE, who was the owner of the transmission infrastructure in the country, and who, by its own nature, should have been the entity interested in building more infrastructure, didn't had the resources to build it because a large part of its revenues were still destined for subsidizing electricity tariffs.

With these problems in mind, and having the urgent need to build more transmission infrastructure in Guatemala, a modernization of the Regulation of the Electricity Law was made in 2007. In the following paragraphs, the modernizations that are considered relevant for the promotion of new investments in transmission infrastructure will be explained.

As explained in the first point above, there was no centralized and mandatory planning of the required expansion of the transmission system, with a long term view. In response to this, and being convinced that a long term planning of the expansion of the system was essential for the future, the modernized regulation established the following:

First, it established that the construction of new transmission lines or substations could be made through the following modes:

1. By agreement between the parties.
2. By own initiative.
3. By public tender or auction mechanism.

This paper will explain the last of the three modes, because in practice, when combined with the Expansion Plan of the Transmission System, it is considered as the most relevant in the effort to aggressively expand the transmission infrastructure in Guatemala.

However, to briefly illustrate modes 1 and 2 of the previous paragraph, the regulation establishes that those interested and requiring the expansion, have to submit the petition for the authorization to CNEE and must include basic information like the description of the installations to be incorporated, technical studies verifying that the proposed installations are appropriate in accordance with the technical standards approved by CNEE and electrical studies evaluating the effect of the new installations on the current transmission system.

For expansions agreed between the parties and by own initiative, those interested can build, operate and maintain the installations destined to electric transmission and are allowed to agree with one existing carrier the property, the price and payment conditions for the construction, operation, and maintenance of the new installations.
In relation to mode 3 above, it was established that the enlargements or expansions that resulted necessary from the Expansion Plan of the Transmission System, should be constructed under a public auction mechanism and that the bidding documents will indicate the requirements that shall be fulfilled by those interested and those awarded with the contract.

13. Article 54 of the former Regulation of the Law established that a group of participants of the Wholesale Market Administrator, called the "initiators", could propose to CNEE the construction of new transmission infrastructure, and that the cost of this should be shared by all generators. The proposal had to include a study that showed how this new infrastructure would benefit all the generators. Then, CNEE had to ask the rest of the generators if they wanted to pay for this new infrastructure, and if generators that represented 70% of the firm capacity installed in the country agreed, then CNEE would authorize the "initiators" to make a public auction to build the transmission infrastructure. As it can be seen, the former process was complicated and not congruent with the public interest. With the former structure, existing generators didn't have the incentive to propose, or "approve" the construction of new transmission lines that, for example, would incentivize the participation in the market of new, more efficient, generation companies that used renewable resources, as they would represent competition.

For the development of the much needed Expansion Plan of the Transmission System, the Ministry of Energy and Mines must create a Specialized Technical Entity entitled to elaborate the Plan[14] . The regulation establishes that The Expansion Plan of the Transmission System should be prepared every two years, and should cover a minimum period of ten years. The Plan should take into consideration generation projects in construction, and those that will come into operation within the scope of time of the mentioned study.

To elaborate the Plan, the Wholesale Market Administrator will provide technical advice, consisting in technical studies and necessary information that may be required to model the behavior of the transmission system, including its current characteristics and restrictions.

The Specialized Technical Entity will determine the most likely scenario of generation expansion and interconnections, hearing current and prospective generators. Any participant of the Wholesale Market is allowed to request the inclusion of transmission lines in the Plan, submitting the studies showing the benefits that may be obtained in the system from the inclusion of their transmission lines or substations.

The modernized regulation also establishes that CNEE will elaborate technical standards for the development of the Plan. Independently from the level of voltage, the new infrastructure must comply with the criteria, methodology and definitions stipulated in the Transmission Technical Norm (NTT from its initials in Spanish) issued by the Commission. The NTT must consider an efficient scenario of electricity supply to satisfy the future demand of the system, minimizing:

- The updated and total cost of investment and operation of transmission works that must be executed, including the losses in the lines.
- The variable costs of the operations of current and future power generation plants, but not the investment or fixed costs of operation and maintenance.

When the process of the elaboration of the Plan is over, it has to be published by the Ministry of Energy and Mines in the first fifteen days of January of the respective year.
In Guatemala's infrastructure sector, not only in electricity but in roads, airports, ports, etc., there is an abundance of beautifully edited "long term plans", that most times highly paid international experts have coordinated, filled with many good intentions and ideas as to what infrastructure needs to be constructed, including budgets, schedules, etc. But in practice, the majority of those plans are inside a drawer or a file or a warehouse of the institution that has elaborated them and they have not serve in practice for the development of the required infrastructure.

So the main point, although important in the case of Guatemala, might not be on how to elaborate a Plan for the expansion of transmission infrastructure, but how to efficiently build the infrastructure defined as necessary in such Plans and make their construction a legal obligation.

An important decision that CNEE took, in regards to elaborating the Plan, was that it employed its own staff to elaborate it. CNEE bought the necessary software, it hired the required technical full time staff and, only when necessary, consulted outside experts. This caused the internal team to be motivated and to be highly compromised in the development of an efficient and realistic technical Plan with a long term view. The team knew, from the beginning, that their success was not going to be measured by the amount of paper they generated in the Plan, but by the final results in the field, in other words, if the infrastructure contemplated in the Plan was built. To make this happen, going from a Plan to building the infrastructure, not only did the internal team at CNEE was motivated, but the tools to do the Plan and the auction for the construction of the planned infrastructure were available under the modernized regulatory scheme.

