

Experiences at the Electricity Control Centers in El Salvador and Nicaragua in the frame of the Electricity Industry Reforms

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Abstract: This paper gives a brief description of the concepts and goals of the Electricity Industry Reforms process with some references about the Central America context. It presents a brief description of the operation of the Electricity Control Centers in the competitive market as result of such Electricity Industry Reforms, where two main functions are treated, the System Operation and the Power Exchange Administration. Two Central American countries, El Salvador and Nicaragua, are specifically treated in this paper. The Electricity Industry organisation is given as context for both countries. The Electricity Control Center operation is explained for each of these countries. The operations of the Electricity Control Center in each country are presented using a novel functional model, based in intuitive graphical representation of the information flow. With this model approach the functions change under demands, because the reforms, can be added, placed, linked and documented. Some conclusions about the induced changes at the Electricity Control Centers in El Salvador and Nicaragua are considered.

Keywords: Electricity Industry Reforms, Central American Electricity Reforms, Electricity Control Center Modelling, Experiences in El Salvador and Nicaragua about Electricity Control Centers reorganisation.

I INTRODUCTION

This paper presents partial results of a joint research work between the Electric and Computer Engineering Department at the National University of Engineering, UNI, Nicaragua and the Industrial Control Systems Department at the Royal Institute of Technology, KTH, Sweden. The research activity is focused in documenting the role and functions of the Electricity Control Centers (ECC) in the Central American region and its organisational and technological migration tendencies in the frame of the Electricity Industry Reforms (EIR) in the region.

I.1 Background

Two countries in Central America are treated in this paper as Case Study, Nicaragua and El Salvador. In both countries, like in the whole Central American region, is undergoing fundamental Electricity Industry Reforms (EIR). The main reasons to conduct these reforms are [8], [9], [10]:

- a. Liberalisation, allowing third parties to be involve in the Electricity Industry (EI) as well allowing the freedom of choice for the customer. In Central America this reason is emphatic oriented to promote third part investing in order to cover the acute deficit of electricity supply due to the state financial deficit.
- b. Deregulation, abolishing pure governmental price control and abolishing restriction for the market entry. This goal also covered the trend to change the current situation of the traditional Electricity Industry (Utilities) that have an electricity tariff lower than the real cost due to governmental subsidies.
- c. Privatisation bound up with a redefinition of the role of the state. In such redefinition the state should stop and not perform entrepreneurial activities when such activities can or will be carried out by the private sector and its main job is oriented to regulate activities that are monopolistic. This creates the need for a national independent regulator of the EI, in several countries such functions were bounded with the national monopolistic Utility. In Central America the funds, assets sales, expected from the privatisation goal already have a role or destination in the macro economy balances.
- d. Competition, as the best way to achieve effectiveness in the management, maintenance, sustainable growth, better prices and services to the customer. The choice of the customer to be supplied from different alternatives, is the real driving force of this concept.
- e. Equalisation of regional price differences, trough the liberalisation third parties from neighbourhood countries can play a role in the local EI market price, so making the local market behaviour more global.
- f. Fulfilment of international economic agencies' requisites to support national macro loans. This goal is especially present in the Central American's countries pursuing credibility at international funding agencies.

Although *competitiveness and effectiveness* in the electricity services, out of the hand and the monopolistic responsibility of the state, seems to be the generic goal in

common in both cases. This means the unbundling of the vertically integrated Utilities.

These goals of the EIR are inducing to understand, design, operate and plan the EI in an economical and a business oriented framework. So the *electric power system* now is treated as the *electricity market*, the *consumer* as the *customer* and all related activities as the *market players or market agents* players (i.e. generators, distributors, traders, retailer and consumers). Economic and business matters are taking priority over technical ones due to the current EIR process.

All Central American countries are developing independent and dynamic EIR. The changes have coincided in several of these countries with the ongoing plans of modernisation of the new generation of the SCADA/EMS Systems at the Electricity Control Centers (ECC). The requirements of the new Control Systems have been specified before knowing the new rules of the markets.

The electrical interconnection of all the countries of the Central America region will also be completed amongst all the countries, with exception of Belize, which brings inherent possibilities for the development of a Regional Electricity Market for all Central America's Countries.

I.2 Purpose of the paper

The main purpose of this paper is to highlight the experiences of the EIR on the current ECC's organisational and operational functions in El Salvador and Nicaragua.