The reformed Regulation of the Law establishes that in the following two months after the publication of The Expansion Plan of the Transmission System, the Commission will determine the infrastructure that will be part of the Main System[15], using information provided by the Wholesale Market Administrator and taking into account the following criteria:

- Specific use or activity of the transmission works, independently from the level of voltage.
- Guarantee of free access to the transmission grid.
- Contributions and benefits derived from the proposed infrastructure to the operations of the Wholesale Market.
- Congruence with the energy policy of the country.
- International agreements for electrical integration.

14. In practice, what happened was that the responsibility was assigned to CNEE, an although it is considered that in theory the regulator should not be the one responsible for plans of this type, in practice, it was the only institution that had the resources and the knowledge to diligently perform the task and the results have been successful to the moment. Up to date, CNEE is still the entity responsible for the elaboration of the Plan.
15. Article 6 of the Electricity Law establishes that the Main System is the transmission system shared by electricity generating companies and that the Commission will define this system, in accordance with a report delivered for this purpose by the Wholesale Market Administrator.

Transmission infrastructure for private use is excluded from the Main System[16]. The construction of the infrastructure that is identified as part of the Main System and necessary for the following two years must be auctioned and contracted through a public and transparent mechanism.

CNEE, within the following three months from the definition of the mandatory execution works, has to elaborate the bidding documents for the open and public auction mechanism, and file them before the Ministry of Energy and Mines for approval. The Ministry has one month for the final approval of the documents and six months to perform the auction[17].

The bidding documents have to include the criteria and procedures to evaluate that the participants in the auction have the experience and financial capability to perform the projects, and also, the mechanisms to evaluate and award, in a transparent and competitive way, the yearly fee that they offer for designing, building, maintaining and operating the transmission infrastructure, always with the basis of minimizing the cost. This annual fee is called the "canon" and the Commission, prior to the final award of the contracts, has to decide about the admissibility or inadmissibility of the value of the canon expected to be transferred into electricity tariffs.

The reformed regulation establishes that for transmission infrastructure constructed under the auction mechanism, the transmission company that is awarded with the contracts will be allowed to charge a wheeling fee that will have two remuneration periods:

1. The Amortization Period: In which the transmission company will receive as sole remuneration the annual fee or "canon" offered and awarded, which will be paid in proportion of the firm power capacity of the system and will be divided into twelve equal amounts to be paid in a monthly basis. This is a fifteen year period.

2. Operation Period: Will be the subsequent period to the amortization period, in which the transmission company will receive, exclusively, the wheeling charges corresponding to the transmission Main System approved by CNEE[18].

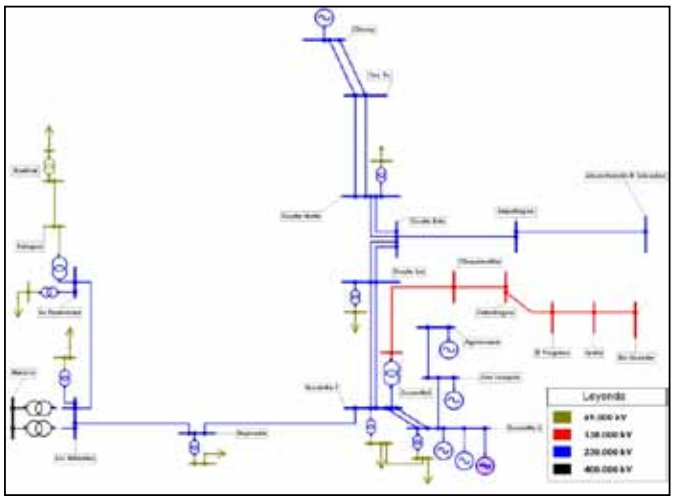
The Ministry, based on the determination of CNEE, can award the contract. The award should include the granting of the authorization as a transmission company[19], if necessary, and the awarded company shall comply with all the requirements of the Law.

With this regulatory framework in place, which was approved in 2007, CNEE completed the "Transmission System Expansion Plan 2008-2018" or "PET" in August 2008[20], which included all of the transmission lines and power substations that needed to be constructed in that period.

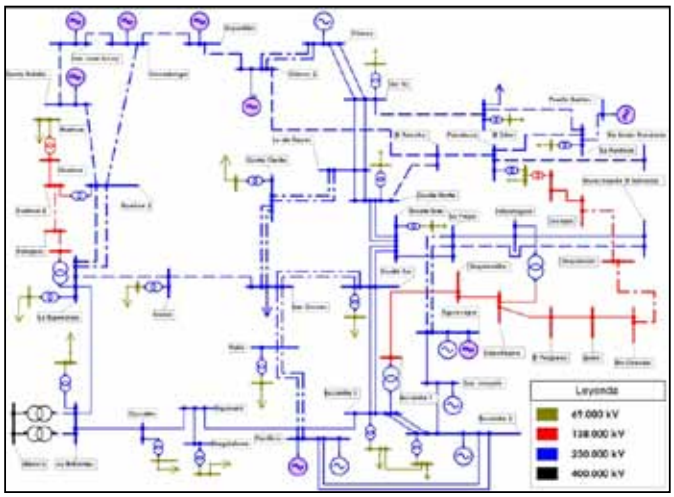
In the following single-line electrical diagram of the main transmission system in Guatemala, the current situation of the system is showed in the left, and at the right, the situation after the construction of the six transmission rings established in the PET, and its associated substations, is showed. The objective is to create six redundancy rings in the main transmission system through the construction of the works established in the PET.

16. Article 65 of the Electricity Law establishes that every generating company connected to the National Electric System is obliged to build the transmission facilities to transport their energy to the Main System, or shall pay the wheeling charges of secondary facilities for that purpose.
17. In practice, what happened was that the auction was designed and implemented by CNEE because it was the institution with the resources to perform the task. Up to date, CNEE is still the entity responsible for the design and implementation of future auctions.

2011



2013, after PET



The PET stipulated a group of new transmission facilities to be built with the objective of converting Guatemala's transmission system from a radial network into a loop network, better suited to cope with contingencies and to supply the increasing demand for electricity. It determined the construction of 17 new double circuit 230Kv transmission lines with a length of approximately 850 kilometers, 12 new power substations as well as renovations to 12 existing power substations[21]. The estimated investment for the construction of this infrastructure was around US$500 million, an investment amount without precedents in the history of the country. Because the amount of infrastructure to be built was considerably large, the works were divided in six packages, to be awarded in six contracts with duration of fifteen years. In the history of the country, it was the first time that this amount of new transmission infrastructure would be built at one time, and it meant that the existing transmission infrastructure will be doubled in capacity in as little as 3 years. The six contracts stipulated the construction of the infrastructure described in this paragraph and represented with a dotted blue line (230Kv lines) and blue triangles (power substations) in the following figures[22] :

18. According to the regulation, the wheeling charges for the transmission system are set by CNEE, with the only exception of the annual "canon" that is publicly auctioned and fixed for a 15 year period, if awarded in an auction process. The wheeling charges are based on efficient costs and the concept of "new value of replacement" and economically adapted infrastructure. The term "economically adapted" refers to a system dimensioned in such way that minimizes the total costs of investment, operation and maintenance; and also reduces the transmission losses (Articles 67 of the Law and 1 of the Regulation of the Law). Article 69 of the Law establishes that the wheeling

Figure 7: Transmission Infrastructure to be Constructed under the Auction Mechanism

Contract (Lote)	Switchgear Substation	Power Substation	Transmission Lines	Length of Lines KM
A	2	4	5	88
B	3	1	5	195
C	0	1	1	102
D	0	1	2	186
E	0	1	1	115
F	0	1	3	140

The main goals and benefits of the "Transmission System Expansion Plan 2008 – 2018" are:

- To increase the reliability and improve the quality of supply of electricity in the country by minimizing the frequency and length of failures (general or partial blackouts) by modifying the grid, which currently has a radial topology to a loop or ring topology.

- Promote investments in new electricity generation power plants based in renewable resources, which are located far away from the main consumption locations, aiding in the process of transformation of the energy matrix of Guatemala.

- Estimated savings of US$523 million.

charges for the use of the main transmission system have to be set by CNEE every two years.
19. A Transmission company is defined in the Law as an individual or legal person owning a facility for electricity transmission and transformation. The authorization for transmission is necessary, when for the construction of the lines and substations, public property, in total or in partial form has to be used; or when rights of way have to be imposed to particulars. This requirement subsists even if the use of public property or the rights of way are only in one section of the route of the works.
20. The complete Plan can be accessed at: http://www.cnee.gob.gt/PEG/PEG%20Library.html
21. The detailed scope of work for the awarded company included: terrain identification and selection for the

Table 6: Estimated Savings with the Construction of the New Transmission Infrastructure

SAVINGS	Amount (millons)
Reduction of operation of fossil fuel power plants	US$237
Reduction of grid losses	US$110
Reduction of marginal cost in the system	US$176
Total	US$523

On December 2009, CNEE launched the first bidding process for six build, own and operate (BOO) contracts for power transmission infrastructure. The bidding process was designed in accordance to the provisions in the regulatory framework explained above and was a crucial effort to go from paper (the Plan) to the field (building the infrastructure). The local newspapers reported both the news about the conclusion of the transmission plan and the launch of the auction as it can be seen in the following figure.

NEGOCIOS

Terminan plan de transmisión eléctrica

Energía Se necesitarán US$504 millones para ampliar en mil 393.4 kilómetros la red de transporte eléctrico del país, según resolución

CNEE licitará en 2009 obras de transmisión

A fundamental element that was present throughout all of the process was that all of the information regarding the Plan, and the auction, was made public through its publication in the official newspaper (Diario de Centroamérica) and trough the local news, because the media was always invited to the important events realted to the process. This is considered a very important step in the success of the project, as the transparency and credibility of the process was enhanced with this publicity.

construction of new substations, acquisition of the rights of way and identification and selection of the final path for the construction of the transmission lines, basic engineering process for the electricity transmission infrastructure, detailed engineering for the infrastructure, development of the environmental impact studies, construction and other licenses procurement, fulfillment of all laws, rules, criteria, standards and policies that apply for this kinds of projects, final design and construction of the transmission infrastructure according to the standards approved by CNEE, commissioning of the works, grant access to the facilities and information to CNEE, the Ministry and the Supervisor and operation and maintenance of the facilities.