A novel operational model of both ECC, El Salvador and Nicaragua is formulated in this paper. With this model approach the functional changes under demands can be added, placed, linked and documented. The model is based in an object oriented like structure, with the representation of the flow and processing of the operational information. The model of the ECC covers the relationships with the external markets agents as well the internal information flow.

This paper is based on theoretical references with reference of several visits and interviews made to personnel of both ECC, from Nicaragua and El Salvador, with key people involved in the new market of the Electricity Industry.

II ELECTRICITY INDUSTRY CONTEXT IN NICARAGUA

In Nicaragua the EI was a vertical integrated and governmental owned National Utility called Empresa Nacional de Electricidad, ENEL, (National Company for Electricity) which monopolised all the functions of the EI. The EIR in Nicaragua unbundled the functions of Generation in six generation companies (HIDROGESA, GECSA, GEOSA, and GEMOSA), and two Distribution companies (DISNORTE and DISSUR) all of them still state own and open to an auction process. It was created a state owned

Transmission Company that includes the ECC, which is still a state property. Three private international investors have built Thermal Generators, namely Coastal Power Company, Amfels Company and Enron Company.

III ELECTRICITY INDUSTRY CONTEXT IN EL SALVADOR

Previous to the Reforms, the EI in El Salvador was formed by a vertical integrated and governmental owned Electricity National Utility called Comisión Hidroeléctrica de el Río Lempa, CEL, (Hydroelectric Commission of the Río Lempa). The CEL monopolised the functions of Generation, Transmission, Control Center, and possessed most of the stocks of the companies in charge of the distribution and final supply.

As product of the EIR at El Salvador, CEL was unbundled into three companies. One company was formed with all the Geothermal and Hydroelectric Generation pool and remain state owned, it was formed the Transmission Company and the Transaction Unit Company, the last one has the ECC attached. The Transmission Company and the Transaction Unit are Companies constituted as companies shared by all market players. The existent Thermal Generation pool was sold to a private investor, Duke Energy Company bought all the Thermal Generation. The stocks of the Distribution Companies were sold to international private investors. As new Generation Plants investment has been made, Coastal Power Company built a plant based on thermal generation.

IV ELECTRICITY CONTROL CENTER OPERATION IN A COMPETITIVE ELECTRICITY INDUSTRY

For handling the open and competitive energy market, product of the EIR, we will address two fundamental tasks. The first one is the one of operating the system in an open access for any entity or market agent and the second is to administer the power exchanges [5].

For assuring the operation of the Electrical System, a function usually called Independent System Operator (ISO) is used. The ISO is a function without bonds with any of the agents or functions that participate in the competition or electricity market. The tasks of the ISO should develop, are basically the same ones that an ECC developed before the EIR. This means operation oriented to satisfying the electricity demand of the users guaranteeing the quality and security of the National Electrical Grid, taking in consideration new constrains coming from a the novel competitive and business oriented operation approach of the EI. For that purposes the ISO still have the same means than the ECC of the traditional Utilities (SCADA/EMS, RTUs, Communications media, etc) [4] [7].

For dealing the administration of the electricity market, a figure called Power Energy Exchange (PX) it is used. This PX is not more than the administrator of the market. Unlike to the previous one, ISO, it is a completely new function and new task, as product of the change of operation of the reformed EI. The task of the PX is to carry out the verification and the declaration of the quantities of Energy Exchange in contracts and to administrate the spot energy market.

Once the PX has carried out the work about the information collection of the exchanges of power available, the results are communicated to the ISO, which should carry out the operation in real time. This PX should inform the ISO about the power exchange and availability before of a period of unit time decided for the operation of the electricity market.

In the countries under study, both functions, ISO and PX, are concentrated on a single entity or institution. In El Salvador is concentrated at the Independent Company called Unit of Transactions (Unidad de Transacciones, UT) and in Nicaragua at the state owned National Center of Load Dispatch (Centro Nacional de Despacho de Carga, CNDC).

V ELECTRICITY CONTROL CENTER OPERATION IN NICARAGUA

In the case of Nicaragua, there is an ongoing definition of the new SCADA/EMS system without a clear definition of the final organisation and normative of the competitive Electricity Market.

The information flow to be processed at the CNDC is still in definition. Starting from January 15th/2000, it is planned to begin the operation of the market in which will compete the unbundled, still state owned companies, as separate and independent companies.

The communication with the market agents will be carried out transitorily by a dial-up computer communication, which will give access to a computer server with a directory structure. In such directory the agents of the market will be able to deposit and to obtain the necessary information for the development of the market operation. Later on the communication will be enabled by means of a more elaborated Web Site approach that will facilitate the exchange of information making it more user friendly, reliable and with a better integration with the internal offices of the CNDC.

For the internal communication the CNDC has a LAN that allows to share information between the offices or departments of the CNDC, it is considering the implementation of a mail server for the offices that will allow, according to the CNDC staff, to speed up the exchange of information.

The interdisciplinary personnel team has begun to work, several industrial engineers (business oriented professional)

have been contracted for make contributions to the commercial operation of the CNDC.

The development of the programs or software tools for the administration of the market is designed and starting to be made in-house.

The power exchanges metering will be carried out by means of a commercial and standard metering system, which should allow open access to the measurements coming from/to any market agent. For this standardised metering system the CNDC has established standard requirement for the access to the measurement points. Those points for connectivity in the metering system will be available in each injection or retirement node of the transmission grid.

The CNDC in Nicaragua, is part of the Transmission Company, which makes the ECC in Nicaragua nearer to expansion plans, improvements and maintenance of the transmission system. For this reason, in the CNDC it remains the function of operative planning.

V.1 Model of operation of the Electricity Control Center in Nicaragua

The ECC are complex systems characterised by a diversity of processes and sub-processes, where hardware, software and human factors are involved.

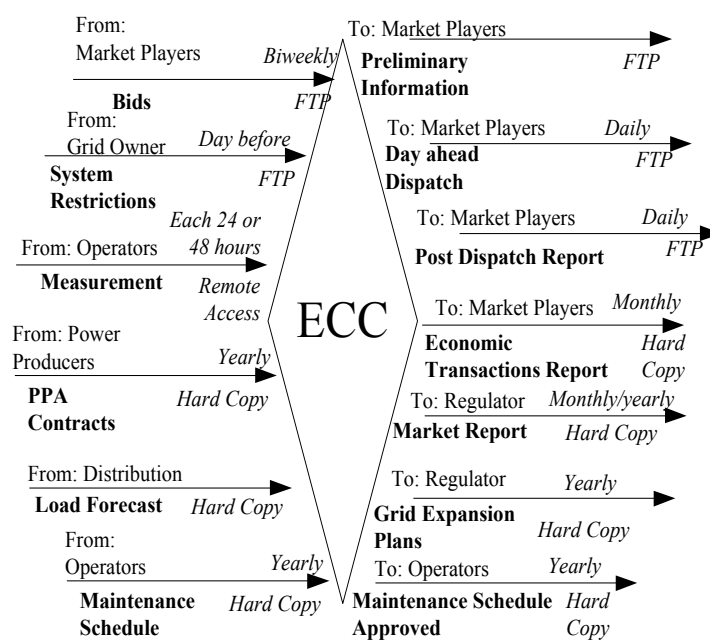


Figure 1. Model of ECC at Nicaragua.

As it was mention in the Electricity Industry Reforms above, the EIR in Nicaragua is not implemented yet. In the figure 1 we represent the model of the ECC, as it is described in the new EI law and normative. The ECC in Nicaragua will be in charge of several transitory tasks, e.g. load forecast,

operational cost definition for the Distribution Companies for the next two years.

In figure 1, we use an intuitive modelling approach where each incoming line represents an operational information, with the attributes: where it comes from; the time frequency; a brief description of the information and the media used for receiving it. Each outgoing line represents an operation information, with the attributes: where it comes from; the time frequency; a brief description of the information and the media used for sending it.

VI ELECTRICITY CONTROL CENTER OPERATION IN EL SALVADOR

In El Salvador the UT already have a new SCADA/EMS system with the functional specification defined for the operation before the EIR.

In the staff structure new departments are related with the function of PX. The function of ISO remains without drastic changes from the previous structure, especially the ones related of the functions of real-time operation of the energy systems, e.g. electricity supply stability and reliability.

However it is very important to notice that the personnel have had to change their operation culture. In El Salvador the ECC has passed from being of state property to a commercial society of shareholders in which the market agents are represented equally.

In El Salvador, the staff at UT, by law, should establish a constant and reliable information of the PX operation day by day, which is settled in hours. The procedure for this day by day information specifies the process of reception of the offers from the generators for the following day. This process begins with the communication of preliminary commercial and technical information from the ECC to the agents of the market, which is used for the formulation of the agents market offers. When the agent market estimate the offers, they should communicate them to the ECC, where the department in charge of the PX, processes them. This exchange of information between the ECC and the agents of the market it is carried out by File Transfer Protocol (FTP). Each agent of the market is linked with the ECC via Dial-up connection and with their password they enter the information and have access to the information that is relevant only to them, guaranteeing the independence, confidentiality and transparency required for a fair business oriented energy market.