22. "Lotes A-F" represents the six different packages or contracts and its associated infrastructure.

The bidding process was developed on the basis of the guidelines of the Transmission Technical Norm or NTT, which was published in the official newspaper of the country in February of 2009, through resolution CNEE-28-2009. The main goal of this process was to obtain the lowest annual fee or "canon", as explained above, for the design, construction, acquisition of rights of way, supervision, operation and maintenance of the transmission infrastructure required in the "Transmission System Expansion Plan 2008-2018".

According to the bidding documents, the process should conclude in the award of the contracts to those bidders whose offers complied with the legal, administrative and financial requirements established in the bidding documents and to those who offer, in the auction process, the lowest annual fee for the 15 year contract.

To make this happen, a detailed analysis as to which might be the most efficient auction mechanism was performed by CNEE's team.

After carrying out several simulations of the auction process in controlled environments in a local university laboratory, under the Experimental Economics umbrella, the best possible auction mechanism for the conditions of the Guatemalan electricity market was determined.

Due to the potential synergies for bidders, CNEE employed a combinatorial procurement auction so more than one contract could be awarded to accommodate the interests, capabilities, and operating and financial conditions of each possible bidder. A combinatorial auction is an auction in which a bidder can make bids for a combination of "packages" as opposed to bidding only on individual items. According to theory, combinatorial auctions have been used in the past to procure different services. To the best of the knowledge of a group of researchers working for CNEE, this was the first time a combinatorial auction was used to assign BOO contracts for electricity transmission facilities. As a result of the experiments in the controlled environment, CNEE, with its in-house team, designed and built a model to implement the auction mechanism, the model was called Combids. This model, and the auction process, was audited by an external firm called Deloitte, in order to guarantee the transparency of the results. The audit company also developed a model that was used in parallel the day of the auction.[23]

Experimental and field evidence also suggested that sealed offer procurement auctions tended to be more resistant to collusion and anti-competitive strategic behavior than ascending or descending procurement auctions with multiple rounds (dynamic mechanisms), so it was determined as a sealed offer auction[24]. An important condition that guaranteed transparency and publicity was that on the same date, the firms will have to present two sealed envelopes: one with the technical offer, where they had to guarantee with formal documents that they met the pre-defined technical and financial capabilities of the company, and another, with the economic offer, or the "annual fee" that they wanted to charge. The first envelope was revised by CNEE's team for two weeks to oversee that the companies met the pre-defined requirements to present an economic offer, and the second one was taken in custody by a local bank and stored in their safety vault for the duration of this two weeks and later given, unaltered, in a public event, to CNEE's team on the pre-defined date where they would be opened if the company met the technical standards.

The auction process was promoted at several international events in order to have more participants and more competition. On April 29 of 2009, in the City of Houston, Texas, during the "Seventh Latin-American Leadership Forum", in which the 50 best infrastructure projects of the region were presented, the "Public Auction PET 1-2009 for the Construction of the Transmission Infrastructure in Guatemala", presented by CNEE, was awarded the first place as the "Financial Project of the Year". This award recognized the project's innovative financial mechanism (combinatorial auction) and the possibility that this mechanism could be replicated in other parts of the region to promote infrastructure development.

Three transmission firms presented a final offer. After complying with all legal, administrative and financial requirements the auction took place. The six contracts were successfully awarded to a Colombian firm, specialized in building and owning transmission infrastructure. The awarded annual fee or "canon" was US$32.34 million, a value considered as efficient and that was considerably lower than the next equivalent offer (for the six packages) of US$68.66 million from the second company and the offer of US$20.69 million for the construction of just package F from the third company!

23. Deloitte, the independent audit company concluded that: "…As a result of the revision, according to the scope and nature of the work previously mentioned, and since there was no evidence of deviations before or during the process of the Auction of the Electric Energy Transmission Works considered in the Transmission System Expansion Plan 2008-2018, specially in the process that was carried out on December 11, 2009, no significant aspect has called our attention to make us consider that the norms established by Comisión Nacional de Energía Eléctrica (CNEE) have not been complied during such process".

The *combinatorial procurement* auction mechanism with a sealed offer was successful in allowing participation from bidders whose constraints allowed them to opt for a single contract, as well as bidders interested in either all of the contracts or none at all. The flexibility of the bidders who could be accommodated by the procurement auction mechanism was crucial in attracting multiple bidders of different types: two international consortia interested in large packages of contracts and one local player (with financial constraints). As theoretical and empirical considerations have shown, attracting bidders is of central concern to practical auction design, and, under some standard assumptions, the value of a marginal bidder is usually high.[25]

Following is a summarized series of events that led to the successful award of the six contracts, the discipline in following a pre-defined schedule of activities and the transparency and publicity of all of the events were important elements to the success of the project:

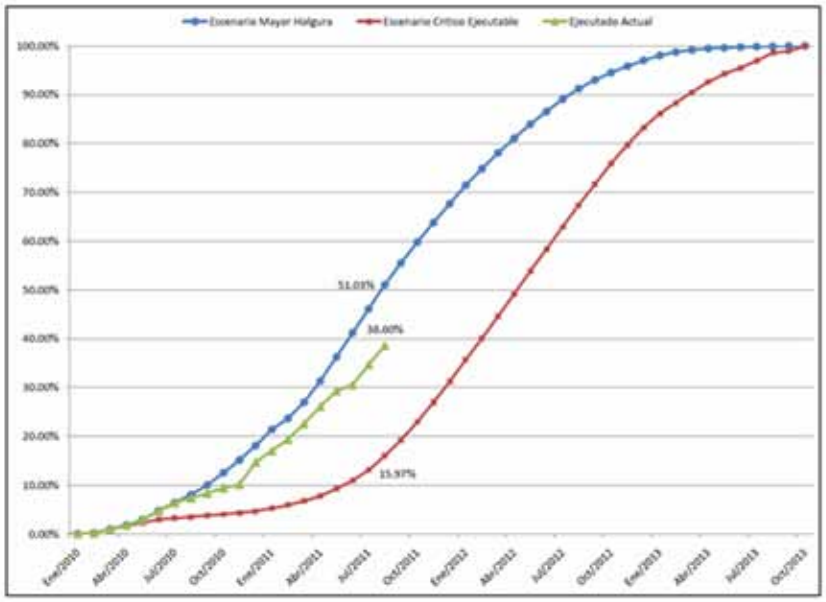
DATE	ACTIVITY
March 13, 2009	Approval of the Terms of Reference for the bid, through Resolution CNEE-43-2009 , and release of the Open Bid (Auction Process) PET-1-2009 for the construction of the works indentified in the PET, announced in Guatecompras (NOG 742676) and CNEE's web site.
April 7, 2009	Approval of Addenda 1 for the Terms of Reference Open Bid PET-1-2009 through Resolution CNEE-67-2009.
April 21, 2009	Publication of the public bid for the "Contract for the Supervision of the Construction of the Works Identified in bid PET-1-2009" in Guatecompras (NOG 761397).
April 23, 2009	Publication of the bid for the "Contract of the Specialized Company for the Valuation of the Real Estate that will be Affected by the Construction of the Works Identified in bid PET-1-2009" in Guatecompras (NOG 762369) .
June 10, 2009	First public informative meeting for open bid PET-1-2009.
July 21, 2009	Publication of the bid for the "Contract of an Audit Company for the Bid Process and all of its Processes and Procedures" in Guatecompras (NOG 822280).
August 14, 2009	Approval of Addenda 2 for the Terms of Reference of PET-1-2009 Open Bid through Resolution CNEE-151-2009.
August 28, 2009	The Supervision Services of the six packages is awarded to a specialized international firm through Agreement CNEE-144-2009, published in Guatecompras.

24. Information from: "Use of a Combinatorial Auction to Allocate 6 BOO Power Transmission Contracts: A Case Study about Guatemala". Authors: Argueta (CNEE), Aycinena, Castro (CNEE), Córdova, Moscoso (CNEE) and Morataya (CNEE). April 2010.
25. Idem.
26. All resolutions mentioned in this document can be accessed at www.cnee.gob.gt
27. Guatecompras is a website where the procurement of all goods and services of the State are announced.
28. One of the main concerns of investors was that they didn't have enough information as to how much the affected land (rights of way, etc.) will cost in practice so this study was contracted by CNEE so investors would have more information.

DATE	ACTIVITY
September 9, 2009	The Audit services are awarded to Deloitte trough Agreement CNEE-145-2009.
September 10, 2009	The second informative meeting for PET-1-2009 Open Bid takes place.
October 23, 2009	Approval of Addenda 3 for the Terms of Reference of PET-1-2009 Open Bid through Resolution CNEE-176-2009.
October 27, 2009	The third informative meeting for PET-1-2009 Open Bid takes place.
November 6, 2009	Approval of Addenda 4 for the Terms of Reference of PET-1-2009 Open Bid through Resolution CNEE-201-2009.
November 27, 2009	Presentation of Technical and Economic Offers for bid PET1-2009 by three firms.
December 11, 2009	The opening, evaluation, auction and award of the economic offers takes place publicly.
December 16, 2009	CNEE determines that the US$32,349,900 “annual fee” offered by the winning company is efficient and that the process can be awarded.
January 20, 2010	The Ministry of Energy and Mines awards the contract for the construction of the transmission infrastructure through resolution 147.
February 22, 2010	The Ministry of Energy and Mines and the winning transmission company sign the contract for the authorization of the execution of the project.

Construction of the infrastructure began in August 2010 and all of the transmission facilities should be finished by October 2013. A specialized supervision company was hired to oversee the progress of the projects and to ensure that the schedule is met. At the moment (September 2011), the progress is represented in the following graph, the green line represents current progress and the blue and red lines represent, respectively, the maximum and minimum progress allowed:

Graph 2: Current Progress of the Projects



The construction of the previously described transmission infrastructure will bring many benefits to the country because:

- The estimated reduction of electricity transmission losses will represent savings of approximately US$110 million for a ten year period.
- The reliability of the electricity power system will be enhanced by having redundancy through the transmission loops.
- The new transmission lines will facilitate the introduction of new renewable energy power plants that are expected to cause an estimated reduction of more than US$400 million in the spot price of the electricity market for a ten year period.
- The transmission facilities were designed so new power plants won't need considerable additional investments in order to connect to the main transmission system to sell their electricity.

Although it is considered that it shouldn't be the regulator's responsibility to do the planning of the expansion of the electricity sector, in the long term, in the case of Guatemala, due to its reality at the time, the regulator was successful in doing the plans, the design and the implementation of an efficient auction mechanism to attract much needed investments in the electricity transmission field. Some of the important practical lessons learned in the process are:

- Developing transmission expansion plans with a long term vision is of upmost importance to the efficient development of the electricity sectors, independently if the markets are vertically integrated through State owned monopolies or open and competitive markets like in the case of Guatemala.

- In the case of Guatemala, investing resources in hiring qualified local professionals and technical staff and buying software to perform a technical and independent

plan of the expansion of the transmission system was an excellent decision and the cost – benefit ratio was extremely positive to CNEE and the country because of the many benefits the infrastructure will have in the future.

- It is possible, even in developing countries, to design and implement mechanisms, like the auction process described in this case, to go from plans in paper to reality, trough the construction of the planned infrastructure.
- The publicity and transparency of both the processes of doing the plans and the auctions is fundamental for their success. Doing both tasks independently and in a technical way, with the objective of satisfying the public interest by aligning the private participants with this goal can be possible and efficient results can be obtained if the processes are correctly designed.
- Applying experimental economics helped to design an auction mechanism more resistant to collusion and anti-competitive strategic behavior from participants.
- Most regulators are not in charge of the planning of the expansion of the transmission infrastructure[29], but they should encourage the respective authorities to do this and to design innovative mechanisms to construct infrastructure with the objective of having a more efficient and competitive electricity market in their countries.
- Transmission infrastructure has to be constructed and available first. Then, the investments in efficient generation power plants of considerable size that utilize renewable resources will flourish.

C. Introduction of New Technologies to the Grid

As mentioned before, the theme of integrating new technologies to the electricity grid is of upmost importance for the future of electricity markets; however, in order to integrate them, the grid needs to be efficiently constructed and available first. Once the grid is constructed, integration of new technologies is possible and desirable, as it will benefit the consumers with a more reliable service, both in the technical and commercial field. This document has the objective of describing practical lessons related on how to build the infrastructure in a developing country so then the introduction of new technologies can take place.

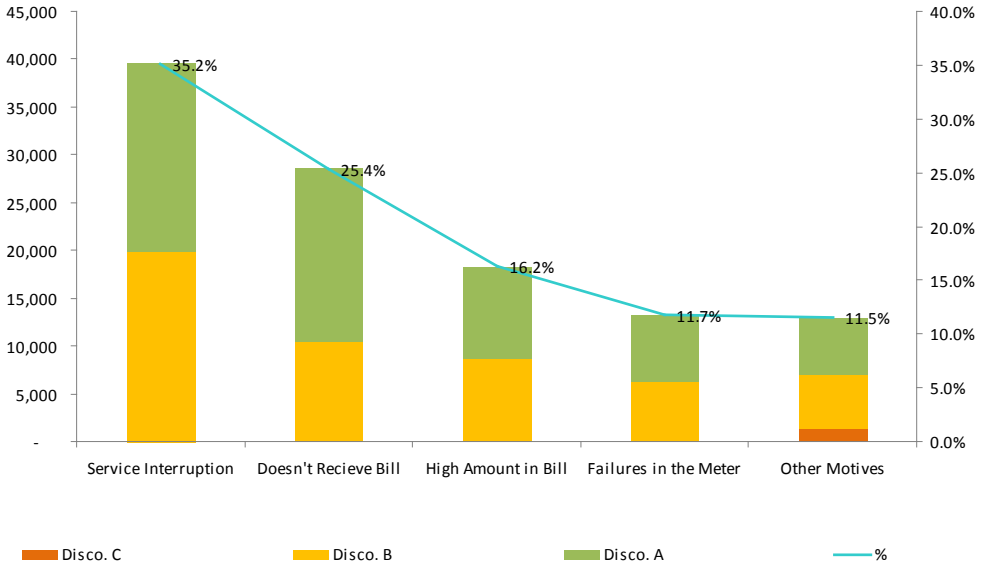
- Introduction of new technologies to the transmission grid will be possible once the infrastructure is constructed and should be encouraged by regulators.

The development of this new transmission infrastructure, combined with the long term generation expansion plan, that has the objective of producing more than 70% of the electricity in Guatemala with renewable resources by the year 2022, will also help the environment, by reducing millions of tons of CO2 and related gas emissions and reducing the import of millions of barrels of fossil fuels[30].

29. As mentioned before, the case of Guatemala is considered atypical, but at the time, and because the construction of the infrastructure couldn't wait, it was decided that the regulator, CNEE, should do the job, as it was the only entity in the country with the technical capability to do it. The results show that the decision was correct.
30. From: "Planes de Expansión, Sistema Eléctrico Guatemalteco, una Visión a Largo Plazo". Comisión Nacional de Energía Eléctrica, 2008. Available at: http://www.cnee.gob.gt/PEG/Biblioteca%20PEG.html

The following graph, constructed from official information from the Quality Assurance Division at CNEE, shows the amount of complaints, and source of the complaint, of the clients of the three largest distribution companies in Guatemala in 2010.