Once the offers are inside the ECC information system, it begins the generation dispatch process. The ECC has the so-called Market Management System (MMS), which carry out in an automatic way the decoding and validation of the offers. It is also prepared in parallel a preliminary dispatch based only in the capacity restrictions of generators; this later is a scenario for emergencies. For the communication inside of the El Salvador's ECC there is an INTRANET that

connects the different offices. The MMS in El Salvador was a need not foreseen in the new ECC specification, so it was made in house.

Another new system that has been necessary in El Salvador, is the so-called System of Commercial Metering (SIMEC), which carries out metering of the real-time quantities of energy injection and energy retirement in the different nodes of the transmission grid. For the proper acting of this task, the ECC has specified the measurement standards and communication standards for the equipment to be connected to the metering system.

The traditional staff structure at El Salvador's ECC has change, some personnel of the former group of engineers that developed the long term planning are, at the present time, the engineers forming the department of PX, together with non technical personnel (e.g. economists, business administrators). The tasks of system operation planning have been kept in to a unit for electrical grid analysis for make recommendations on the expansion of the transmission grid.

Part of the personnel from the former group of engineers belong to an specific department of the ISO where they determine the technical viability of the exchanges of power carried out by the PX, adding the technical restrictions of the system, forecasting and solving transmission congestion problems, etc.

In general a new operation atmosphere has begun inside of the El Salvador's ECC, where more proximity exists among each one of the inner departments. This is leading to a need for a better information interchange and settlement of common mission.

In addition, in the stage of implementation of the latest rules of the market, resources have been dedicated for the training and clarification of the market agents; about their rights, responsibilities and information links in the new competitive market.

VI.1 Model of operation of the Electricity Control Center in El Salvador.

In the section VI it was mentioned as the processes of: EIR and the impact in El Salvador's ECC. Below it is presented a model of operation of such ECC, reflecting the flows of information. It is already clear at the ECC that they should implement new functions, designate new offices to cope with new demands and to carry out certain changes from the former operation.

In figure 2 it is shown the ECC model, based in the same intuitive approach, as in figure 1, each incoming line represents an operation information, with the attributes: where it comes from; the time frequency; a brief description of the information and the media used for receiving it. Each outgoing line represents an operation information, with the attributes: where it comes from; the time frequency; a brief

description of the information and the media used for sending it.

The figure 2 shows the operation information about the function of PX. Parallel to these, some incoming and outgoing information, related to the function of the existing ISO, are not included for simplification reasons. However, they are the traditional set of commands and instructions for the operation in real time and the monitoring of the electrical system.

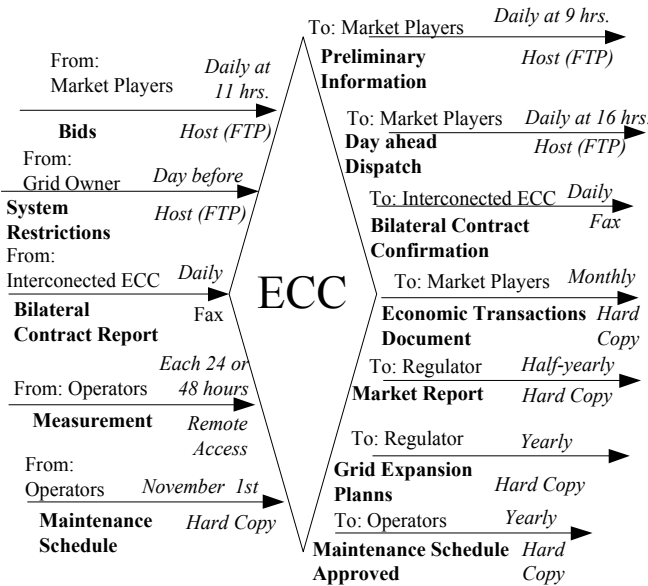


Figure 2 Model of ECC at El Salvador.

In figure 3 (Appendix A) it is shown the information flow inside of the El Salvador's ECC, the thin line-arrows denotes the information valid only for the internal ECC use. The bold lines-arrows denote the information coming in and out of the ECC. For exemplification purposes some details have been simplified, transportation media can be notice in the figure2.

VII CONCLUSIONS

The Electricity Industry Reforms (EIR) bring changes in the operation and organisation procedures in the traditional known functions of the former state owned National Electricity Utilities (i.e. Generation, Transmission, Control Center, Distribution, Final Supply). These functions are linked as entities or agents building the so-called National Electricity Market or Electricity Industry (EI) in each country.

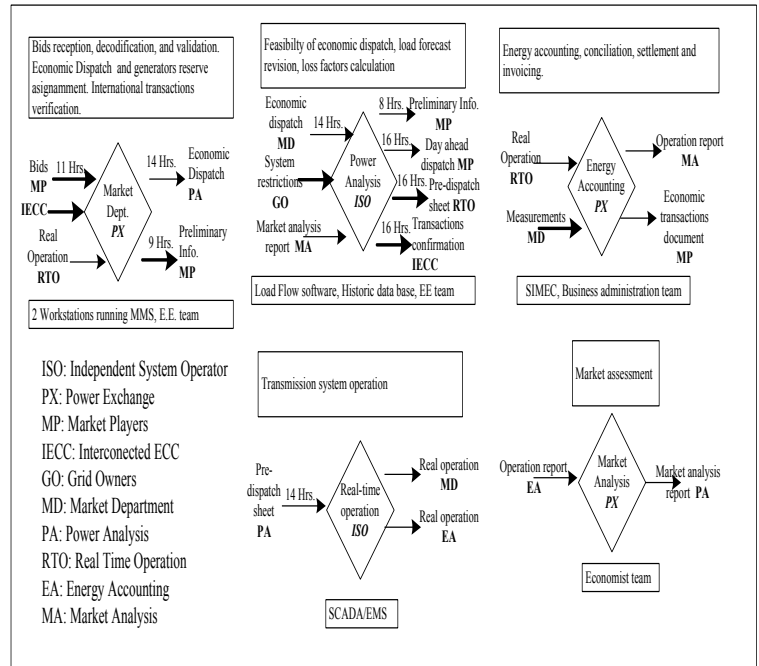


Figure 3 Model of Information flow inside of the ECC at El Salvador

These changes induce modifications to the organisational structures, changes to the traditional relationships among the entities or agents and adjustments in the operation procedures. The necessities of new or renovated technology (i.e. software and hardware) as well as changes that involve retraining of the operators (human factor). The key personnel involved with anyone of the functions of the Electricity Industry (EI) have to learn how to deal with the new concept of open and business oriented procedures.

The EIR described here indicates that the competitive electricity market design has a significant impact on the ECC operational procedures and organisation.

Of the two functions that the ECC assumes in a competitive market, the one that demands more technological changes or implementation of new systems is the task of PX. For a proper administration of the markets it is necessary to: create standard communication procedures, formats and media with the market agents. The communication issues take a very important role inside the ECC.

In El Salvador the situation now is that all decisions taken by the personnel of the ECC affect the market agents directly. Therefore, affecting the shareholder and implying financial aspects, so the personnel feel that their work at the present time has a bigger importance. The results of any decision, which previously remained in anonymity, is now exposed before a council where the decision should be properly supported by arguments and not show discriminatory bias.

The operation model presented here, based in an intuitive graphical representation of the information flow can facilitate the traceability and follow up of the evolution and the answer for the need of changes at the ECC. The international

experiences have demonstrated that processes of EIR are dynamic with a tendency to correct problems that may occur on the way.

The value of any model is laying in its ability to help us to represent the characteristics of an *entity* for a system and the system it self (Electricity Control Center and inner structure). The intuitive graphical modelling approach here proposed is using the information interchange for the market operation of the EI in El Salvador and in Nicaragua. The sources of such model are the new laws and normative induced of the EIR, and validated by interviews and comments from the ECC staff. The attributes so far related to the model are the fundamental data for any information "going in" and "going out" of the ECC. Such attributes are: where the information comes from; where the information is going to; the time frequency the information is received a brief description of the information content; and the media used for receiving or sending it.

The model is more than a drawing tool. It is intended to promote effective communication through graphical representation of operation and organisational information flow. The end goal of the model is to improve the follow up of relationships in order to have a blueprint for the large complex systems as the Electricity Industry.

According to our interviews to the Control Center staff in El Salvador and in Nicaragua, it is not difficult to adapt the new defined SCADA/EMS systems to the technical realities of the EIR of each country. The staff accepts that it is not well defined the needed of the commercial software that should gathers the specific requirements for the PX functions. The staff at the ECC has been validating the basic models here presented, and so far is adopted in Nicaragua as references for further detailed definition in the inner structure of the ECC.

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