Graph 3: Amount of complaints, and source of the complaint, of the clients of the three largest distribution companies in Guatemala in 2010



As it can be seen, the highest number of complaints is related to a technical parameter regulated in the Electricity Law: service interruption (35.2%); followed by three commercial parameters: people complain they don't receive their bills, or they don't receive them in a timely way (25.4%), the amount billed is "high" (16.2%) and failures in the meter (11.7%).

Having this information in mind is very important at the moment the distribution companies decide which new technologies should be introduced to their grid and also when the regulator aligns the behavior of these companies, with the public interest, through the regulatory mechanisms, in this case, enforcing that the companies meet the technical and commercial parameters established in the Law. If the signals sent by the regulator are efficient, the distribution companies will be incentivized to invest in new technologies that will help them satisfy their clients and comply with the regulation. As it will be explained in this section, the prioritization in the design and the investment in the introduction of new technologies in Guatemala have taken into consideration the information shown in the graph above, so as to improve the quality of service the clients receive.

The regulatory framework in Guatemala allows the distribution companies to integrate new technologies to their grid, for example, in the commercial area[31]. In the following paragraphs, some of the new technologies that have been incorporated in the distribution grid in the country are explained.

Probably the most number of new technologies incorporated to the distribution and transmission grid in Guatemala, are related to automation of the systems, in order to reduce service interruptions, that as shown in Graph 3, it's the highest source of complaints by the clients of the distribution companies. Automation is defined as "the technique of making an apparatus, a process, or a system operate automatically" or "automatically controlled operation of an apparatus, process, or system by mechanical or electronic devices that take the place of human labor"[32].

31. Article 96 of the reformed Regulation of the Electricity Law establishes that: "…The distribution company, in order to benefit the user and in order to be in accordance with technical advances, can perform the measuring and collection of payments for consumption, or for other concepts, with new systems and technologies, previously authorized by the Commission. To this effect, the distributor shall submit the documentation or digital means containing all the detailed information about the proposed model and the system to be used."
32. From: http://www.merriam-webster.com/dictionary/automation

In relation to the distribution service, the objectives of automation are related to the control, the monitoring and protection of the grid; as well as with the quality of service, lowering the time of response when failures occur. In the case of Guatemala, this helps the distribution companies because the regulation establishes maximum values related to the average frequency of interruptions (FMIK) and total time of interruptions (TTIK) in their grid, and automation helps them to reduce these values, that in turn, helps them by having satisfied clients and being more profitable by not being penalized when the values are within the regulation.

Automation is applied in the substations and in its feeders, and in each level; it is supervised and controlled by a centralized dispatch and information center. In this dispatch center, the computerized systems are located and they are operated by a grid administrator from the distribution company. In the case of one Distribution Company, this person is responsible for 55 substations and 163 feeders. With the help of the communications system, the dispatch center can obtain information from all of the distribution system and also activate automation functions in the substations and feeders.

The automation functions in the substation are very important as this is the most important element of the distribution system because it contains the main transformers, circuit breakers, etc. In the case of Guatemala, the control automation is related to the automatic control of the breakers and re-closers, the ground fault systems in the transformer and the rest of the substation.

In regards to supervision, the automation functions are related to monitoring the voltage, current, power factors, etc.

The feeders are also important elements of the distribution grid, so in the case of Guatemala, new technologies have been implemented with the objective of identifying failures and protecting the grid through the isolation of the failed area, also reducing the areas without electricity service. This has led to an increase in the levels of quality of service. It's important that regulators encourage distribution companies to invest in new technologies related to automation in order to reduce the frequency and duration of failures in the grid.
Because the resources are always limited, especially in developing countries, the location of the automation devices must be prioritized taking into consideration the following criteria:

- Importance of the load that a circuit is supplying, so in case of failure of its main feeder, the load can be saved.
- The type of load served, dividing the rural load and the urban load.
- Length of the circuit and size of the load, prioritizing long circuits.

In automation, it is always important to have an efficient communications system for the transmission of control and information signals. In recent years, new technologies have been incorporated to the control of the grid with the addition of radio, telephone, optical fiber and hybrid communication systems. Information from the grid are collected through a SCADA system (Supervisory Control and Data Acquisition) and after analyzing them, the operator in the dispatch system makes decisions that are sent as control signals to the automation devices.

In the case of Guatemala, it can be concluded that the integration of new technologies related to automation have led to a reduction in the cost of the system by not having personnel in all of the substations[33] higher security in the system and better quality of service, reducing the complaints of the users.

Another area were the introduction of new technologies has been important is in the area of improving the quality of commercial service. As explained before, three of the first four highest complaints by clients of the distribution companies are related to commercial service, specifically to the reading of the electricity meter, failures in the meters and the invoicing or billing process. Users complain that the amount of kilowatt-hours that they are being charged in their invoice is not correct and also that the tariff applied is not the approved tariff.

To deal with these problems, some distribution companies have introduced the technology of handheld electricity meter readers and utility billing software. According to information from the distribution companies, the process of meter reading through handheld devices and on site billing starts with the annual planning of the routes of meter reading and billing. Later, this is information is detailed in a monthly program and a daily execution plan:

- Detailed information of the route corresponding to the day, the numbers of the meters and of the accounts that correspond to the users to be billed, and other miscellaneous information, is introduced to the handheld readers each day.
- The daily activity of reading the meter and on site billing starts between 6 and 8AM, depending on the location.
- The average time of the route is 5 hours, without taking into account the time it takes to pick up and return the handheld device.
- In the field, the person with the handheld device only has information related to the number of the meter and the address. After he types the values read (many meters are still analog) the billing software makes a validation and compares the typed reading with the average consumption of the user for the last 6 months. If the typed value is inside an acceptable range, the software asks if the bill has to be printed, if it is outside the range, it asks the person to confirm the reading and if the bill can be printed. The average process of reading the meter, typing the value and printing the bill takes nine seconds.

33. Additionally, in a study performed by INDE, it was concluded that the power substations with the lowest index of failures were the ones without personnel and that were automated.

- The person can also type in the conditions of the meter and if it needs to be changed (this helps in solving the fourth complaint shown in the graph above).
- The person also carries a backup printed list with the number of the meters and the addresses in case he needs to do the process manually.
- The handheld device is returned to the distribution companies were the information is downloaded to a computer so it can be verified.

From practical experience, the benefits associated with this technology are:

- In practice, the amount of complaints associated to the billing process have been reduced in the distribution companies that use handheld devices because the users receive the bill at the same time the meter is read, and they perceive the process as more transparent. They can confirm that the reading is correct, and if necessary, can make immediate comments; also they have more time to pay the bill.
- The costs of reading the meters and billing are reduced because the bill is given to the user on the same trip the meter was read and the bill is printed on site with thermal paper.
- The distribution companies collect their resources faster and more efficiently.
- Diminution in the amount of bill reposition and reduction of re-billing.
- More efficiency in the commercial process due to more filters to detect fraudulent consumptions on site and controls on the times the persons take to read the meters.

It is considered that the incorporation of new technologies to the grid is very important for the improvement of the final quality of technical and commercial service that the users of the electricity transmission and distribution grid receive. This case study has illustrated that in developing countries, learning how to prioritize investments is of upmost importance. In the case of Guatemala, not only did the priority was to expand the coverage of electricity service through the reforms of the regulatory framework and the execution of efficient rural electrification plans, or the expansion of the transmission system, but also to incorporate new technologies and efficiencies to the grid, of course, also prioritizing the investments, taking into consideration the social and economical realities of the country, to name two things.

In the case of the new technologies described above, because of their direct impact on the improvement of the quality of technical and commercial service, an important step was to start with the automation of the electricity distribution systems and improving some of the basics of the commercial service, like the reading of the meters and the invoicing process described. In other latitudes of the world, this might not be considered “new” technologies by some, and although the adjective “new” is subjective, there is no doubt that in the future, regulators should continue to make efforts to incentivize, through efficient regulatory mechanisms, and taking into account the concept of gradualism, the incorporation to the electricity grid of new technologies that serve the public interest, not only to incorporate them because is fashionable. The foundation of the incorporation of new technologies has to be that they are in line with the public interest.

IV. CONCLUSIONS

- The timely development of new infrastructure and the incorporation of new technologies are fundamental elements for the improvement of the functioning of any public service sector. Electricity markets and the public can benefit largely from this by having a more efficient, reliable and competitive public service.

- In order to integrate new technologies, the grid needs to be efficiently constructed and available first. Once the grid is constructed, integration of new technologies is possible and desirable, as it will benefit the consumers with a more reliable service, both in the technical and commercial field.

- It is important to contextualize the discussion about "integration of new technologies and development of new infrastructure", and differentiate what developed countries can do, are doing, and must do, and what developing countries can do, are doing, and must do. The prioritization of things that must be done is important, as the two groups of countries differ largely due to their realities.

- The reforms to open the electricity sector in Guatemala in 1996, and the further privatization of the distribution companies, contributed to the success in the construction of rural electrification projects, due to a combination of a well defined regulatory structure, founded on a new Electricity Law, and the implementation of a transparent and well funded rural electrification plan, that led to the doubling of electricity users in almost ten years.

- The long term planning of the expansion of the electricity transmission and generation infrastructure is essential for the public interest because it can help achieve efficiencies in the electricity market by identifying the needed infrastructure and then using this as a foundation for its construction.

- An important point in the case of Guatemala was to define efficient, practical and transparent mechanisms to build the infrastructure defined as necessary in the long term plans.

- The decision of using experimental economics to define efficient auction mechanisms to build transmission infrastructure proved to be an excellent decision by the regulator because it helped to design an auction mechanism more resistant to collusion and anti-competitive strategic behavior from participants.

- The publicity and transparency of both the processes of doing the plans and the auctions is fundamental for their success.

- In developing countries, learning how to prioritize investments related to the introduction of new technologies to the grid is very important.

- Identifying and having in mind the major sources of complaints by the users of the electricity service is important at the moment of deciding which new technologies should be introduced to the grid because it can improve the quality of service and reduce complaints.

- Regulators, having the public interest and the efficiency of the markets in mind, should continue to make efforts to incentivize, through efficient and transparent regulatory mechanisms, the construction of new infrastructure and the incorporation of new technologies to the electricity grid.

- A crucial element that needs to be present in all of the activities that regulators perform is the ethical values element. Having them as a foundation in all of the technical, legal and economical decisions that need to be taken will facilitate the regulators job.

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